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ENGINEER ANALYSIS OF THE LIGHT INFANTRY DIVISION (ELID)

VOLUME I

Prepared by
Engineer Studies Center
US Army Corps of Engineers

DECEMBER 1986

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This study analyzes the engineer requirements of the light infantry division (LID) during two very different 1988 wartime scenarios, and determines the engineer force needed to support the division in either scenario.

The general study methodology compares engineer requirements with engineer capability. The requirements are unconstrained but realistic. They are unadjusted project site requirements for personnel and equipment, while capability is degraded with such commonly accepted factors as casualties and movement. As a result, the comparison provides time-phased estimates of what requirements can be accomplished in priority order.

The study concluded that:

*The LID engineer battalion working alone can successfully support the division during the initial phase of a short-duration, low-intensity conflict, but needs immediate EAD

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augmentation to support the division during mid- to high-intensity conflicts. Given the LID's most likely deployment conditions, the EAD unit best configured to support the division is the corps airborne battalion.

The LID has the right kind and number of trucks to meet the engineer requirements imposed by various wartime scenarios. However, a 1-to-1 mix of ACE-to-SEE equipment (including a full complement of SEE attachments) is better suited than the LID's current mix to helping the divisional engineer battalion meet the requirements imposed by various scenario conditions.

Adding scatterable mines and improved conventional mines to the LID's equipment inventory will broaden the range of mobility and countermobility tasks the division can undertake. They also will likely reduce the divisional engineer requirements for transporting Class IV and V materiel.

The LID's few large-gap bridging requirements can best be met by a lightweight, easy-to-transport bridge that can be placed over both wet and dry gaps, and which can be erected, in emergencies, by LID engineers working without EAD support.

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VOLUME II is classified SECRET

EXECUTIVE SUMMARY

1. The light infantry division (LID) is the army's newest division. A total of five LIDs (four active and one reserve) have been activated and are in various stages of formation. The LID's organic engineer battalion was formed quite small in order to meet overall divisional manpower and deployability constraints. Little is known of the LID's new engineer battalion's concept of operation. Questions arise as to what role, organization, and structure is appropriate for divisional and echelons-above-division (EAD) engineers? This study is a comprehensive assessment of these questions. The study was sponsored by the Army Development and Employment Agency, and performed by the US Army Engineer Studies Center (ESC).

2. The table of organization and equipment (TOE) mission of the LID states that it "rapidly deploys to defeat enemy forces in low-intensity conflict and, when properly augmented, reinforces US forces committed to a mid- to high-intensity conflict."* GEN John A. Wickham Jr., Chief of Staff of the US Army has commented on these missions and reinforced them by stating "Light divisions are designed to function in the low- to mid-intensity environment, to get to crisis areas rapidly, either to deter hostilities or to influence them to our advantage...with adequate support capability [they] can be used in mid- to high-intensity conflicts should the need arise."** Based on this dual mission, two US Army Training and Doctrine Command scenarios (gamed by the JIFFY model) were used to generate engineer requirements. The two contrasting -- but very representative -- sets of theater requirements were in Latin America and Europe.

3. The study concluded that the LID engineer battalion, working alone, can successfully support the division during the key combat situations which occur during the initial phase of a short-duration, low-intensity conflict. However, the LID needs immediate EAD augmentation to support the division's key situations which occur during mid- to high-intensity conflicts (Figure i). Given the LID's most likely deployment area and the fielding of future mining and explosive systems, the EAD unit best configured to support the division is the corps airborne battalion (load-and-unload version).

4. The study also concluded that the LID has the right kind and number of trucks to meet the engineer requirements imposed by various wartime scenarios, if logisticians push supplies at least to brigade support areas and provide occasional helicopter support. Figure ii provides a comparison of the equipment mixes generated by each scenario with the current TOEs and the resultant ESC recommended mix. However, a shown in Figure ii a 1-to-1 mix of ACE-to-SEE equipment (including a full complement of SEE attachments) is better suited than the LID's current TOE mix. This changed equipment mix would greatly help the divisional engineer battalion meet the requirements imposed by various scenario conditions.

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*Table of Organization and Equipment 77-00J800 (Department of the Army, 1 April 1984).

**"A Proud Place to Be -- a Good Place to Go and Serve," Army: The Magazine of Landpower, Volume 36-9 (September 1986).

SCENARIO BASED ENGINEER BATTALION REQUIREMENTS

	Latin American	Europe Today*	Europe Future**
Combat-essential force (needed at H-hour):	LID Battalion	LID Battalion Corps Battalion	LID Battalion Airborne Battalion
Sustainability force (needed at D+14):	Airborne Battalion	Corps Battalion	Light Equipment Co
Total force (battalions)	2	3	2+

*Scenario with current mining and explosive systems.
**Scenario with Volcano and improved conventional mines, plus liquid explosives.

Figure i

DIVISION EQUIPMENT REQUIREMENTS AND COMPARISON
(In Support of Engineer Workload)

	LID Engineer Battalion			
	Armored Combat Earthmover (ACE)	Truck	Small Emplacement Excavator (SEE)	Combat Aviation Brigade Helicopters
Key situation requirements*				
Latin America	10	3	6	1
Europe	14	2	14	0
Composite scenario**	11	3	9	NA
1988 TOE quantity	6	3	18	30
ESC Recommended quantity	11***	3	10***	NA

*Important priority groups and preparation and combat time periods.
**2/3 Latin America; 1/3 Europe.
***With no increase in C-141B sorties, but higher quantities possible if about a 1:1 ratio (ACE:SEE) is maintained.

Figure ii

5. The study's conclusions and the resulting mobility and countermobility recommendations reinforce the design concepts of the LID. To those more familiar with mechanized and armored operations, the study's final conclusions may seem very rudimentary. Light infantry operations with their complementary engineer support roles outwardly are very basic. However, the simple structure tinted with just the right amount and kind of modern technology is very dynamic and consequently very powerful.

a. When the study project team started this analysis, it had reservations about many of the LID's unusual engineer organizational and operational concepts. How adept is an engineer battalion with only 290 men containing squads without vehicles and only two major kinds of engineer equipment totaling 24 pieces?

b. ESC's data base was the 13th Engineer Battalion, 7th Infantry Division (Light) (7th ID [L]), stationed at Fort Ord, California. The 7th ID(L) was selected as ESC's data base because it has been organized longer than any other LID. During the course of this 12-month study, ESC confirmed the LID concepts by its analysis and observed the leadership of the 13th Engineer Battalion through its actual training and practice. For example, during the August 1986 division certification test, a shortage of ACEs and a surplus of SEEs was experienced. This result is similar to that projected by ESC's study findings.

c. The LID concept works. The fact that it works is known to the 7th ID(L) which, at this writing, has become a highly motivated well trained elite division. The LID engineer concept makes sense because it is rooted in historical principles.

(1) **The LID has small areas of operation.** Engineer workload is directly equatable to the terrain that engineers must change. Small AOs with less area for movement to maneuver leads to reduced engineer requirements.

(2) **The LID operates in closed terrain.** Engineer workload is reduced in closed terrain because closed terrain offers more natural cover and obstacles. More point obstacles are required than linear obstacles, but overall less effort is involved (point obstacles are less time consuming to construct than linear obstacles). Difficult terrain also slows enemy advances, giving engineers more time to complete their mission-related tasks.

(3) **The LID must deploy fast.** LID systems must be light so that the division can move quickly. These light systems are easy to learn, easy to operate, and easy to resupply. These characteristics make them very effective and powerful. For engineers, heavy explosives give way to equipment with relatively low fuel resupply needs.

(4) **The LID has limitations in high-intensity conflict.** In Europe, the LID must be augmented so that threat advantages are offset. This augmentation requires a heavy brigade for maneuver operations, more artillery firepower for suppression, and correspondingly, as determined by this study, one or two corps engineer battalions for altering the terrain.

6. ESC's findings constitute a data base that can be adjusted if light infantry concepts or equipment characteristics change in the future. Presently the division accepts certain risks, such as resupply limitations and lodgement security, that are shared equally by engineers. ESC's recommendations are based on doctrine, TOEs, and representative scenarios. The scenarios used by ESC apply the operational concept of the LID to include the two applications of Combat Aviation Brigade employment, which is currently under debate. The requirements generated by the scenarios and the resulting conclusions and recommendations of the study outline rather general recommendations that enhance the engineer support to the division. No attempt is made to recommend detailed line item changes to the divisional engineer battalion's TOE.

ABBREVIATIONS AND ACRONYMS

ABN......................airborne
ACE......................armored combat earthmover
ADA......................air defense artillery
ADAM.....................artillery delivered anti-personnel munition
ADEA.....................US Army Development and Employment Agency
AFPDA....................Army Force Planning Data and Assumptions
AO.......................area of operations
AOS......................aircraft operating surface
AP.......................antipersonnel
APC......................armored personnel carrier
AR.......................Army Regulation
ARTEP....................Army Training and Evaluation Program
AT.......................antitank
ATP......................ammunition transfer point
avn......................aviation

BCY......................bank cubic yard
BDE......................brigade
bn.......................battalion
BOIP.....................basis of issue plan
BSA......................brigade support area

CAA......................US Army Concepts Analysis Agency
CAB......................Combat Aviation Brigade
CACDA....................US Army Combined Arms Combat Development Activity
CAORA....................US Army Combined Arms Operations Research Activity
CASTFOREM................Combined Arms and Support Task Force Evaluation Model
CAV......................cavalry
CCM......................cross-country mobility
CEWI.....................Communication EW Intelligence
CFA......................covering force area
CMALB....................Countermobility in Support of AirLand Battle
co.......................company
CORDIVEM.................Corps-Division Evaluation Model
CP.......................command post
CRA......................corps rear area
CSE......................combat support equipment
CSH......................Combat Support Hospital
CY.......................cubic yard

DA HQ....................Department of the Army Headquarters
DISCOM...................division support command
DRA......................division rear area
DS.......................direct support
DTOC.....................divisional tactical operation center

EAD....................echelon above division
EEA....................essential elements of analysis
E-FOSS.................Engineer Family of Systems Study
EFFORT.................ESC Factor Force Readiness Tabulation
ESC....................US Army Engineer Studies Center
EW.....................electronic warfare

FA.....................field artillery
FAAR...................forward area alerting radar
FARP...................forward area refueling point
FDC....................fire detection center
FEBA...................forward edge of battle area
FLOT...................forward line of own troops
FM.....................Field Manual
FSSP...................fuel system supply point

GEMSS..................Ground Emplaced Mine Scattering System
GOP....................General Outpost
GS.....................general support
GTSC...................German Territorial Southern Command
GDP....................general defense plan

HHC....................headquarters and headquarters company
HEMMS..................Hand Emplaced Minefield Marking System
HMMWV..................high mobility multipurpose wheeled vehicle

ICOM...................improved conventional mines
ID(L)..................Infantry Division (Light)
IPR....................In-Process Review

LAPES..................Low Altitude Parachute Extraction System
LCY....................loose cubic yard
LID....................light infantry division
LOC....................lines of communication

MAOS...................minimum aircraft operating surface
MBA....................main battle area
MICLIC.................mine cleaning line charge
MOPMS..................Modular Pack Mine System
MP.....................military police
MSR....................main supply route
MTOE...................modified table of organization and equipment

NBC....................nuclear, biological, chemical

O&O....................organization and operation
OPLAN..................operations plan

RAAM....................remote antiarmor mine
RBE.....................rubble blast emplacement

SAG.....................Study Advisory Group
S&S.....................supply and services
SEE.....................small emplacement excavator
STON....................short tons
SWA.....................Southwest Asia

TB......................Technical Bulletin
TC......................Technical Circular
TEXS....................Tactical Explosives System
TFOB....................tactical forward operating base
TM......................Technical Manual
TOC.....................tactical operations center
TOE.....................table of organization and equipment
TOW.....................tube launched, optically tracked, wire-guided missile
TRADOC..................US Army Training and Doctrine Command
TRANSANA................TRADOC Systems Analysis Activity

USACE...................US Army Corps of Engineers
USAES...................US Army Engineer School
USAREUR.................US Army, Europe

WES.....................US Army Waterways Experiment Station

I. INTRODUCTION

1. Purpose. This study analyzes the engineer requirements of the light infantry division LID under two 1988 wartime scenarios, and determines the engineer force capabilities needed to support the division.

2. Background.

a. During the development of the LID, the size of its divisional engineer battalion was reduced to meet manpower and deployability constraints. Little is known about the engineer mission capabilities of this smaller battalion, or the specific needs for engineer support from echelon-above-division (EAD) units.

b. On 30 July 1985, MG Donald S. Pihl, the Commander of the US Army Development and Employment Agency (ADEA), wrote LTG E. R. Heiberg III, Chief of the US Army Corps of Engineers (USACE), asking for his help in conducting a study to definitively measure the impact of the LID's new engineer organizational design on the division's operation. MG Norman G. Delbridge, Jr., USACE Deputy Commander, responded to that request by tasking the US Army Engineer Studies Center (ESC) with a comprehensive assessment of the LID's engineering capabilities and requirements under two likely combat scenarios with very different deployment and battlefield conditions.

c. In September 1985, ESC published a study plan for the project, outlining its intentions of evaluating the divisions's ability to complete mobility, countermobility, survivability, and general engineering tasks under the scenarios approved by the project's Study Advisory Group (SAG). That plan was accepted at the SAG's first in-process review (IPR) on 10 October 1985 and is summarized in Annex A.

d. The 7th LID was ESC's primary source of information and interpretation of the division's published concept of operations, since the 7th LID had been organized the longest as a LID. In October 1985, the study team visited the 7th LID at Fort Ord, California, to collect data on the division's engineer requirements. At the same time, the 13th Engineer Battalion of the 7th LID developed and staffed the divisional priorities for engineer support for each combat phase of the scenarios to be considered by the study.

e. A Latin American scenario and priority task lists were approved by the SAG at the second IPR, 10 December 1985; a European scenario and priority task lists were approved at IPR 3, 3 April 1985. A final draft of the study was completed and presented for comment at IPR 4 on 4 September 1986.

3. Scope. As a requirements-based study, the focus of this effort was to:

a. Find the time-phased mix of engineer units needed to satisfy the engineer requirements within the LID's area of operations (AO).

b. Suggest changes to the division's engineer battalion and engineer EAD units that would enhance their ability to support the division.

4. Organization. Volume I of this report is unclassified and describes the study's methodology and summarizes significant findings, conclusions, and recommendations. A series of annexes provide the details of each step in the assessment and describes the new structures ESC recommends be considered for the division's organic battalion and EAD units. Volume II, which is classified SECRET, gives the details of the Latin American and European scenarios that were the basis of this analysis.

5. Assumptions and Their Significance.

a. ASSUMPTION: The organization of the LID is fixed as of November 1985 and identifies all equipment that will be available to the division between 1988 and 1992. SIGNIFICANCE: This assumption establishes the division's future design capability, ignoring any existing surrogate items of equipment which could be changed later because of a revised divisional concept, a technology breakthrough, or delays in developing new equipment.

b. ASSUMPTION: Engineer requirements are accurately represented by the two JIFFY scenarios developed by the US Army Combined Arms Operations Research Activity (CAORA) and by the division's operational concept, as published by US Army Combined Arms Combat Development Activity (CACDA).[1] SIGNIFICANCE: The scenarios provided a wide range of terrain and combat conditions upon which to base engineer requirements. Where concepts are either changing or can be interpreted differently, they were tested by using additional study excursions developed especially by the study team for this analysis.

c. ASSUMPTION: The EAD units supporting the LID and working within the divisional AO are defined by the Summary of the Infantry Division (Light) Wargame prepared by CAORA and modified by ESC.[2] SIGNIFICANCE: Corps engineer capability and EAD requirements were computed and compared only for operations after the lodgement phase. The unit arrival dates provided in the scenario do not match any operations plan (OPLAN) deployment schedule.

d. ASSUMPTION: Engineer Class IV and V materiel and munitions will be delivered to the brigade support area (BSA) by other than engineer

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[1] US Army Operational Concept: The Light Infantry Division (US Army Combined Arms Combat Development Activity [CACDA], 15 March 1984).
[2] Summary of the Infantry Division (Light) Wargame (US Army Combined Arms Operations Research Activity [CAORA], 28 June 1984).

transportation assets. SIGNIFICANCE: Failure of the division transportation and logistical systems to deliver engineer material to the BSA will greatly reduce the number of squad-hours that can be directly expended on engineer support tasks, and will place more demands on engineer transportation assets.

e. ASSUMPTION: Only large gap crossings (over 18 meters) will be considered in the EAD bridging requirements and capability analysis. SIGNIFICANCE: This study can neither confirm nor reject the small gap (less than 18 meter) crossing requirements and the engineer small gap capability for the LID.

6. Essential Elements of Analysis (EEA).

a. What engineer missions are best done by divisional engineers and (within constraints) what organizational improvements are needed to accomplish these missions?

b. What engineer augmentation is required from EAD and what organizational improvements for these units are needed?

c. What is the Class IV and V logistical requirement for the divisional engineers and how can this materiel be transported? What is the divisional engineers internal transportation capability and what part of the division's total logistical requirement must be met by division and EAD sources?

d. How does terrain in a contingency area affect the frequency and type of engineer missions?

7. Study Methodology.

a. Figure 1 shows the general study methodology used to compare engineer requirements with engineer capability for the Latin American and European scenarios. The requirements were unconstrained, but realistic; they were calculated at the work site, assuming the optimum size workforce. Capability was degraded by such commonly accepted factors as casualty and movement rates. (Annex B fully describes all degradation factors.) The methodology generated, as a time-phased estimate, what engineer requirements can be executed in which order during the battle phases of each scenario (Figure 2). The results for each scenario are presented and then combined to provide a common basis for the study's recommendations. The SAG approved ascenario weighting scheme in which the results of the Latin American scenario are valued twice that of the results of the European scenario; the weighting scheme helped ESC evaluate how well the organization of the LID engineer battalion met the engineer requirements it was designed to satisfy. The primary rationale for the weighting scheme was based on the divisional mission and operational concept, which emphasizes a rapid response in a crisis — similar to the situation presented by the study's Latin American scenario.

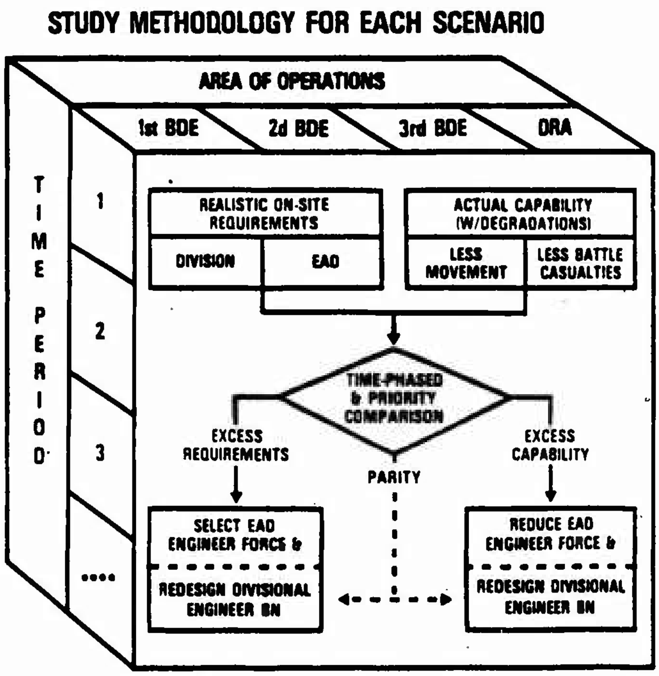


Figure 1

TIME PERIODS

Period	From	Through	Days	Battle Phase
				Latin American Scenario
1	D+1	D+2	2	Deployment, lodgement, and secure AO.
2	D+3	D+4	2	Move to and defend divisional AO.
3	D+5	D+8	4	Attack on main avenue of approach, move to brigade tactical forward operating base (TFOB).
4	D+9	D+10	2	Move to and attack within new brigade TFOB.
				European Scenario
1	D-10	D+7	18	Deployment, lodgement, and movement to AO.
2	D+8	D+10	3	Prepare defensive positions.
3	H-hour	H+23	1	Defend.
4	H+24	H+47	1	Counterattack.
5	H+48	H+95	2	Delay.

Figure 2

b. ESC's study team asked the 7th LID's staff to rank each of the division's expected engineer tasks, by battle phase for each scenario, using a special task ranking system developed by ESC (see Annex A). Figure 3 briefly defines each priority group in ESC's ranking system; Figures 4 and 5 are a consolidated version of the rankings selected by the 7th LID for the LID under the scenarios considered by this analysis. A detailed description of each functional area increment is given in Annex C (Mobility), Annex D (Countermobility), Annex E (Survivability), and Annex F (General Engineering).

PRIORITY GROUPS

Short Title	Implications of Nonsupport
Vital	Jeopardizes the existence of the division; high loss of life; and early defeat of the division.
Critical	Failure of division operations; increased probability of defeat; paramount to success in pivotal situations.
Essential	Short-term degradations in sustainability; significant equipment and material losses (may be deferred 1 to 2 weeks).
Necessary	Long-term degradation in sustainability; moderate equipment and material losses (may be deferred up to 4 weeks).

Figure 3

CONSOLIDATED INCREMENT PRIORITY LIST -- LATIN AMERICAN SCENARIO*

Rank	Priority Group	Battle Phase: Lodgement	Battle Phase: Offense	Battle Phase: Defense
1	Vital	G-1	M-1	S-1
2	Vital	S-1	C-1	C-2
3	Vital/Critical	(V) M-1	(C) S-1	(V) G-1
4	Vital/Critical	(V) G-2	(C) M-2	(V) C-1
5	Vital/Critical	(V) S-2	(C) G-1	(C) S-2
6	Critical	M-2	G-2	S-3
7	Critical	S-3	S-2	G-2
8	Critical/Essential	(C) G-3	(E) M-3	(E) C-3
9	Essential	S-4	M-4	G-3
10	Essential	C-2	S-3	M-2
11	Essential	G-4	G-3	C-4
12	Essential/Necessary	(E) C-3	(N) C-2	(E) S-4
13	Necessary	M-3	G-4	G-4
14	Necessary	C-1	S-4	M-1
15	Necessary	M-4	C-3	M-3
16	Necessary	C-4	C-4	M-4

*Ranked by increment level (letters indicate engineer mission areas): M = Mobility; C = Countermobility; S = Survivability; G = General Engineering.

Figure 4

CONSOLIDATED INCREMENT PRIORITY LIST -- EUROPEAN SCENARIO*

Rank	Priority Group	Battle Phase Lodgement	Battle Phase Offense	Battle Phase Defense
1	Vital	S-1	M-1	S-1
2	Vital	S-2	M-2	C-2
3	Vital	S-3	G-1	S-2
4	Vital/Critical	(V) G-1	(C) G-2	(V) S-3
5	Vital/Critical	(C) C-2	(C) M-3	(V) C-3
6	Vital/Critical	(C) S-4	(C) C-1	(V) C-4
7	Critical/Essential	(E) G-2	(C) S-1	(C) G-1
8	Critical/Essential	(E) M-2	(C) S-2	(C) C-1
9	Critical/Essential	(E) G-3	(E) M-4	(C) G-2
10	Essential	C-3	S-3	S-4
11	Essential	G-4	G-3	G-3
12	Essential/Necessary	(N) M-3	(N) C-2	(E) M-3
13	Necessary	C-1	G-4	M-2
14	Necessary	M-1	S-4	G-4
15	Necessary	C-4	C-3	M-1
16	Necessary	M-4	C-4	M-4

*Ranked by increment level (letters indicate engineer mission areas): M = Mobility; C = Countermobility; S = Survivability; G = General Engineering.

Figure 5

c. Figures 6 lists the 12 study excursions the study team used to address the issues raised by the SAG and by the EEA that could not be answered by the study's general methodology. These excursions are extensions of the study's base case. In brief, the study base case is confined to these conditions:

(1) The 1988 timeframe using the design (or objective) LID Table of Organization and Equipment (TOE) 77-00J800.

(2) Only conventional explosives are available and the Volcano mine system is not available.

(3) The LID's 105-mm artillery howitzers are upgraded to 155-mm in the European scenario.

d. During the conduct of the study, ESC determined that the combined impact of the scatterable mines and liquid explosive logistics excursions (numbers 4 and 6 in Figure 6) on the engineer capability of the LID battalion was very significant in Europe. This was a direct result of the heavy percentage of mining tasks required under that scenario, and the corresponding decrease in squad- and truck-hour capability available in the vital priority task group. As a result, these excursions were combined into a separate case -- the European new explosive excursion. The results of this excursion are displayed alongside the results of the base case scenarios throughout this report.

e. The study methodology allows ESC to consider changes to the operational concept of LID forces. The SAG is sensitive to this possibility, and has asked ESC to analyze two additional European scenarios for the LID being prepared by two elements of the US Army Training and Doctrine Command (TRADOC). These new scenarios will apply the LID operational concept as written in 1984 -- the basis of the analysis presented here. They will,

STUDY EXCURSIONS

Title	Engineer Capability: Division	Engineer Capability: EAD	Force Requirements: Division	Force Requirements: EAD	Location in Volume I
1. Attached corps battalion (light)	X	X	X	X	Annex J
2. Organic engineers -- forward**	X		X		Annex I
3. EAD engineer -- rear**		X	X	X	Annex I
4. Scatterable mines	X	X	X		Annex D
5. Vital & critical tasks	X	X	X	X	Main report
6. Liquid explosive logistics	X		X		Annex G
7. SEE attachments	X		X	X	Annex I
8. Engineer Class IV/V	X	X	X		Annex G
9. Corps bridging*		X	X	X	Annex J
10. Airfield construction*	X	X		X	Annex F
11. Added TOE vehicles*	X		X	X	Annex H
12. Fourth line company	X		X	X	Annex H

*Analysis conducted for Latin American scenario only.
**Analysis conducted for European scenario only.

Figure 6

however, apply that concept differently. In addition, the strength of ESC's study methodology is the weakness of the TRADOC studies and, correspondingly, the weakness of ESC's methodology is the corresponding strength of the TRADOC efforts. The TRADOC and ESC efforts should complement each other and broaden the base of information available about LID engineer initiatives.

f. The development and gaming of the TRADOC scenarios began in late 1985, and is scheduled for completion in 1986. These new scenarios will differ from the scenarios used for this analysis, which were based on 1984 CAORA wargames. The major differences are outlined below:

(1) Countermobility in Support of AirLand Battle (CMALB) scenarios. This effort is a two-scenario study sponsored by the US Army Engineer School (USAES). The study agency for the European scenario is the TRADOC Systems Analysis Activity (TRASANA). TRASANA will use the Combined Arms and Support Task Force Evaluation Model (CASTFOREM), which models a blue battalion versus a red regiment. The scenario area is located in the V US Corps sector and will utilize available digitized terrain. For the Southwest Asian (SWA) scenario, CAORA's JIFFY model is being used. The SWA area has some similarities to Europe and therefore a few JIFFY findings may apply to both theaters. The ESC study will estimate all division requirements; CASTFOREM will simulate the division requirements based on a battalion sample, and JIFFY will play some engineer tasks at the division level. The ESC methodology will provide specific estimates on the size of the engineer EAD force; CASTFOREM will provide estimates on the values of the engineer combat multiplier, and JIFFY will validate maneuver concepts.

(2) EUROPE VI operational scenario. This is a TRADOC study, with each school or center providing input and CAORA providing the gaming. CAORA will use the Corps-Division Evaluation Model (CORDIVEM), which includes one LID in the wargame. This scenario will share part of the same closed area for the LID's operations in Europe used for the ESC study scenarios. The USAES will provide the initial task inputs for the preparation phase, which lasts 2 days longer in the CORDIVEM wargame than in this study's scenario. However, the preparation phase is entered before the wargame begins, and no check is made on whether the engineers have the capability to emplace the total workload. In contrast, the ESC study will execute the capability phase and provide a check against the preparation phase in its parallel effort. Both studies use the LID operational concept as written in 1984, but with slightly different applications. The most noticeable difference is the employment of the combat aviation brigade (CAB). In this study, the CAB occupies the forward edge of battle area (FEBA) and supports the other maneuver brigades with helicopter support; in the CAORA game, the CAB is the LID's counterattack force. As of September 1986, the gaming had not been completed. Therefore, ESC will not compare battle results or determine if the CAB is used as planned.

8. <u>Format of Analysis Results</u>.

a. Figure 7 is an example of the sliding bar charts developed to graphically compare how engineer capability was allocated during each battle phase of each scenario. As much information as possible was compressed onto each chart to completely record the results of the analyses of each different base case and excursion for the Latin American and European scenarios. Squad- or equipment-hours are listed on the vertical axis of the charts and are expressed as per-day averages to make it easier to compare time periods of varying lengths (horizontal axis). The top of the bars within the chart shows the available squad (or equipment) capability within the time period. For example, in Figure 7, there are 3,000 (or 3,500) hours per day per time period available to do work.

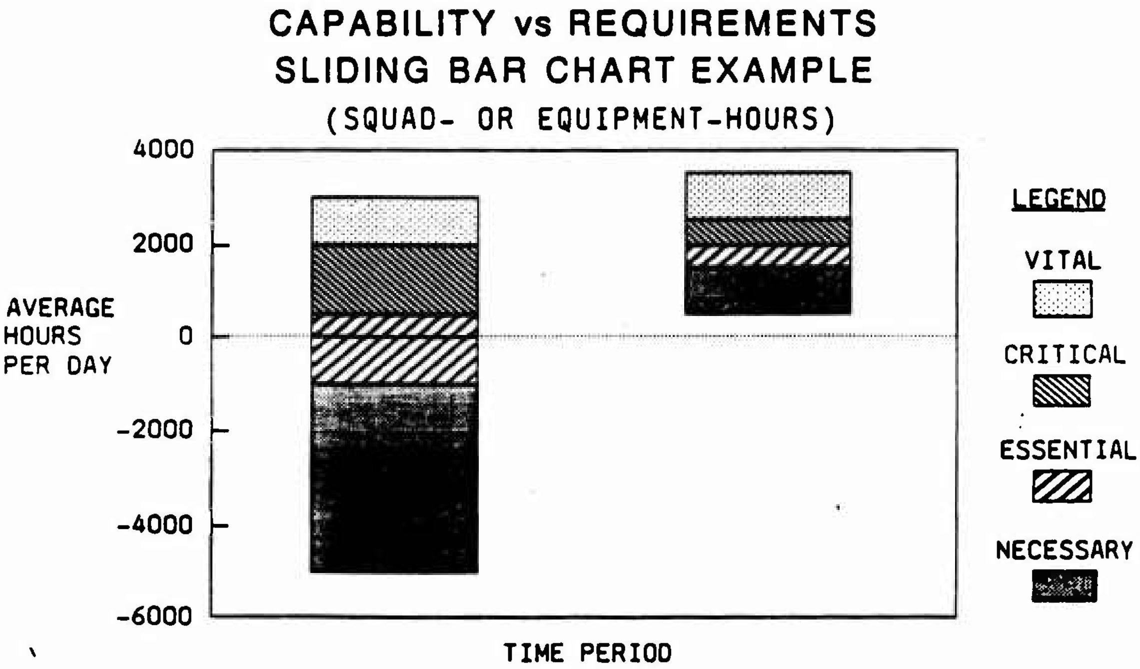


Figure 7

b. The bar charts also show how requirements were subtracted, in priority order, from the available hours-per-day capability using the four priority groups in ESC's task ranking methodology -- vital, critical, essential, and necessary. The point at which the bar crosses the zero axis indicates where capability is exhausted. The segment below the axis represents shortfall (i.e., requirements which cannot be met). If the bottom of the bar is above the zero axis in any time period, then all requirements can be met in that period. Blank space between the bar and the zero axis means there is surplus capability within a time period.

c. In the example in Figure 7, the available capability indicated on the first bar is only sufficient to meet vital and critical requirements and to complete the most important one-third of the essential tasks. The rest of the essential and all the necessary tasks cannot be performed. The bottom of the bar shows the total shortfall is 5,000 hours per day. However, the capability indicated on the second bar is enough to complete tasks in all four priority groups and still leave a surplus capability of 500 hours.

9. General Capability Results. Each base case scenario includes the capability of the engineer battalion organic to a LID. This unit is organized as TOE 5-155J8 with 290 individuals; if it were to deploy separately, it would require the equivalent of about 16 C-141B sorties. The base case for the Latin American scenario has no EAD engineer units. In the European base case scenario, there are two engineer EAD units -- one forward-deployed corps battalion with 673 individuals, and the separate engineer company organic to a deploying active Army armored brigade with 211 individuals. For the new explosive European excursion (substitution of new mines and explosives), the corps battalion is changed to the lighter airborne version of only 559

individuals. This conceptual airborne battalion and the separate armored brigade company are airlifted to the divisional AO. Figure 8 shows the capability for the LID's engineer battalion, in average squad- and equipment-hours by battle phase, under the Latin American scenario. Figure 9 shows the same information for the European scenario, including the capability represented by the augmentation of the engineer EAD units.

a. Capability observations -- Latin America and Europe.

(1) The average engineer capability during both scenarios' deployments is moderate. This is caused by the staggered deployment, and is especially noticeable during the European scenario, when most units arrive near the end of the 18-day deployment and lodgement period.

(2) Engineer capability for the combat periods during both scenarios declines as a direct result of casualties; the scenario models do not replace casualties.

b. Capability observations -- Europe only. During the European new explosive excursion, the EAD corps battalion is replaced by the airborne battalion. This lighter airborne battalion has less manpower, but more equipment. In Europe, capability is greatest during the battle preparation period when all engineer units are working and there are no engineer casualties.

10. <u>Latin American Scenario -- Capability Versus Requirements</u>.

a. Capability. Figures 10 and 11 display the results of the capability versus requirements comparisons made for each battle phase of the Latin American scenario. Several trends are evident in the figures.

(1) During Period 1, the deployment and lodgement phase, all tasks are completed, leaving a surplus of capability. The study methodology parcels many of the lodgement tasks (such as airfield maintenance and repair)

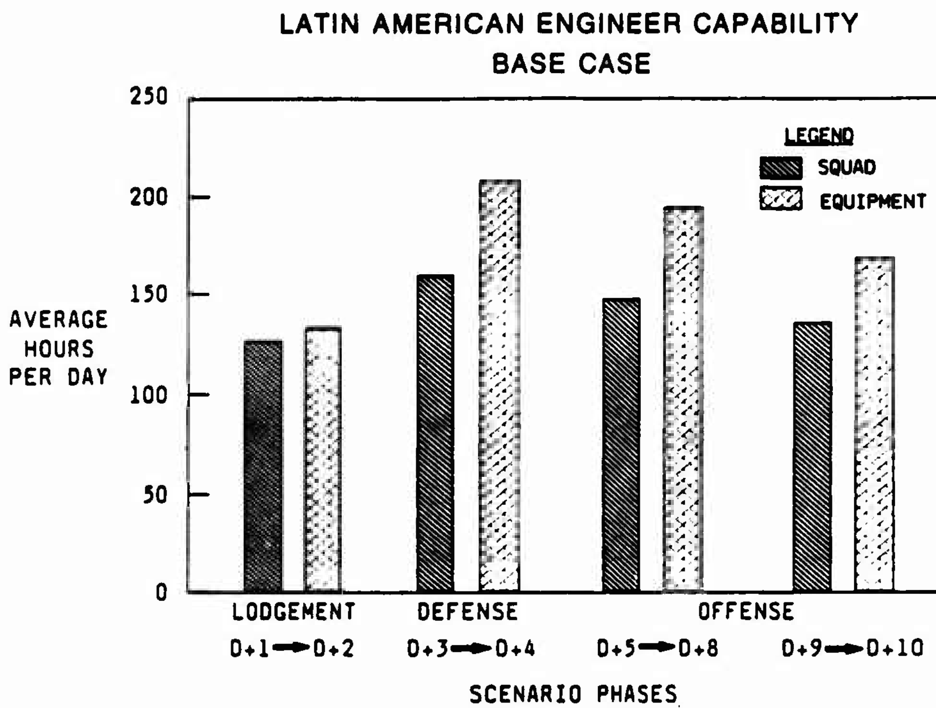


Figure 8

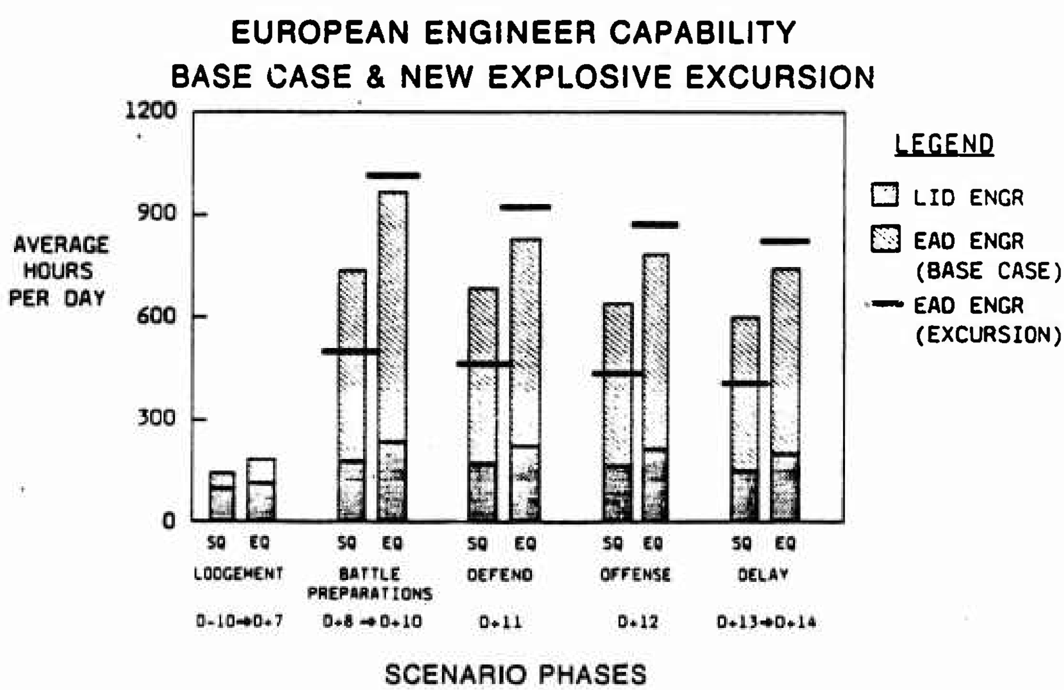


Figure 9

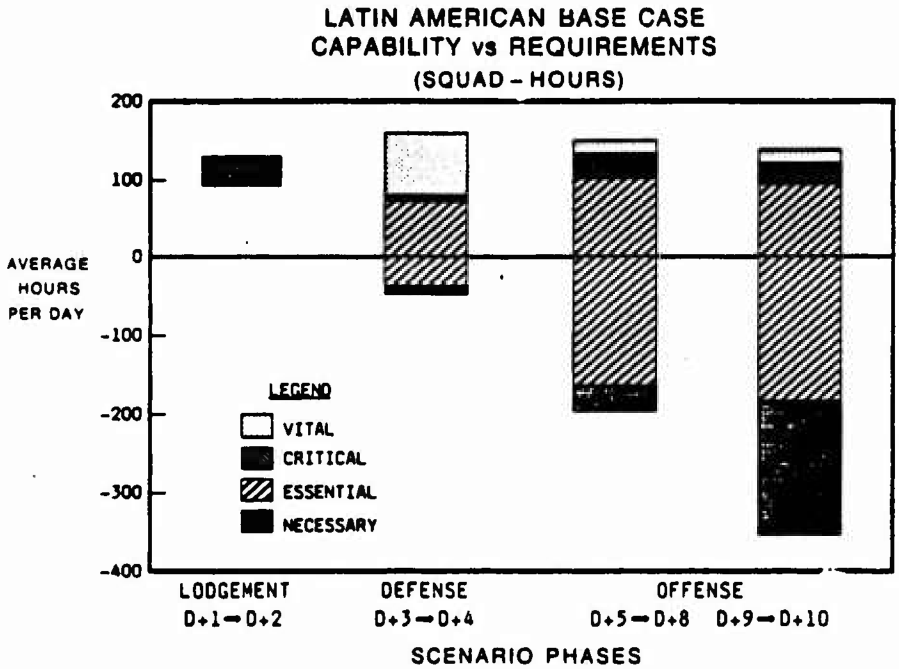


Figure 10

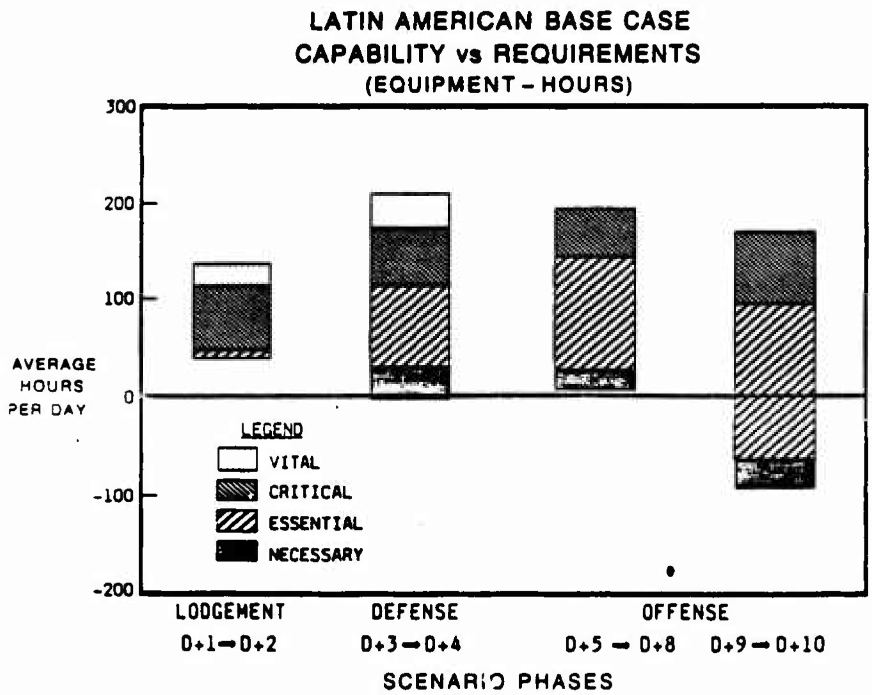


Figure 11

divisional engineers are needed to prepare initial defensive positions and to support combat operations, they must be deployed during this period.

(2) During Period 2, the defensive phase, the LID moves to engage the enemy and stop his advance. The LID engineers can accomplish all vital and critical tasks during this defensive period, but run out of squad-hours when they reach tasks in the essential priority group. They also have the equipment needed to accomplish all vital, critical, essential, and necessary tasks. The shortfall in squad capability is a trend established here that continues to the end of the scenario.

(3) Period 3 is the start of 6 days of offensive actions that employ two division brigades on and near a major highway. The LID engineers' level of accomplishment is similar to that during period 2 -- all equipment tasks are completed and part of the essential squad-hour tasks are finished. In this period, the level of completion stabilizes, but the change from defense to offense increases the workload in the essential priority task category. This trend continues into the next period.

(4) Period 4 completes the offensive phase. LID engineers are still able to complete all vital and critical tasks. However, the backload of essential and necessary work grows and for the first time there is a shortfall in equipment-hours. At the conclusion of this period, the need for EAD engineers is quite apparent -- the LID engineer battalion's capability is strained and pressure to do more tasks will increase if the scenario were extended. It is also during operating bases (TFOBs), two of which are isolated from road resupply.

b. Requirements. Figure 12 shows the Latin American scenario requirements during the scenario's key situation, grouped into different categories.

(1) More than 95 percent of all requirements are generated by divisional units. For this reason, the study methodology did not separately analyze EAD workload.

DISTRIBUTION OF DIVISIONAL AO REQUIREMENTS -- LATIN AMERICAN SCENARIO BASE CASE (Percentage)

Requirement Group	Hours	
	Squad	Equipment
Force		
Divisional units	100	95
EAD units	--	5
Priority groups		
Vital	9	6
Critical	8	33
Essential	64	53
Necessary	19	8
Time		
Lodgement	3	11
8-day battle	97	89
Battle zone		
Brigade areas	99	78
DRA	1	22
Force allocation		
Combat-essential force*	80	81
Sustainability force	17	8

*Key situation base case: 8-day battle; vital, critical, & essential priorities.

Figure 12

(2) For this scenario, the requirements are concentrated among those tasks in the essential priority group which occur during the 8-day

battle period (defense and offense) that follows the 2-day lodgement. The brigade areas generate just about all squad-hour requirements; the division rear area (DRA) generates only about one-fifth the equipment-hour requirements.

(3) The force allocation category is divided between the combat-essential force and the sustainability force. The design of the combat-essential force is based on the requirements generated by the engineer tasks in the vital, critical, and essential priority groups during the battle phases which fall within the last 8 days of the scenario, and on all battle zone requirements. The combat-essential force must be deployed early to support those LID maneuver elements which are engaged in combat operations. The remaining sustainability force requirements are based on the requirements generated by tasks in the necessary priority group during the same battle phases and in the same battle zones used to define the combat-essential force. The sustainability force supports follow-on engineer units which must complete tasks which occur beyond the length of the 10-day scenario; these tasks can be deferred but must eventually be done. The DRA workload was not separated from force allocation categories because it is small, and because it is as important as the workload generated in the forward brigade TFOB. About 80 percent of the scenario's workload is in this combat-essential force -- the key situation which formed the basis of ESC's analysis of the organizational structure of the LID's engineer battalion (Annex I). The remaining 20 percent of the workload is left for the sustainability force. The level of sustainability support could increase if the scenario was extended beyond 10 days, but it is envisioned that the increase would be more in the corps rear area (CRA); consideration of CRA requirements was beyond the scope of this study.

11. <u>European Scenario -- Capability Versus Requirements</u>.

a. Capability. Figures 13 through 16 compare engineer capability to the base case and new explosive excursion of the European scenario. There are both similar trends and differences in these two sets of results.

(1) During period 1 (lodgement) of the base case scenarios and the new explosive excursions (the use of scatterable mines and liquid explosive), the division apparently has sufficient engineer capability (both squad- and equipment-hours) to satisfy its requirements. The lack of scenario information concerning the arrival dates of deploying units prevented a detailed evaluation of the events of this period. It was assumed that most EAD units arrived the last day and that the LID engineer battalion deployed during the last few days of this 18-day period. It was also assumed that fewer requirements were generated in the lodgement area, as it was shared by the forward-deployed corps and host nation resources. Additionally, the CAORA scenario was constrained by the assumption that the LID did not arrive in the divisional AO until period 2. As a result, period 1 was not evaluated for use as a basis for the force allocation categories developed by this study. Despite all these assumptions, constraints, and theater conditions, engineer units are required to arrive during this phase so they can start the battlefield preparations as soon as the LID is ordered into its AO.

(2) During period 2, engineers have 3 days (D+8 to D+10) to prepare the battlefield. Positions which must be constructed within the brigade areas include two phase lines with direct-fire weapon positions and obstacle zones that provide 360-degree protection. All of these tasks fall into the vital priority group. There are enough equipment-hours to accomplish this vital workload during both versions of the scenarios. Under the base case

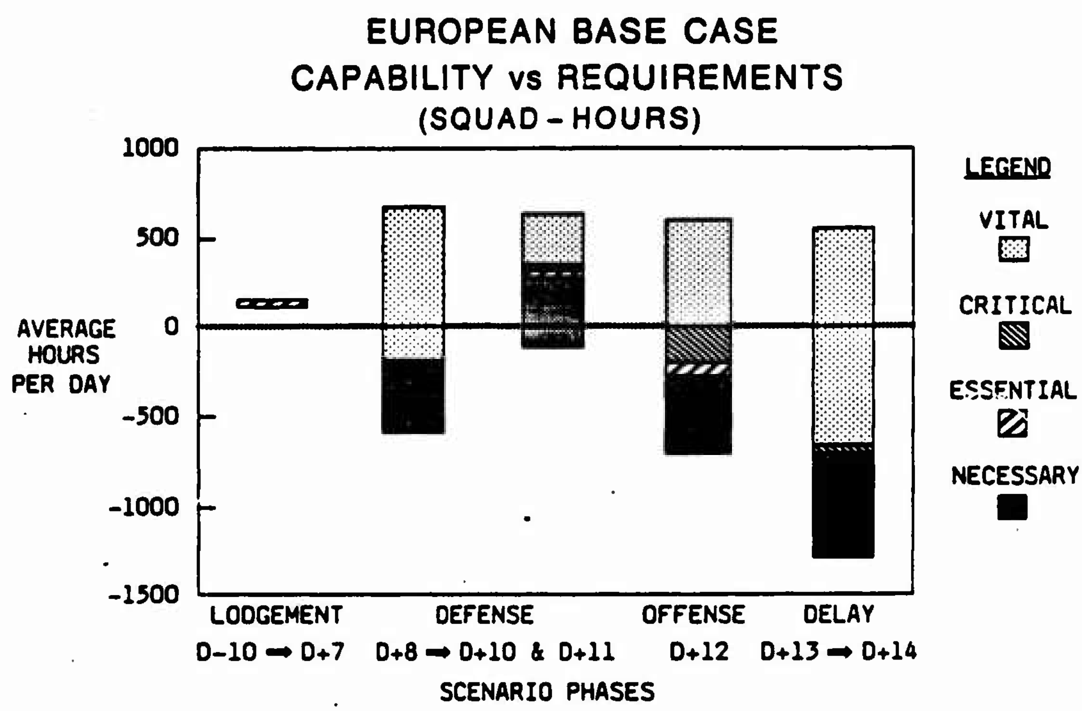


Figure 13

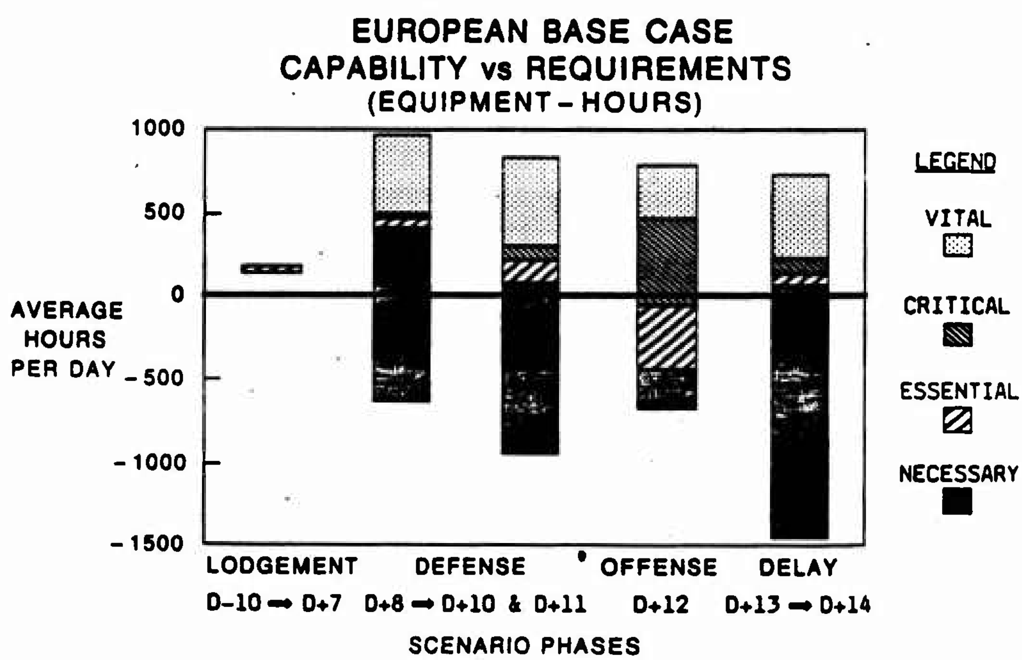


Figure 14

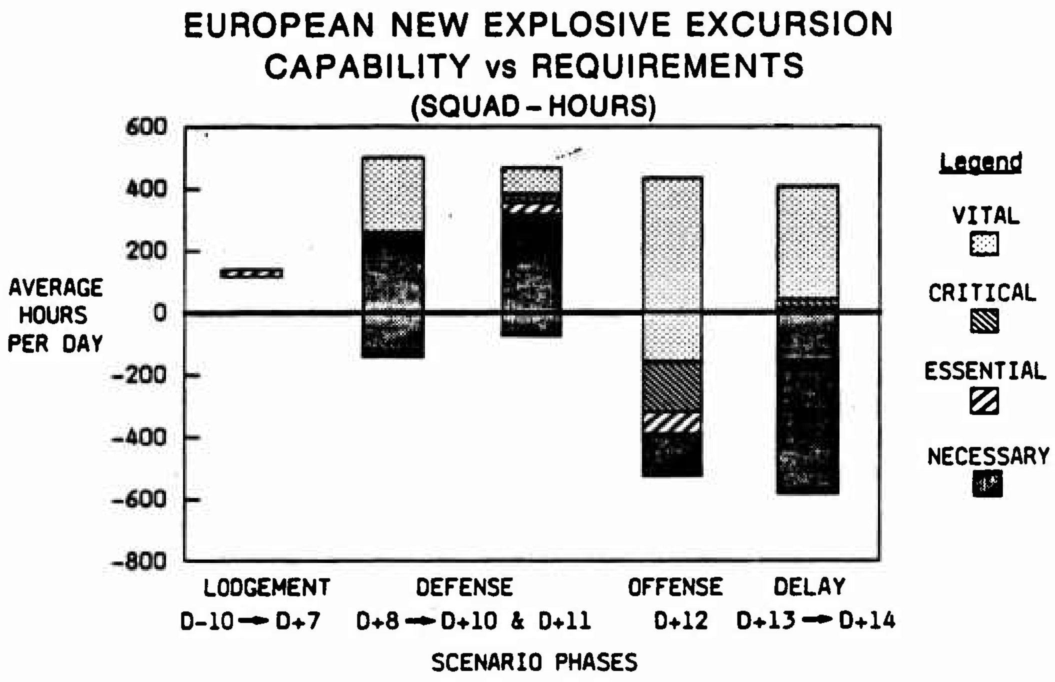


Figure 15

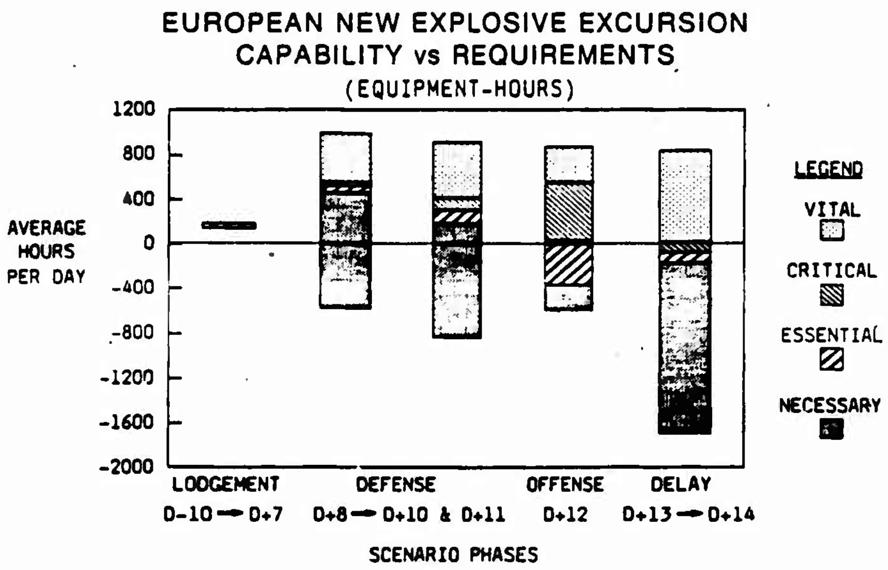


Figure 16

scenario, there are only enough squad-hours to complete 80 percent of the vital tasks. Under new explosive excursion, there is enough squad-hour capability to complete all vital tasks. The different squad-hour completion rates are caused by the reduction in manhours required to use the newer scatterable mine systems provide in the new explosive excursion. The 20 percent of the squad-hour tasks which remain unexecuted during the base cases constitute a largely deferrable workload, as it represents tasks on battle positions to the rear of the forward line of own troops (FLOT). These tasks can be accomplished during period 3 in lieu of lower priority necessary tasks.

(3) Period 3 (D+11) is the scenario's first defensive battle phase, and is 24 hours in duration. Engineers can accomplish tasks in the top three priority groups in both scenario versions and for both squad- and equipment-hours during this first combat phase. This high rate of accomplishment is directly attributed to the battlefield preparation work executed during the previous period. The division suffers slight setbacks during this positional defense.

(4) Period 4 (D+12) characterized by a 24-hour offense as the LID regains its original FEBA traces. Most vital squad-hours and most vital and critical equipment-hours are accomplished in both scenario versions. However, the vital workload is now mostly mobility breaching tasks located within the attached armored brigade area. In fact, most of the scenario's offense is conducted by the attached armored brigade and two other brigades that conduct counterattack operations by passing through the LID's positions. The critical workload, however, contains a large share of survivability and countermobility tasks -- neither the base case scenarios nor excursions have sufficient squad-hours to accomplish these tasks in these priority groups. If the corps

battalion only supported the LID's on-line brigades during this period, all critical squad-hours could be completed. (This suggestion must be tempered by the observation that the collapse of the armored brigade's AO would leave an open door into the LID's DRA.)

(5) In period 5, the LID returns to a 2-day defense, but by the last day is forced into delaying operations. This delay is characterized by the construction of more phase lines with direct-fire weapon positions and many mined road craters. The engineers can accomplish 45 percent of the vital squad-hours in the base case, but 100 percent of the vital and critical squad-hours in the excursion. The reduced manhour requirements associated with scatterable mine systems explains the improved performance displayed by the LID engineers during the scenarios' new explosive excursion. For equipment-hours, critical tasks can be accomplished in the base case scenarios, but not in the excursion. This unusual reversal (Figure 16) is caused by the increase in SEE auger-hours needed to dig holes for the numerous road cratering charges required during the excursion.

b. Requirements. Figure 17 shows the base case divisional requirements for all five periods, grouped into different categories.

(1) Over 95 percent of all requirements during the European scenario base case are generated by divisional units. This situation is similar to that found in the Latin American scenario and resulted in the same decision -- EAD requirements were too few to analyze separately.

(2) The other categories -- priority groups, battle zones, and battle phases -- were used to determine appropriate key situations for division and force structure analysis.

(a) For the combat essential force, the 4-day length of battle restricted the analysis to only tasks in the vital and critical

DISTRIBUTION OF DIVISIONAL AO REQUIREMENTS --
EUROPEAN BASE CASE SCENARIO
(Percentage)

Requirement Group	Hours	
	Squad	Equipment
Force		
Divisional units	100	96
EAD units	--	4
Priority groups		
Vital	60	25
Critical	3	7
Essential	5	12
Necessary	32	56
Time		
Lodgement	4	6
Battle preparations & 4-day battle	96	94
Battle zone		
Brigade areas:		
LID	61	48
Armored	26	30
DRA	13	22
Force allocation		
Combat-essential force		
EAD structure*	63	31
(Division structure)**	(46)	(18)
Sustainability force	33	63

*Key situation base case: battle preparation and combat phases; vital & critical priorities.

**Key situation base case: battle preparation and combat phases; vital & critical priorities, less armored brigade workload.

Figure 17

priority groups. If these tasks are completed, it will help protect the LID from early defeat and high loss of life.

(b) The DRA workload was included in ESC's evaluation -- although the requirements generated in the DRA are few, they are important. The DRA workload is generated by the scenario's high-intensity threat, which inflicts rear area damage with both indirect-fire weapons and enemy airplanes.

(c) The lodgement phase, which constitutes about 5 percent of the workload, was omitted from the analysis of the European scenario's base case.

(3) For the purpose of structure analysis, the European scenario has two key situations -- one for the division structure analysis, and one for the EAD structure analysis. The key situation for both includes tasks in vital and critical priority groups generated in the DRA and brigade battle zones during the battle preparation and combat phases of the scenario.

(a) For the EAD structure analysis, the key situation captures 63 percent of the total squad-hour requirement, and 31 percent of the equipment-hour requirement. As shown in Figure 17, the remaining 33 percent of the squad-hour and 63 percent of the equipment-hour base case requirement (less the lodgement requirement) is generated by tasks in the essential and necessary priority groups. These are not combat-related tasks, and are therefore reserved for the division's follow-on sustainability force. These sustainability tasks consist mostly of maintaining degraded line-of-communication (LOC) networks, and can be completed later in the scenario.

(b) The divisional structure analysis is based on the requirements generated during the EAD key situation, minus the workload generated by the attached armored brigade (Annex I explains the rational for this omission). This attached brigade generates more than 25 percent of the total workload. This subset of requirements reflects only LID requirements; the result is that 46 percent of the total squad-hours and 18 percent of the total equipment-hours served as the basis for analyzing the organizational structure of the LID engineer battalion.

III. FORCE STRUCTURE PROPOSALS

12. Methodology.

a. ESC's force structure analyses determined the engineer force structure best suited to meeting the key situation of each scenario. Each scenario's key situation omitted the lodgement phase and included engineer tasks in the top two or three priority groups to measure the full range of engineer requirements and capabilities. The methodology uses these key situations for the combat-essential force in the EAD and divisional engineer force structure proposals.

b. In both scenarios, the EAD methodology defines the sustainability force based on the requirements generated by tasks in the lower one or two priority groups. This force is required 2 to 4 weeks after the division is committed to combat operations.

c. In ESC's divisional structure proposal, the requirements for the attached armored brigade are omitted (Annex I).

d. The impact of Class V future systems is so dramatic that those future systems were considered when EAD and divisional structure proposals were developed for the European scenario. In the figures that follow, this logistical comparison is called the new explosive excursion versus the base case.

e. The European base case analysis that follows uses the dump truck capability of 50 percent of the squad trucks belonging to those corps engineer battalions which support units within the maneuver brigade AOs. Both ESC's analyses and interviews with LID engineers indicate that these trucks would actually be available during battle, since they are not required for road maintenance when the EAD corps battalion is assigned to forward combat engineer support.

13. Divisional Engineer Battalion.

a. The redesign of the divisional engineer battalion was based on the requirements generated during the key situation of each scenario base case, the requirements generated during the European new explosive excursion, and the following criteria:

(1) The squad-to-equipment ratio of requirements to TOE capability. (Annex H amplifies the results presented here.)

(2) The distribution of equipment requirements to TOE capability. The study methodology captured the requirement distributions, but an excursion (Annex I) was needed to fully evaluate the required attachment mix distribution for the SEE.

(3) The engineer battalion must be prepared to fight in either low-intensity or mid- to high-intensity conflicts. (Since the LID's primary mission is low-intensity conflict, the results of the Latin American scenario were weighted twice those of the European scenario.)

b. Figure 18 shows the squad-to-equipment ratios calculated using the study methodology. The TOE squad-to-equipment ratio is 40:60, versus a weighted scenario requirement ratio of 62:38 for the base case key situations. For the new explosive excursion, the European requirements more closely match the TOE with a ratio of 34:66. However, when the European new explosive excursion is weighted with the Latin American new explosive excursion, the future requirement ratio is 51:49. (The future requirement is the requirement expected after Class V systems are fielded, as portrayed in ESC's new explosive excursion.) Thus, the engineer battalion needs more squad power both now and in the future. Adding a third platoon to each existing company, or adding a fourth company, adds six to nine squads. But ESC could identify no tradeoff for this increase in personnel or deployment sorties. One solution to this problem is to add a light corps battalion to the EAD force structure that is specifically designed to support LIDs (see the following paragraph). The LID engineer battalion attempts to make up for this squad shortfall by striving to maximize its level of support by ranking tasks, selecting innovative methods of accomplishing missions, and by training intensely. LID training reinforces engineer expertise, as observed by ESC's study team during its data collection trip to the 7th ID(L) in October 1985.

SQUAD-TO-EQUIPMENT RATIO

	Percentage	
	Squad	Equipment
1988 TOE capability:	40	60
Latin American scenario key situation requirements*	61	39
European scenario key situation requirements**	65	35
Weighted scenario requirements***		
Base case key situations	62	38
New Explosive excursion key situations	51	49

*Base case: 8-day battle; vital, critical, and essential priorities.
**Base case: battlefield preparation and 4-day battle; vital and critical priorities, minus armored brigade AO.
***Two-thirds Latin America plus one-third Europe.

Figure 18

c. Figure 19 summarizes the equipment mix requirements based on the requirements indicated by this study's analyses of the key situations in each scenario.

EQUIPMENT DISTRIBUTION

	Dominant Equipment (%)					
	ACE D-7	Loader	Grader	5-Ton Trucks	SEE/ JD410	Total
1988 TOE capability:	22	--	--	11	67	100
Latin American scenario key situation requirements*	38	8	2	35	17	100
European scenario key situation requirements**	25	9	--	39	27	100
Weighted scenario requirements***						
Base case key situation	36	8	4	37	15	100
New Explosive excursion key situation	36	9	3	28	24	100

*Base case: 8-day battle; vital, critical, and essential priorities.

**Base case: battlefield preparation and 4-day battle; vital and critical priorities, minus armored brigade AO.

***Two-thirds Latin America plus one-third Europe.

Figure 19

(1) ESC calculated effort for five dominant classes of equipment, but only three of these five are found in the LID engineer battalion:

(a) D7 bulldozer or armored combat earthmover (ACE).

(b) The 2-1/2 cubic yard loader (engineer EAD units only).

(c) A grader (engineer EAD units only).

(d) The SEE or JD410 tractor (both with front-end loader and backhoe attachments).

(e) Nondedicated 5-ton truck. In the LID engineer battalion, six of eight cargo trucks are nondedicated -- three in the S-4 section of the headquarters and headquarters company (HHC) and one in each of three line companies. The line company vehicles become dedicated in the European new explosive excursion to carry the ground Volcano system. EAD nondedicated trucks include many 5-ton dump trucks, including a percentage of squad trucks if the unit is working forward of the brigade rear boundary.

(2) Figure 19 shows that the ACE requirements are approximately 1.5 to 2.4 times the small emplacement excavator (SEE) requirements (per the scenarios' weighted requirements). The European base case key situation has about an equal requirement for ACEs and SEEs, but this is tempered by the weighted scenario results. The LID TOE has three SEEs for every one ACE.

(3) Figure 19 also shows there is more demand for 5-ton truck capability than the current TOE can offer. This shortfall can be compensated for and overcome in several ways. One way is to transfer the surplus calculated for the logistical use of trucks to project work (ESC's methodology roughly split a 12-hour truck day into 8 hours of project work and 4 hours of logistical haul). Additionally, when the EAD corps battalion is added to the combat-essential force, its larger truck capability will offser the LID's smaller capability (see also Figure I-5). One corps battalion should accompany the LID when it deploys. This re-examination also confirmed that the lack of a squad truck is no hindrance to the mission of the LID engineer battalion.

(4) During the last 6 days of battle in the Latin American scenario, truck requirements for engineers were generated in only two of the four AOs in the division area. The other two AOs were inaccessible by road and were serviced by aviation assets. For the base case, five UH-60 Blackhawk helicopters are required for engineer Class V haul; during the new explosive excursion, this requirement drops to one helicopter. The concept of operations for the LID envisions that as many as 15 of 30 Blackhawks may support logistical operations. Considering the high priority of support provided

engineers, combined with the fact that the LID main attack can be supported by road, this appears to be an acceptable task for the CAB.

(5) Figure 20 combines all of ESC's findings pertaining to the equipment mix of the LID engineer battalion. The mix percentages have been converted to items of equipment. In light of the two specific scenarios and new explosive excursions examined in this study, ESC recommends adding five ACEs and deleting eight SEEs from the TOE. The recommended 21 ACEs and SEEs occupy the same space in C-141B transport planes as the 1988 TOE mix of 24. (If the transport limitation were lifted, ESC would recommend 12 of each to better match the organizational structure.) ESC did not recommend changing truck quantities. ESC's final recommendations for equipment mix satisfy all Latin American requirements and will more closely match the needs of the European scenario than the mix represented by the current TOE.

EQUIPMENT MIXES

	Base Case			New Explosive Excursion		
	ACE	Truck	SEE	ACE	Truck	SEE
Key situation requirements:						
Latin America	10	4	5	10	3	6
Europe	14	6	5	14	2	14
Weighted scenarios*	11	5	5	11	3	9
1988 TOE Quantity	6	6	18	6	3**	18
ESC-recommended quantity	11	6	10	11	3**	10

*Two-thirds Latin America; one-third Europe.
**Three of six 5-ton cargo trucks diverted to hold the ground Volcano system.

Figure 20

d. Figure 21 summarizes ESC's analysis of the proper SEE attachment mix. ESC calculated equipment mixes for both scenario base cases and the new explosive excursion, but chose to base its final recommendations on the excursion results, since they represent peak usage of the SEE requirement. The new explosive excursion requirements call for six SEEs in Latin America and 14 in Europe for a weighted scenario total of nine. These nine SEEs were increased to 10, based on the results of the equipment mix analysis.

SEE ATTACHMENTS

		New Explosive Excurison			
	1988 TOE	Latin America	Europe	Weighted Scenarios	ESC-Recommended[b]
3/4-CY loader[c]	18	3	5	4	10
Boom with:		(6)	(14)	(9)	(10)
7-CF backhoe	—	3	5	4	10
12-in. auger[d]	--	3	14	7	10
85-in. blade[e]	—	2	—	1	—
7-in. trencher	18	—	—	—	--
4,000-lb lift	—	—	3	1	—
Auger handtool	No	Yes	No	No	Yes
TOTAL ATTACHMENTS	36	11	27	17	30
TOTAL SEEs	18	6	14	9	10

[a]Key situation
[b]Assumes sequential construction of fighting positions, followed by countermobility targets.
[c]Multipurpose or 4-in-1 bucket preferred (will replace both attachments).
[d]For crater construction using liquid explosives.
[e]New Explosive excursion.

Figure 21

(1) ESC concluded that the modest or zero requirement for the trencher, forklift, and blade did not warrant inclusion in the TOE. However, if the multipurpose bucket (bulldozer-grader-loader-clam) were purchased, this attachment's versatility could perform both the loader and blade functions shown in Figure 21.

(2) ESC would retain the basic loader/backhoe mix on all 10 SEEs. These two attachments are the backbone of the engineer survivability mission. However, the backhoe and auger attach to the same boom, so only one can be used at a time.

(3) ESC recommends the auger attachment be added to the basic SEE attachment mix. This attachment can easily drill holes for cratering charges, which would eliminate some of the logistics burden associated with shaped charges. (The bore charges can be conventional or liquid explosives.) ESC believes there is no decrement for having 30 attachments, even when only 20 can be fastened to the SEEs at one time. The auger may be transported on the same pallet as the other attachments when the division is moved on C-141Bs, and can be carried in the loader bucket when the division is on the ground.

(4) Ten SEEs are fewer than the 14 required by the new explosive excursion for Europe (Figure 21). That excursion also requires 14 ACEs -- therefore a 1:1 ratio of ACEs to SEEs is the first priority. Second, the full 14 SEEs will not be needed until the auger and liquid explosives are available, which is sometime in the future. This means they could be added latter as a separate line item in TOEs or modified TOEs (MTOEs). Third, the mission can still be accomplished with 10 SEEs, although there will be some slippage of requirements from the preparation phase to the first battle period. However, all phase lines (direct-fire positions and obstacles) will be completed before enemy contact. Fourth, EAD engineer units are needed to emplace the entire obstacle system, because that total task is beyond the capability of the LID. Therefore, the LID engineer battalion need not contribute all the support equipment. In this situation, the airborne engineer battalion only

needs five SEEs -- it currently has 18. Finally, it was determined that 10 SEEs could simultaneously dig in all nine maneuver battalions, plus the ground troops of the CAB. After this, the obstacles could be constructed in turn; however as mentioned above, there is slippage from the battle preparation period to the first battle period before all SEE work is accomplished.

(5) The last observation documents the need for the auger handtool. The hand auger has the capability to assist in the explosive emplacement of individual and crew-served weapon positions. This latter capability is especially useful in the dominant Latin American scenario for fast emplacement of firebase perimeter fighting positions in the TFOBs.

14. EAD Force.

a. Figure 22 shows the proposed engineer EAD force structure for the Latin American scenario; Figures 23 and 24 show the proposed engineer EAD force structure for the base case and new explosive excursion of the European scenario. The separate engineer company shown in the European proposals is the organic engineer unit assigned to the attached armored brigade. All proposals show the combat-essential force, the sustainability force, and the sum of these two force structures. The force needs for these scenarios have both similarities and differences.

b. In Latin America (Figure 22), only one EAD unit was required -- the airborne corps battalion (TOE 5-195L2, land and unload version). This unit is primarily needed for the sustainability force, since the LID is fairly self-sufficient at the beginning of conflict.

c. For the European base case (Figure 23), the corps engineer battalion (TOE 5-35H5) is the EAD solution. Two of these units are needed to do all critical tasks that are a part of the combat-essential requirements, and a

LATIN AMERICAN SCENARIO REQUIREMENTS
(Percentage of Tasks Completed by Priority Group)

Force Package	Priority Group Vital	Critical	Essential	Necessary
Combat-essential force				
LID engineer battalion	100	100	70	NA
Airborne corps battalion*	--	--	30	NA
Sustainability force				
LID engineer battalion	NA	NA	NA	20**
Airborne corps battalion***	NA	NA	NA	80
Total force				
Both engineer battalions	100	100	100	100

*Partial deployment at midpoint of scenario.
**An average of 40-percent equipment and no squad capabilities.
***Full deployment at end of scenario.

Figure 22

ERUOPEAN SCENARIO -- BASE CASE REQUIREMENTS
(Percentage of Tasks Completed by Priority Group)

Force Package	Priority Group Vital	Critical	Essential	Necessary
Combat-essential force*				
LID engineer battalion	34	--	NA	NA
Separate engineer company	36	--	NA	NA
Corps engineer battalion A	19	50	NA	NA
Corps engineer battalion B	11	50	NA	NA
Sustainability force				
Corps engineer battalion A	NA	NA	50	14
Corps engineer battalion B	NA	NA	50	43
Corps engineer battalion C**	NA	NA	--	43
Total force				
Organic LID/AR brigade units	70	--	--	--
Three EAD corps battalions	30	100	100	100

*Deploy during lodgement period.
**Add at end of scenario.

Figure 23

third joins these two to accomplish sustainability requirements. If the requirements generated by the attached armored brigades were removed from consideration by this analysis, only two corps engineer battalions would be required to support the LID's total combat-essential and sustainability force.

EUROPEAN SCENARIO -- NEW EXPLOSIVE EXCURSION REQUIREMENTS
(Percentage of Tasks Completed by Priority Group)

Force Package	Priority Group			
	Vital	Critical	Essential	Necessary
Combat-essential force*				
LID engineer battalion	49	--	NA	NA
Separate engineer company	26	--	NA	NA
Airborne corps battalion	25	100	NA	NA
Sustainability force**				
Airborne corps battalion	NA	NA	100	17
Corps engineer battalion	NA	NA	--	62
Light equipment company airborne (ABN)	NA	NA	--	19
Total force				
Organic LID/AR brigade units	75	--	--	--
Two EAD battalions & a light equipment company (ABN)	25	100	100	98

*Deploy during lodgement period.
**Add at end of scenario; the airborne battalion used in the sustainability force are the same one used in the combat-essential force.

Figure 24

d. In the European new explosive excursion (Figure 24), the combat-essential force requires the airborne corps battalion, as it did in the Latin American scenario. However, in Europe, this battalion is needed to accomplish critical tasks. For the sustainability requirements, a second battalion is needed. This second battalion, the corps engineer battalion, is the same unit used to augment the LID during the base case scenario, except now its capability is needed to fulfill tasks in the necessary priority group. A light equipment company rounds out the sustainability force, giving the division the equipment-hour capability it needs to finish the few remaining necessary equipment tasks. The new explosive excursion EAD force is equivalent to about two battalions, which is one fewer battalion than is needed during the base case. When the armored brigade tasks are again removed from consideration by the analysis, the EAD force supporting only the LID is almost the same as the EAD force used in Latin America -- just one battalion plus a separate company.

e. Figure 25 compares requirements to the available equipment mix for the two types of EAD battalions in the ESC proposal. The requirements only consider those scenarios where the unit is ideally suited to theater, force allocation, and timeframe criteria.

(1) The airborne corps battalion's equipment mix closely matches the requirements generated by the scenarios where it will be most needed -- Latin America or Europe in the future. The unit's bulldozer blade capability is perhaps too small and that of the loaders and graders slightly too large. The LID scenarios do not document a mission for this unit's nine scrapers. Squads could operate with a smaller vehicle such as the high mobility multipurpose wheeled vehicle (HMMWV), since the squad trucks are not required for hauling missions. In the previous divisional structure analysis, the observations included the conclusion that these squads should be organized into companies that were separate from the equipment companies.

EAD EQUIPMENT-HOUR MIX
(Percentage)

Unit Comparisons	ACE	Loader	Grader	Truck	SEE/JD410
Airborne Corps Battalion					
Capability*	27	18	14	23	18
Requirements					
Latin American total force	39	8	2	34	17
European new explosive excursion					
Combat-essential force	45	7	4	17	27
Corps Engineer Battalion					
Capability**	19	13	6	46	16
European base case requirements:					
Combat-essential force	51	7	5	30	7
Sustainability force	27	18	7	48	--

*No squad trucks counted (0 of 18).
**50% of squad trucks counted (18 of 36).

Figure 25

(2) The corps engineer battalion needs different equipment and mixes, depending on whether it is used early or late in the European base case scenario. The unit has an ACE-hour deficit that is especially noticed in its early combat-essential role. Many of its squad dump trucks are needed when the unit is deployed later in the scenario, as part of the sustainability force. While capability is adequate for dump trucks in the sustainability role, trucks in the combat-essential role are primarily used for cargo haul -- a very inefficient use, given the smaller surface area of the dump truck bed. If this unit is expected to provide engineer mission support both early and late and both forward and rear, it needs to increase its versatility with a large-surface dump truck, such as the Federal Republic of Germany's Army vehicle. For sustainability tasks, the SEE is surplus unless this unit is sent forward to prepare the battlefield for a LID, before the LID occupies its

assigned AO. ESC did not recommend changing this unit's equipment mix to match the combat-essential requirements in Europe, since the airborne corps should assume those responsibilities. As the corps battalion is now organized, its equipment mix is well suited to the engineer sustainability requirements generated by the European base case scenario, especially if it adds ACEs.

(3) The light equipment company (TOE 5-54L2, land and unload version) was used in the European excursion only to provide low-priority equipment. The unit's scraper capability was not used. If this unit is to support all types of light divisions, perhaps its mission and mix of equipment should be re-evaluated. It would be perhaps better oriented forward for survivability (more ACE and SEE capability), or oriented to the rear for expedient army airfield construction, or some other combination. The land and unload version of this unit is not fielded and only one airborne version of the unit is organized. Both TOE organizations have their capabilities duplicated within the airborne corps battalion. The decision to activate an additional airborne corps battalion to the Army engineer force structure has been made, but other activations are not firm.

IV. OTHER SUPPORT REQUIREMENTS

15. Tactical Bridging Requirements. Site-specific bridge requirements are calculated separately in Annex J and were not included in the equipment-hour scenario summaries given in paragraphs 10 and 11.

a. The Latin American scenario had one unfordable river, which was encountered early in the offensive phase at D+6. The river's width of about 40 meters would require a bridge, since the space is too narrow for rafting. The scenario writers discounted this obstacle, but the river must be bridged so resupply can continue behind the division's main attack. Unless this road is kept open, the air resupply of ammunition (especially artillery rounds) is believed to be impractical, if not impossible. This bridge mission is an EAD tasking and adequate for a M4T6 float bridge set with an air compressor. This set allows for either a float bridge across the waterway or fixed spans that bridge the damaged spans. LID engineers could erect the bridge if no bridge unit was deployed; however, divisional engineer support missions would suffer. The Ribbon Bridge is a possible wet gap solution, but requires EAD bridge unit personnel to erect, more C-141B sorties to deploy, and has bridge trucks that are not needed for hauling after the bridge is erected. Unfortunately, M4T6 units have all bu disappeared in the force structure. The equipment is still stocked in depots, however. As so happens throughout this analysis, this evaluation points out the desirability of simple and light solutions to problems of LID engineer support. Unforturately, EAD engineer bridge units are just about all organized with very fast but heavy-technology bridging. Perhaps future bridge developments will provide better answers.

b. In the European scenario, all the river gaps can be forded and no EAD bridge support is needed. This situation is compatible with the LID mission, where the division must fight against a high-intensity threat force only in closed terrain. This mission also does not include a capability for supporting a deliberate river crossing, and most closed terrain areas lack sizable rivers in Europe. Additionally, Europe has an extensive road net giving the engineers many options for keeping roads open for logistical resupply without having to resort to tactical bridging.

16. Class IV and V Supply Requirements. Figure 26 lists the engineer Class IV and V requirements calculated for each scenario base case and the new explosive excursion. In this figure, the average daily requirement is expressed in short tons (STON) and then converted to the number of helicopters and trucks needed per day to move the materiel from the BSA to engineer project sites. Helicopters are only used when the project work site is inaccessible by road.

ENGINEER CLASS IV AND V AND MOVEMENT REQUIREMENTS
(Average per Day)

	Base Case			Excursion		
	STON	UH-60	Trucks	STON	UH-60	Trucks**
Latin America	53	5	1**	10	1	1
Europe	307	--	29*	85	--	3

*5-ton dump trucks.
**5-ton cargo trucks.

Figure 26

a. Most differences between scenarios and scenario versions are caused by the differences in the mining mission. Mining was more extensive in Europe than in Latin America. The new explosive excursion incorporated scatterable mines, which are lighter than the conventional mines used in the base cases. Consequently, the European base case has the largest Class IV/V requirement -- 307 STON per day. The Latin American excursion has the smallest requirement -- 10 STON per day. Figure 26 also shows the tonnage converted to 5-ton trucks, and for Latin America, to UH-60 Blackhawk helicopters. These quantities are part of the project work plus logistical haul requirement shown before in Figure 20. Truck capability is based primarily on cubic volume, and therefore has only a slight correlation to weight.

(1) Trucks are used more efficiently during the European new explosive excursion than during any other scenario or scenario excursion. This is explained mostly by the characteristics of scatterable mine weights and packing configurations, the use of cargo trucks that have a greater capacity for mines, and shorter haul distances than in Latin America.

(2) The quantities listed in Figure 26 represent mostly Class V materiel. The only Class IV item considered by this analysis was the HEMMS, and it constituted just 1 to 2 percent of the total Class IV and V requirement.

(3) Mines account for about 80 to 90 percent of the total tonnages calculated. For the ground Volcano portion of the scatterable mine total, ESC determined that the three dispensers planned for that system are adequate. The LID engineer battalion has eight trucks, and it is ESC's evaluation that three ground Volcanos could be mounted on three of these trucks without affecting the battalion's ability to perform logistical missions.

(4) The rates calculated for the European base case and excursion include the total generated for the attached armored brigade. This brigade's share of the total is 30 percent, which means 70 percent of the Class

IV and V requirement is generated exclusively by the LID. In terms of trucks, this 70-percent requirement represents 20 trucks for the base case and two trucks in the new explosive excursion, instead of the 29 and three trucks listed in Figure 26.

(5) The Class V calculations are reflected in the EAD unit selections made in Annex J. The European base case force requires several engineer corps battalions. The squad dump trucks of these battalions will be needed to haul mines. However, in the European new explosive excursion, the lighter scatterable mines and improved conventional mines (ICOMs) allow the substitution of the corps battalion with the lighter airborne battalion. The airborne battalion does not have to contribute squad trucks to the hauling mission. In both scenarios, the EAD battalions are required to both transport the mines from the BSA and to help emplace the obstacle system. Both these tasks are beyond the capability of the LID engineer battalion and its trucks. The sum of these circumstances reinforces the suggestion that cargo trucks are more valuable than dump trucks to LID engineers and to those EAD engineer units that support the LID.

b. This Class IV and V analysis did not consider requirements for MICLIC and TEXS, both heavy explosive systems. The MICLIC clears lanes for vehicles, but the LID needs lanes for infantry. The closed areas where the LID is employed do not offer much opportunity to emplace antitank ditching; if it must dig antitank ditches, the ACE is capable of executing that task at a lower logistic cost.

c. ESC evaluated the impact of two requirements the engineers place upon the LID aviation assets. The first requirement was in Latin America, where engineer Class V was transported by UH-60 Blackhawk helicopters to two

TFOBs isolated from engineer trucks. This equated to five Blackhawks in the base case and one in the excursion -- a reasonable CAB mission. The second requirement was for the Blackhawks to transport the air Volcano system. The air Volcano is used in both scenarios, but the demand is higher in Latin America than Europe (just the opposite is true of the demand for the ground Volcano system). ESC recommends using three air Volcanos, the same number as recommended in the Basis-of-Issue Plan (BOIP). By coincidence, this is the same number of ground Volcanos recommended by ESC and authorized by the BOIP.

V. CONCLUSIONS AND RECOMMENDATIONS

17. General. This study reached seven specific conclusions about the LID engineer battalion's ability to carry out its mobility, countermobility, survivability, and general engineering missions on the battlefield under two very different combat scenarios. Each conclusion is matched by recommendations which follow these practical guidelines:

a. Any changes recommended to the divisional engineer force structure must follow the zero-sum increase rule. The study recommendations do not suggest an increase in the battalion's end-strength or the number of C-141B sorties required to deploy it.

b. Changes must be attainable at low cost. This left some leeway for recommending changes based on long-term development proposals for new types of equipment.

c. ADEA, the study sponsor, must be able to initiate or influence any action recommended by this study.

18. The LID Engineer Battalion Can Successfully Support the LID in Low-Intensity Conflicts. The mission of the LID states that it "rapidly deploys to defeat enemy forces in low-intensity conflict and, when properly augmented, reinforces US forces committed to a mid- to high-intensity conflict."[3] The LID engineers are centrally organized for this mission: all equipment is located in the HHC, and all squads are in the three line companies. During both scenarios, the LID engineer battalion's combat-essential workload is made up of vital and critical tasks. In Latin America, this combat-essential workload also includes essential tasks and begins as soon as the division is

[3] Table of Organization and Euqipment 77-000J800 (Department of the Army, 1 April 1984).

committed. In Europe, the combat-essential workload begins at the start of the battle preparation phase, when the battalion is called upon to reinforce the battlefield terrain.

a. CONCLUSIONS:

(1) The current centralized organization of the LID engineer TOE coincides with the nature of the requirements generated by the Latin American base case scenario (the dominant scenario in this analysis), and the way in which those tasks are divided between forward and rear areas of the battlefield.

(2) During both base case scenarios and the new explosive excursions to those base cases, more than 80 percent of the battalion's combat-essential requirement is generated in the forward brigade areas. The remaining 20 percent of the combat-essential requirement is generated in the DRA.

(a) In Latin America, the LID engineers can accomplish all requirements generated by tasks in the vital and critical priority groups, plus a portion of the tasks in the essential priority group, during both the base case scenario and the new explosive excurison.

(b) In Europe, LID engineers can only accomplish one-third of the vital tasks generated during the base case scenario, and just one-half of the vital tasks generated during the new explosive excursion.

(3) During both base case scenarios, the engineers' initial capability shortfall is always in squad-hours. In Latin America, squad- and equipment-hour shortfalls increase sharply on the third day of combat. In Europe, the total workload is beyond the LID engineer battalion's capability from the first day of the battle preparation period.

(a) In Latin America, the LID engineers have sufficient squad-hour capability to complete 42 percent of the requirements generated in the brigade areas by tasks in the essential priority group, but can complete none of the DRA workload. However, the battalion has enough equipment-hour capability to accomplish all necessary brigade tasks, plus 87 percent of the essential DRA tasks.

(b) In Europe, the LID engineers are able to complete 24 to 71 percent more squad-hour vital tasks than equipment-hour vital tasks in the brigade areas, but have no squad- or equipment-hour capability left for any critical tasks or for any tasks generated within the DRA.

b. RECOMMENDATIONS:

(1) The LID engineers should be structured to work alone and unsupported in low-intensity, short-duration conflicts, when they will have enough organic squad- and equipment-hour capability to complete the first few days of the combat-essential workload. However, by the start of the fifth day, the workload represented by tasks in the essential priority group is so great that the battalion's organic engineer capability must be augmented by EAD engineers.

(2) The LID engineers should deploy during the lodgement phase of the battle, so their capability is available when combat operations begin.

(3) The LID should be first supported by EAD companies able to make up the divisional engineer battalion's shortfall in squad-hour capability (i.e., companies without dedicated construction equipment).

19. <u>The LID Engineer Battalion's Equipment Mix Could Be Better Configured</u>. Since the conceptional design of the LID was published in 1984, the 13th Engineer Battalion of the 7th ID(L) has been equipped with all of its ACEs, and with one-third of its SEEs. Field exercises by the 13th Engineer Battalion have confirmed the usefulness of the LID TOE's centralized concept,

which places all equipment in the HHC and employs this equipment separately from squads. This analysis determined that the mix and quantities of ACEs and SEEs needed to meet the requirements generated by the base case scenarios are different from the mix and quantities alloted in the LID TOE. This is not unexpected, since the TOE and operational concept were designed concurrently and this study is the first in-depth evaluation of that TOE and concept.

a. CONCLUSIONS:

(1) The LID engineer battalion needs 1.5 to 3 times as many ACE-hours as SEE-hours to meet requirements generated during the Latin American base case scenario and new explosive excursion, and by the European base case scenario; ACE and SEE requirements are about equal in the European new explosive excursion. The LID's current TOE has three SEEs for every one ACE (a total of 18 SEEs versus six ACEs). When ESC's calculations of equipment-hour capability are expressed as pieces of equipment, ESC determined that 10 ACEs are required in Latin America, 14 in Europe for both the base cases and new explosive excursions -- a weighted requirement of 11. For the SEE, the results ranged from five SEEs required for the base cases to a peak of 14 SEEs for the European new explosive excursion -- a weighted requirement of 9. The specific numerical requirement for each item of equipment is derived from a detailed analysis of only two relatively short scenarios. Although the exact requirements presented in this conclusion and recommendation may be open to interpretation, the trend of more ACEs and fewer SEEs is clear.

(2) ESC's evaluation of the attachments for the SEE indicated there is an equal requirement for loaders, backhoes, and augers. Depending on scenario, the auger attachment comprised 25 to 50 percent of SEE-hour usage. The auger attachment is not now authorized and was used in the study scenarios

instead of shaped charges to dig bore holes for cratering. The authorized backhoe and loader are the backbone of the engineer survivability mission.

(3) ESC determined that the auger handtool is a valuable asset for the tasks generated at Latin American TFOB firebases. This hydraulic handtool is used to assist in the explosive emplacement of individual and crew-served weapon positions.

b. RECOMMENDATIONS: The LID engineer battalion should be configured with equipment and attachments that match scenario key situations. This means that:

(1) The equipment mix within the battalion should be adjusted to better meet requirements. ACEs should be increased from six to 11 and SEEs should be decreased from 18 to 10 in the TOE. Note: the reduction from 24 to 21 total pieces of ACE and SEE equipment is necessary in order to keep C-141B deployment loads constant for the engineer battalion.

(2) All 10 battalion SEEs should be configured with loader, backhoe, and auger attachments. The added auger can be transported in the loader bucket both for C-141B transport and for highway movement.

(3) The handtool allotment for all SEEs in the LID should be authorized the auger handtool. This hydraulic tool can be used to drill small holes for expedient explosive excavation of fighting bunkers.

20. <u>The Impact of Scatterable Mines on Engineer Capability Will Be Substantial</u>. To support the division, the LID engineers must undertake both countermobility and mobility tasks that vary in scope and magnitude by scenario. Today, many conventional mining systems are being augmented or replaced by new-generation systems. Especially striking is the introduction of the new scatterable mines, which will dramatically change engineer requirements in Europe.

a. CONCLUSIONS:

(1) The LID engineers require obstacle systems that are lightweight. These lightweight systems, especially mines, are easier to transport by C-141B aircraft to places such as Latin America or require fewer trucks to transport in a European AO.

(2) Because of the high-intensity threat in the European theater, the LID is assigned a defensive mission in a relatively small AO that is characterized by closed terrain. This closed terrain inhibits linear mining and favors point obstacles. Point obstacles require less effort to emplace than linear obstacles. Although the European AO has some open areas, that open terrain is very rough, making mining operations difficult. Minefields in Europe also may need to be concealed and emplaced at night for security reasons. As a result of all these factors, the LID's obstacle workload in the defense is 65 percent less than that of a heavy division in Europe.

(3) Scatterable mines and improved conventional mines (ICOMs) are from 50 to 75 percent faster to emplace than conventional mines for all forces — both heavy and light.

(4) Artillery mining is important in Europe because of the closed and difficult terrain; aerial mining is more important in Latin America because of the LID uses some AOs which are inaccessible by road.

b. RECOMMENDATIONS:

(1) The LID should improve its operational performance, provide logistical savings, and reduce manhour requirements by procuring the NATO ICOM (which is available now) or developing a US version of the NATO ICOM immediately.

(2) LID engineers should consider replacing those trucks intended to carry the ground Volcano with a high-mobility carrier (such as the HMMWV).

(3) Since the LID has no attack vehicles and few antitank ditch requirements, EAD engineer units are the appropriate units to support the LID with the MICLIC or TEXS.

(4) The air Volcano adds the required versatility to LID operational tactics. This analysis validated the LID's operational concept for three of these systems.

21. LID Engineers Have Sufficient Truck Capability. The LID engineer battalion has no squad trucks, eight 5-ton cargo trucks, and no dump trucks. The EAD battalions considered in this analysis have 5-ton dump trucks for squads, platoons, and companies, plus a few 5-ton cargo trucks in the S-4 Section of the HHC. ESC found truck requirements varied depending on unit battlefield location and scenario conditions.

a. CONCLUSIONS:

(1) The LID has the right kind and number of trucks to meet the requirements generated by the base case scenarios. The LID engineer battalion has no squad trucks and they were not required in any of the scenarios or excursions considered by this study. The 5-ton cargo trucks in the companies of the battalion match base case scenario and European new explosive excursion requirements, but there is a three-truck excess in the Latin American new explosive excurison.

(2) The conclusion above assumes the availability of EAD support consisting of one engineer battalion after 1 to 2 weeks in Latin America and starting during the battle preparation phase in Europe.

(a) EAD engineer trucks supporting forward brigades are needed mostly for logistical haul, especially in the European base case scenario. The dump trucks now alloted to the EAD units likely to augment the LID engineer battalion are not well suited to this purpose.

(b) When the new mine systems are fielded, they will reduce the currently large requirement to transport Class V materiel from the BSA. If corps engineer battalions were dedicated and employed forward in the brigade areas, their squad dump trucks could be converted to a more appropriate vehicle or downsized.

(c) The corps engineer battalion assigned to help the LID engineer battalion accomplish sustainability tasks has a requirement for dump trucks.

b. RECOMMENDATIONS:

(1) The eight 5-ton cargo trucks in the LID engineer battalion should not be increased or decreased at this time. In the future, the battalion can divert three of these trucks to haul the ground Volcano system with no loss of capability.

(2) The EAD corps battalion which supports forward LID operations should have more cargo trucks than dump trucks. However, if one of the corps engineer battalion missions continues to be to support heavy and light forces both forward and rear, this unit cannot convert its dump trucks. One way to support this dual mission is to convert all 5-ton dump trucks to a combination dump-cargo truck. Such a truck can dump to both sides and the rear, has a large flat-bed surface, and drop sides. (Note: the Federal Republic of Germany Army has a truck with these characteristics.) Another solution would be to convert some of the corps battalion's dump trucks to cargo trucks.

22. <u>The Corps Airborne Battalion Can Meet Many LID EAD Support Requirements</u>. The study methodology was especially designed to calculate the size and type of the engineer EAD force required to support the LID under the conditions of two very different combat scenarios. The LID will depend on this EAD force to complete all the work that the LID engineer battalion cannot do. This total EAD force is divided into two parts: a combat-essential force and a sustainability force. The combat-essential force is needed at or close to deployment of the LID, while the sustainability force is required some 2 to 4 weeks later.

a. CONCLUSIONS: Figure 27 expresses ESC's recommended combat-essential and sustainability forces, and the EAD total force, in terms of battalion equivalents for the base case of the Latin American scenario and for the European scenario base case and new explosive excursion. The Latin American and European base cases use conventional mines and explosives. The European new explosive excursion introduces scatterable mines and ICOMs, plus liquid explosives and is examined as a the future situation. Additionally, for both European situations, the divisional AO is shown divided between the organic LID AO (three to four maneuver brigades on line and in DRA) and the attached armored brigade AO. The separate armored brigade is broken out to show requirements for a single LID without attachments, since Army force structuring is done by individual divisions and separate brigades.

b. RECOMMENDATIONS:

(1) The separate armored brigade should be supported by about one corps engineer battalion. Even when the requirements generated by the armored brigade are removed from consideration, the EAD support required by the LID in Europe today is still extra-demanding -- a total of three

battalions. The LID needs only two battalions to meet requirements in Latin America and two battalions plus a light equipment company to meet the requirements of the future situation in Europe.

SCENARIO ENGINEER BATTALION EQUIVALENTS

	Latin America	Europe Today		Europe Future	
	LID	LID	AR Brigade	LID	AR Brigade
Combat-essential force:	LID bn	LID bn Corps bn	Engr co Corps bn	LID bn ABN bn	Engr co Corps bn
Sustainability force:	ABN bn	Corps bn	--	Lt equip co	--
Total force (bn):	2	3	1+	2+	1+

Figure 27

(2) The EAD battalion assigned to support the LID in Latin America and the future European situation should be the corps airborne battalion (TOE 5-195L2, land and unload version). Several of these airborne battalions should be organized to support LIDs with deployment missions. (Today no units have been organized.) ESC's analysis has determined that this unit should be organized under these guidelines:

(a) Squad-only and equipment-only companies.

(b) HMMWV squad trucks.

(c) 5-ton cargo trucks.

(d) More ACEs; no scrapers.

23. <u>The LID Has Few Large-Gap Bridging Requirements</u>. Rivers and streams generally are no obstacle to the LID's maneuver elements. The light infantry soldier is flown over or wades through rivers, floats across them on TOE or expedient log rafts, and occasionally traverses them on engineer-built rope or

monkey bridges. Logistical elements, however, prefer to use roads for resupply, although helicopter, Low Altitude Parachute Extraction System (LAPES), and C-130 airfield options are also available and used. The importance of roads increases as the threat increases from low- to mid- to high-intensity. Mid- to high-intensity conflicts place high demands on artillery resupply and subsequently on engineers to keep open the main supply routes (MSRs) for trucks transporting artillery rounds. The European scenario is at the upper end of this spectrum of conflict intensity, while the Latin American is at the midpoint.

a. CONCLUSIONS: The LID has few requirements for large-gap bridges (e.g., only one one bridge is needed during the Latin American scenario). However, even a minor bridging task will fall within the vital or critical priority group. A unit the size of a bridge platoon can provide all the engineer effort required to bridge gaps in the AOs typical of LID operations.

b. RECOMMENDATION: LID large-gap bridging support should be provided by for EAD engineers. Because bridging tasks are so crucial, they must be anticipated from terrain intelligence and planned for early in the battle. The type of support the LID needs invites the use of lightweight, simple-technology bridging that can be transported by vehicles or division helicopters. A bridge with a dual wet- and dry-gap capability is preferred that can be emplaced by LID engineers in emergencies. Depot-stocked M4T6 bridging is the closest solution now available, but a less complex bridge should be developed some day for LID use. The development and fielding of a lightweight bridge suitable for rapid deployment and support of the LID should be made a high-priority program for the Army's materiel development community.

24. <u>Class IV and V Engineer Requirements Differ by Theater and Time-frame</u>. Countermobility tasks dictate most of the requirements generated by the engineer Class IV/V workload. This workload changes with scenario and timeframe.

a. CONCLUSIONS:

(1) Class V materiel generates most of the requirement in the Class IV/V category. The only Class IV item used by the LID engineers is the HEMMS, which generates only 1 to 2 percent of the overall requirement. Most of the Class V requirement (80 to 90 percent) is mining, which is used frequently in the European theater. Since conventional mines are three to six times heavier than the new generation of mines, the European base case scenario generates the largest Class V requirement.

(2) Scatterable mines and ICOMs can reduce the LID engineers' truck transport requirements by more than 90 percent, and make it possible for LID engineers to better support the division in more mobile operations. This will prevent the division's logistical tail from hindering its performance and give the engineers the ability to emplace obstacle systems in a very mobile environment, which will enhance the LID's role in rear area protection.

(3) Substituting liquid explosives for conventional explosives may reduce the division's Class IV and V requirements, but by how much is impossible to document, given the state of the art as described in the published information about liquid explosive research or testing. (The bibliography to this report, Annex K, lists most of the documents published about liquid explosive testing during the last decade.)

b. RECOMMENDATIONS:

(1) Under the conditions of the European base case scenario, the LID should be supported by one engineer EAD battalion which is deployed

early. This will provide the truck capability needed to haul engineer Class V supplies from BSAs to project sites.

(2) More research should be done to determine the cratering geometry (number and size of bore holes and amount of explosives per hole) for new candidate liquid explosives.

25. Recommendation Postscript. This study's conclusions and recommendations reinforce the design concepts of the LID. To those more familiar with mechanized and armored operations, the study's final seven sets of conclusions may seem very rudimentary. Light infantry operations with their complementary engineer support roles outwardly are very basic. However, the simple structure tinted with just the right amount and kind of modern technology is very dynamic and consequently very powerful. When the study project team started this analysis, it had reservations about many of the LID's unusual engineer organizational and operational concepts. How adept is an engineer battalion with only 290 men containing squads without vehicles and only two major kinds of engineer equipment totaling 24 pieces? Perhaps the reader shares these concerns. In any case, while the team pondered these doubts, others contemplated them as well -- including those working within the concept. ESC's data base was the 13th Engineer Battalion of the 7th ID(L), stationed at Fort Ord, California. The 7th LID was selected as ESC's data base because it has been organized longer than any other LID. During the course of this 12-month study, ESC confirmed concepts by analysis that were simultaneously formed with the leadership of the 13th Engineer Battalion through its actual training and practice. The concept works. The fact that it works is known to the 7th LID which, at this writing, has become a highly motivated, well-trained, elite

division. The engineer concept makes sense by analysis upon reflection to four aspects rooted in historical principles:

a. **The LID has small AOs.** Engineer workload is directly equatable to the terrain that the engineers must change. Small AOs with less movement to maneuver leads to reduced engineer requirements.

b. **The LID operates in closed terrain.** Engineer workload is reduced in closed terrain because it offers more natural cover and obstacles. More point obstacles are required than linear obstacles, but overall there is less effort involved (point obstacles are less time consuming to construct than linear obstacles). Difficult terrain also slows enemy advances, giving engineers more time to complete their workload.

c. **The LID must deploy fast.** LID systems must be light so the division can move quickly. These light systems are easy to learn, easy to operate, easy to resupply. These characteristics make them very effective and powerful. For engineers, heavy explosives give way to equipment with relatively low fuel resupply needs and speed of emplacement can be sacrificed for more simple technologies.

d. **The LID has limitations in high-intensity conflict.** In Europe, the LID mission requires augmentation -- a heavy brigade for maneuver operations, more artillery firepower for suppression, and correspondingly, as determined by this study, one to three corps battalions for engineer support.

LAST PAGE OF MAIN PAPER

ANNEX A

STUDY METHODOLOGY

ANNEX A

STUDY METHODOLOGY

1. Purpose. This annex describes the significant steps of the study methodology.

2. Scope. Figure A-1 shows the general structure and level of resolution of the study methodology. The methodology compares engineer requirements with engineer capability. The requirements are unconstrained, but realistic; they are calculated on-site with no degradation. Capability is degraded with commonly accepted factors such as casualty and movement rates. The comparison

STUDY METHODOLOGY FOR EACH SCENARIO

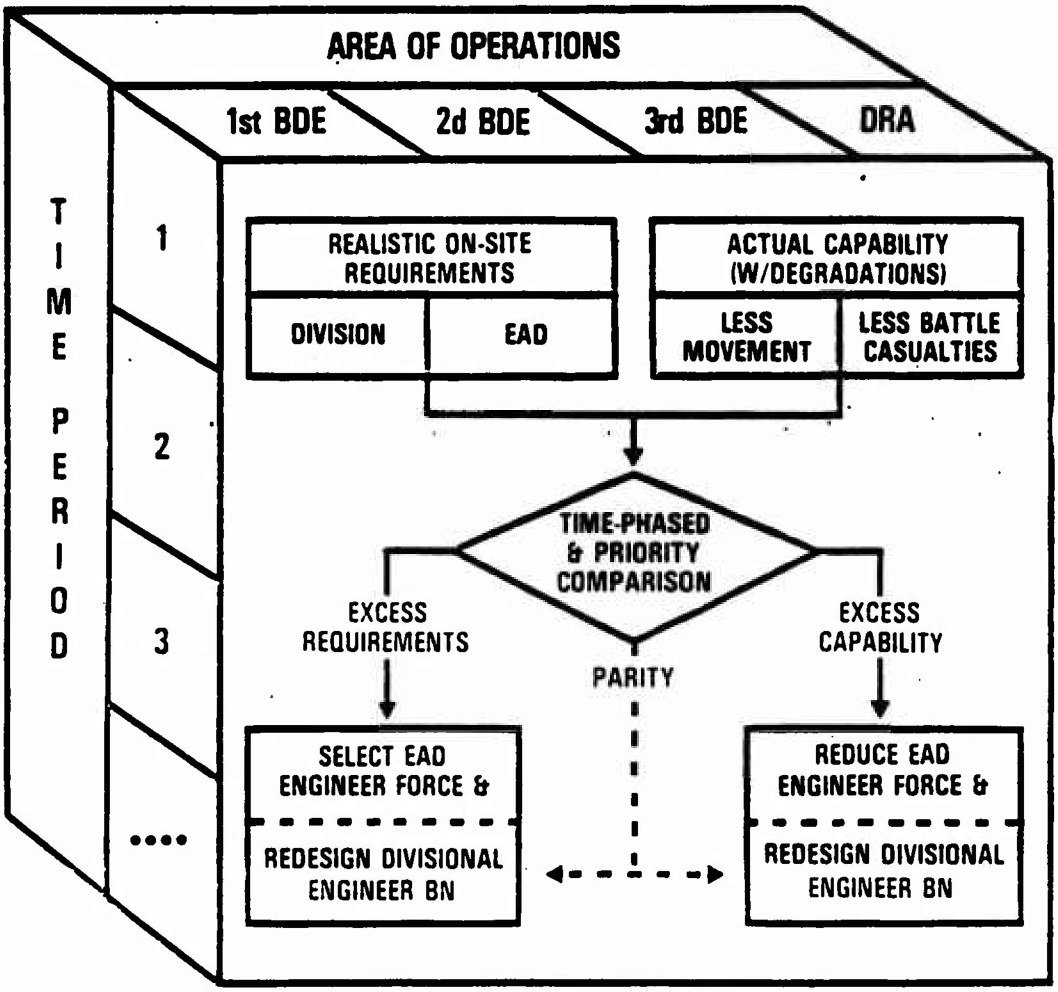


Figure A-1

of requirements and capabilities produced time-phased estimates on what requirements can be satisfied in priority order.

3. Resolution. The study methodology has four main levels of resolution.

a. The most significant level of resolution calculates into one of two scenarios. (The Latin American and European scenarios are detailed in Volume II, which is classified SECRET.)

b. The second level divides each scenario into battle phases. The battle phases are subdivided into consecutive time periods (Figure A-2).

TIME PERIODS

Period	From	Through	Days	Battle Phase
				Latin American Scenario
1	D+1	D+2	2	Deployment, lodgement, and secure AO
2	D+3	D+4	2	Move to and defend new division AO
3	D+5	D+8	4	Attack on main avenue of approach, and move to brigade TFOB
4	D+9	D+10	2	Move to and attack within new brigade TFOB
				European Scenario
1	D-10	D+7	18	Deployment, lodgement, and movement to AO
2	D+8	D+10	3	Prepare defensive positions
3	H-hour	H+23	1	Defend
4	H+24	H+47	1	Counterattack
5	H+48	H+95	2	Delay

Figure A-2

c. The third level addresses the divisional AO. For each time period, requirements and capability are tracked for each of the committed maneuver brigades, plus the DRA. The sum of these areas will be displayed for the total division. (NOTE: When the CAB does not occupy a separate area, its requirements are counted where subelements are located within the divisional AO.)

d. The last level of resolution divides the study into two parts for each scenario. Each part splits capability and requirements between the LID-only and EAD units working in the division AO. Figure A-3 lists the EAD units which augment each scenario. Fewer EAD units augment the European scenario because the LID is supported by the in-place corps plus the German Territorial Southern Command (GTSC).

4. Base Case and Excursions. The base case, as defined below, is calculated for each level of resolution of the study methodology, while the SAG-approved excursions use only the applicable portions of the general study methodology.

a. The timeframe for the base case is 1988. As a result, ESC used the design or objective TOE 77-000J800, LID. Figure A-4 shows some of the significant equipment projected for this TOE during the study timeframe. The threat forecasted in each scenario also meets this designated timeframe. Since the modified table of organization and equipment (MTOEs) of the five projected LID are slightly different in organization and mission, the study employs the use of a notional division with the fictional designation of the 17th ID(L). Some significant aspects of the 17th ID(L) are:

(1) The division's basic artillery piece is the 105-mm towed howitzer. The 155-mm artillery battery of the 7th ID(L) is not present.

(2) The Volcano series mine systems are not yet available.

(3) The divisional resupply concept makes full use of helicopters, LAPES zones, roads, and C-130 airfields.

(4) When employed in Europe, USAREUR will replace all divisional 105-mm artillery howitzers one-for-one with 155-mm artillery howitzers using war reserve stocks.

EAD AUGMENTATION FOR 17th ID(L)

TOE	Unit Description	Scenario Latin America	Scenario Europe
3-17J	NBC defense company	--	1
5-35H	Engineer battalion (corps)	--	1
6-307J2	Counterbattery radar section, Target acquisition company	--	1
6-365H	Field artillery (FA) battalion, 155-mm, self-propelled	--	1
6-445H	FA battalion, 203-mm, self-propelled	--	1
7-115H110	Antiarmor battalion (TOW)	--	1
08-123H	Combat support hospital	1	--
9-64H	Ordnance company, Ammunition, Conventional direct support (DS)	1	--
9-520H	EOD, team FA	1	--
9-550H	Rocket and Missile Support LID team KY	1	--
10-227H	Petroleum Platoon, Petroleum Supply Company	1	--
19-077H	Military Police (MP) company	1	--
29-114H4	Graves Registration section, and organization maintenance section, field service company, general support (GS)	1	--
29-119H510	Class IX storage section, repair parts supply company, GS, corps	1	--
29-146H	Headquarters and headquarters company (HHC), Supply & Services (S&S) battalion	1	--
29-147H500	S&S Company	1	--
29-209H9	CE/GSE Maintenance Platoon and Artillery Battalion Maintenance Support Team, Maintenance Company, nondivision, DS	1	--
34-105J	Electronic warfare (EW) Section, Operations Company, Communication EW Intelligence (CEWI) Battalion	--	1
55-167J	Medium-lift platoon (CH-47D), medium helicopter company	1	1
55-67H710	Medium truck squad and light truck squad, light-medium transport company	1	--

Figure A-3

SIGNIFICANT EQUIPMENT LIST*

Items Unique to Engineer Units	Items Found in Both Engineer and Non-Engineer Units
Divisional battalion	High mobility multipurpose wheeled vehicle (HMMWV)
ACE	Tactical 5/4-ton cargo truck
SEE	5-ton cargo trucks
Explosive demolition sets**	107-mm mortar
Mine detecting sets	DRAGON
Carpenters tool kit (platoon)	TOW
Carpenters tool kit (squad)	105-mm light towed howitzer
Chain saw	VULCAN, towed
	Observation helicopter OH-58C
Corps units (above plus):	Attack helicopter, TOW
D-7 bulldozer	Utility helicopter UH-60A
Tractor w/backhoe & loader	Fuel system supply point (FSSP) (60,000 gal)
5-ton dump trucks	Forward area refueling equipment
2-$^{1}/_{2}$ CY scoop loaders	2-wheel motorcycle
Grader	5-ton tractor truck w/22.5-ton semi-trailer

*Design TOE 77-000J (Department of the Army, 1985).
**No liquid explosives.

Figure A-4

b. The lodgement phases of each base case scenario have certain study limitations.

(1) For the Latin American scenario, the lodgement airfield is a US Air Force responsibility. Follow-on fixed bridging on the main supply route (MSR) is a corps responsibility beginning at D+11 (one day after the scenario is terminated for study purposes). Resupply by ship also starts at D+11.

(2) For the European scenario, air deployment of the 17th ID(L) is mixed with other deploying units. As a result, the study artificially limits the start of defensive positions until the entire division has assembled in the divisional AO.

c. The SAG has approved 12 excursions to the base case which provide additional analysis in special areas of interest. These excursions are briefly described below, and summarized in Figure A-5.

(1) Excursion 1: the effect on performance of allocating two engineer battalions (one divisional & one corps) to divisional requirements.

(2) Excursion 2: the effect on performance of allocating the divisional engineer battalion solely to requirements in the brigade sectors.

(3) Excursion 3: the effect on performance of allocating the corps engineer units solely to requirements in the DRA.

(4) Excursion 4: the effect on performance of adding divisional Volcano systems on scenario requirements and on level of performance. This excursion is conducted in conjunction with the countermobility analysis (Annex D).

(5) Excursion 5: the effect on performance of allocating the total capability to only the vital and critical priority group requirements.

STUDY EXCURSIONS

Excursion Number	Short Title	Engineer Capability		Force Requirements	
		Division	EAD	Division	EAD
1	Attached corps engineer battalion (light)	--	X	X	--
2	Organic engineers forward**	X	--	(brigade sectors)	
3	EAD engineers rear**	--	X	(DRA)	
4	Scatterable mine capability	X	--	X	--
5	Priority work	X	X	(vital and critical priority groups)	
6	Liquid explosives (logistics analysis)	X	--	X	--
7	SEE attachment mix	X	--	X	X
8	Engineer class IV/V	X (includes DISCOM assets)	X	X (includes artillery & aviation)	--
9	Corps bridging*	--	X	X	--
10	C-130 airfield construction*	X	X	X	--
11	Additional vehicles*	X	--	X	X
12	Fourth line company	X	--	X	X

*Latin American scenario only.
**European scenario only.

Figure A-5

This analysis is a by-product of the overall study methodology, and is described in the final section of the main report.

(6) Excursion 6: the substitution of liquid explosives for plastic and other solid explosives. The analysis is limited to the logistical aspects and is evaluated as part of the Class IV and V excursion analysis (Annex G).

(7) Excursion 7: the effect on performance of using the optimum mix of 36 SEE attachments for the divisional engineer battalion's 18 SEEs. This excursion and excursions 2 and 3 are addressed as part of the divisional structure analysis (Annex I).

(8) Excursion 8: ESC will estimate the Class IV and V requirements in support of engineer survivability, mobility, and countermobility missions. For the latter mission, artillery and aviation mine expenditures will also be included. These excursions will be covered in Annex G.

(9) Excursion 9: the calculation of the corps bridging requirement. This is treated as an excursion, since the EFFORT capability model does not input bridge units. This excursion, and excursion 1 are examined as part of the EAD structure analysis (Annex J).

(10) Excursion 10: the effect of upgrading a C-130 airfield within the second divisional rear area in the Latin American scenario. This excursion is covered in the general engineering analysis (Annex F).

(11) Excursion 11: the effect on performance of adding vehicles to the divisional engineer battalion. These excursions are presented separately as a sensitivity analysis (Annex H).

(12) Excursion 12: the effect on performance of adding a fourth line company to the divisional engineer battalion. This excursion is part of the sensitivity analysis described in Annex H.

5. Requirements. The requirements process must determine what engineer tasks are to be accomplished, how tasks will be grouped, how task calculations will be kept consistent, and how requirements will be ranked.

a. Calculated engineer requirements in the divisional AO are reduced by any host nation engineer support that is received. This results in study requirements where only US capability will be applied (if available). This process is documented under the four engineer missions of mobility, countermobility, survivability, and general engineering (see Annexes C, D, E, and F, respectively).

b. There are 67 identified tasks (many with additional subtasks) divided among the four major engineer missions. For computational ease, these tasks are organized as follows:

(1) The 67 tasks are first compressed into 16 increments, four increments for each of the major engineer missions -- mobility, countermobility, survivability, and general engineering.

(2) The 16 increments then are grouped into four priorities: vital, critical, essential, and necessary. These priority groups served as a framework for judging the relative capability of engineer support. Figure A-6 lists the criteria for each priority group. Vital increments constitute support which is indispensable to the existence and continuance of the division. Critical increments are defined as pivotal support which may be decisive in the success or failure of the division's planned operations. Essential increments are those intrinsic fundamental tasks which must be accomplished, but which are not immediately indispensable. Necessary increments are routine support tasks for which there is a definite need, but which can be deferred for more urgent requirements.

PRIORITY GROUPS

Short Title	Implications of Nonsupport
Vital	Jeopardizes the existence of the division High loss of life Early defeat of the division
Critical	Failure of division operations Increased probability of defeat
Essential	Short-term degradation in sustainability Significant equipment and material losses
Necessary	Long-term degradation in sustainability Moderate equipment and material losses

Figure A-6

(3) The composition of the four priority groups change during the principal battle phases of lodgement, offense, and defense. For each of the three battle phases in each scenario, ESC asked the SAG to place each of the 16 increments into one of the four priority groups. Figures A-7 through A-9 show these three priority lists for the Latin American scenario; Figures A-10 through A-12 show the European scenario. The emphasis when using these lists is on planning, not necessarily execution. In reality, all tasks would carefully be integrated based on need and most efficient use of equipment. This need and allocation will change constantly and will only occasionally exactly match the approved priority list. However, it is important to have a basic average priority system that equates to the broader comparison made possible by the four priority groups. In this way, ESC can compare requirements to capability by summing the squad- and equipment-hours required by tasks in the four priority groups. The SAG approved all priority lists at IPR 3 on 3 April 1986.

c. For estimating squad- and equipment-hours, ESC uses on-site engineer planning factors with no degradations. These unconstrained values are an important part of the analysis.

LODGEMENT PHASE PRIORITY LIST —
LATIN AMERICAN SCENARIO

Priority	Level of Support*	Priority Increment**	Condensed Description
1	V	G-1	Construct or repair primary Lines of Communication (LOCs).
2	V	S-1	Protect primary positions for TOW, forward area altering radar (FAAR), and divisional tactical operation center (DTOC); clear FA fire bases.
3	V	M-1	Breach minefields, fortified positions, and enemy strongpoints; destroy enemy bunkers.
4	V	G-2	Construct or repair secondary LOCs; protect secondary facilities.
5	V	S-2	Protect primary positions for FA fire direction centers (FDCs) Vulcan, and alternate TOW, tank, and armored personnel carrier (APC) weapon positions.
6	C	M-2	Maintain MSRs and combat trails; breach other obstacles to maneuver plan.
7	C	S-3	Protect primary position for FA 81-mm and 107-mm howitzers, battalion command posts (CPs), brigade support areas (BSAs), mortars and forward area refueling points (FARP); protect secondary TOW, tank, and APC weapon positions.
8	C	G-3	Construct and repair tertiary LOCs; protect secondary facilities.
9	E	S-4	Protect primary positions for FA ammunition and BSA generator noise suppression slot/berms.

Figure A-7 (Continued on Next Page)

LODGEMENT PHASE PRIORITY LIST --
LATIN AMERICAN SCENARIO (Continued)

Priority	Level of Support*	Priority Increment**	Condensed Description
10	E	C-2	Install point targets, minefields, and wire obstacles on the main avenues of approach.
11	E	G-4	Construct and repair other needed LOCs and facilities.
12	E	C-3	Install point targets, minefields, tank ditches, and wire obstacles on secondary avenues of approach.
13	N	M-3	Construct combat trails; support river crossing operations; construct LAPES zones.
14	N	C-1	Execute raids to deny road junctions and key installations.
15	N	M-4	Clear tank ditches and minefields; repair new damage to roads and bridges; retrieve and replace tactical bridging with fixed bridging.
16	N	C-4	Complete the obstacle plan in depth.

*Levels of support: V = Vital, C = Critical, E = Essential, N = Necessary.

**Corresponds to the increment levels in each functional area (e.g., C-1 means countermobility tasks, first increment).

S -- Survivability
C -- Countermobility
M -- Mobility
G -- General Engineering

Figure A-7

DEFENSIVE PHASE PRIORITY LIST --
LATIN AMERICAN SCENARIO

Priority	Level of Support*	Priority Increment**	Condensed Description
1	V	S-1	Protect primary positions for TOW, tank, APC, crew-served weapons, FAAR, and DTOC; clear FA fire bases.
2	V	C-2	Install point targets, minefields, tank ditches, and wire obstacles on the main avenue of approach.
3	V	G-1	Construct or repair primary LOCs.
4	V	C-1	Execute raids to deny road junctions and key installations.
5	C	S-2	Protect primary positions for FA FDCs, Vulcan and alternate TOW, tank, and APC positions.
6	C	S-3	Protect primary positions for FA howitzers, battalion CPs, BSA, 81-mm and 107-mm mortars, and FARP. Protect secondary TOW Tank, and APC weapon positions.
7	C	G-2	Construct or repair secondary LOCs; protect primary facilities.
8	E	C-3	Install point targets, minefields, tank ditches, and wire obstacles on secondary avenues of approach.
9	E	G-3	Construct and repair tertiary LOCs; protect secondary facilities.

Figure A-8 (Continued on Next Page)

DEFENSIVE PHASE PRIORITY LIST --
LATIN AMERICAN SCENARIO (Continued)

Priority	Level of Support*	Priority Increment**	Condensed Description
10	E	M-2	Maintain MSRs and combat trails; breach other obstacles to maneuver plan.
11	E	C-4	Complete obstacle plan in depth.
12	E	S-4	Protect primary positions for FA ammunition and BSA generator noise suppression slot/berms.
13	N	G-4	Construct and repair other needed LOCs and facilities.
14	N	M-1	Breach minefields, fortified positions, and enemy strongpoints; destroy enemy bunkers.
15	N	M-3	Construct combat trails; support river crossing operations; construct LAPES zones.
16	N	M-4	Clear tank ditches and minefields; repair new damage to roads and bridges; retrieve and replace tactical bridging with fixed bridging.

*Levels of support: V = Vital, C = Critical, E = Essential, N = Necessary.

**Corresponds to the increment levels in each functional area (e.g., C-1 means countermobility tasks, first increment).

S -- Survivability
C -- Countermobility
M -- Mobility
G -- General Engineering

Figure A-8

OFFENSIVE PHASE PRIORITY LIST --
LATIN AMERICAN SCENARIO

Priority	Level of Support*	Priority Increment**	Condensed Description
1	V	M-1	Breach minefields, fortified positions, and enemy strongpoints; destroy enemy bunkers.
2	V	C-1	Execute raids to deny road junctions and key installations.
3	C	S-1	Protect primary positions for TOW, tank, APC, crew-served weapons, FAAR, and DTOC; clear FA fire bases.
4	C	M-2	Maintain MSRs and combat trails; breach other obstacles to maneuver plan.
5	C	G-1	Construct or repair primary LOCs.
6	C	G-2	Construct or repair secondary LOCs; protect primary facilities.
7	C	S-2	Protect primary positions for FA FDCs, Vulcan and alternate TOW, tank, and APC weapon positions.
8	E	M-3	Construct combat trails; support river crossing operations; construct LAPES zones.
9	E	M-4	Clear tank ditches and minefields; repair new damage to roads and bridges; retrieve and replace tactical bridging with fixed bridging.

Figure A-9 (Continued on Next Page)

OFFENSIVE PHASE PRIORITY LIST --
LATIN AMERICAN SCENARIO (Continued)

Priority	Level of Support*	Priority Increment**	Condensed Description
10	E	S-3	Protect primary positions for FA howitzers, battalion CPs, BSA, 81-mm and 107-mm mortars, FARP and DTOC; protect secondary positions for TOW, tank, and APC.
11	E	G-3	Construct and repair tertiary LOCs; protect secondary facilities.
12	N	C-2	Install point targets, minefields, tank ditches, and wire obstacles on the main avenues of approach.
13	N	G-4	Construct and repair other LOCs and facilities.
14	N	S-4	Protect primary positions for FA ammunition and BSA generator noise suppression slot/berms.
15	N	C-3	Install point targets, minefields, tank ditches, and wire obstacles on secondary avenues of approach.
16	N	C-4	Complete obstacle plan in depth.

*Levels of support: V = Vital, C = Critical, E = Essential, N = Necessary.

**Corresponds to the increment levels in each functional area (e.g., C-1 means countermobility tasks, first increment).

S -- Survivability
C -- Countermobility
M -- Mobility
G -- General Engineering

Figure A-9

LODGEMENT PHASE PRIORITY LIST --
EUROPEAN SCENAIRIO

Priority	Level of Support*	Priority Increment**	Condensed Description
1	V	S-1	Protect primary positions for TOW, tank, APC, crew-served weapons, FAAR, and DTOC; clear FA fire bases.
2	V	S-2	Protect primary positions for FA FDCs, Vulcan and alternate TOW, tank, and APC weapon positions.
3	V	S-3	Protect primary positions for FA howitzers, battalion, CPs, BSA, 81-mm and 107-mm mortars, and FARP; protect secondary positions for TOW, tank, and APC.
4	V	G-1	Construct or repair primary LOCs.
5	C	C-2	Install point targets, minefields, tank ditches, and wire obstacles on the main avenue of approach.
6	C	S-4	Protect primary positions for FA ammunition and BSA generator noise suppression slot/berms.
7	E	G-2	Construct or repair secondary LOCs; protect primary facilities.
8	E	M-2	Maintain MSRs and combat trails; breach other obstacles to maneuver plan.
9	E	G-3	Construct and repair tertiary LOCs; protect secondary facilities.

Figure A-10 (Continued on Next Page)

LODGEMENT PHASE PRIORITY LIST --
EUROPEAN SCENARIO (Continued)

Priority	Level of Support*	Priority Increment**	Condensed Description
10	E	G-3	Construct and repair tertiary LOCs; protect secondary facilities.
11	E	G-4	Construct and repair other needed LOCs and facilities.
12	N	M-3	Construct combat trails; support river crossing operations; construct LAPES zones.
13	N	C-1	Execute raids to deny road junctions and key installations.
14	N	M-1	Breach minefields, fortified positions, and enemy strongpoints; destroy enemy bunkers.
15	N	C-4	Complete the obstacle plan in depth.
16	N	M-4	Clear tank ditches and minefields; repair new damage to roads and bridges retrieve and replace tactical bridging with fixed bridging.

*Levels of support: V = Vital, C = Critical, E = Essential, N = Necessary.

**Corresponds to the increment levels in each functional area (e.g., C-1 means countermobility tasks, first increment).

S -- Survivability
C -- Countermobility
M -- Mobility
G -- General Engineering

Figure A-10

DEFENSIVE PHASE PRIORITY LIST --
EUROPEAN SCENARIO

Priority	Level of Support*	Priority Increment**	Condensed Description
1	V	S-1	Protect primary positions for TOW, tank, APC, crew-served weapons, FAAR, and DTOC; clear FA fire bases.
2	V	C-2	Install point targets, minefields, tank ditches, and wire obstacles on the main avenue of approach.
3	V	S-2	Protect primary positions for FA FDCs, Vulcan, and protect alternate TOW, tank, and APC weapon positions.
4	V	S-3	Protect primary positions for FA howitzers, battalion CPs, BSA, 81-mm and 107-mm mortars, and FARP; protect secondary TOW, tank, and APC weapon positions.
5	V	C-3	Install point targets, minefields, tank ditches, and wire obstacles on secondary avenues of approach.
6	V	C-4	Complete obstacle plan in depth.
7	C	G-1	Construct or repair primary LOCs.
8	C	C-1	Execute raids to deny road junctions and key installations.
9	C	G-2	Construct and repair secondary LOCs; protect primary facilities.

Figure A-11 (Continued on Next Page)

DEFENSIVE PHASE PRIORITY LIST --
EUROPEAN SCENARIO (Continued)

Priority	Level of Support*	Priority Increment**	Condensed Description
10	E	S-4	Protect primary positions for FA ammunition and BSA generator noise suppression slot/berms.
11	E	G-3	Construct and repair tertiary LOCs; protect secondary facilities.
12	E	M-3	Construct combat trails; support river crossing operations; construct LAPES zones.
13	N	M-2	Maintain MSRs and combat trails; breach other obstacles to maneuver plan.
14	N	G-4	Construct and repair other LOCs and facilities.
15	N	M-1	Breach minefields, fortified positions, and enemy strongpoints; destroy enemy bunkers.
16	N	M-4	Clear tank ditches and minefields; repair new damage to roads and bridges; retrieve and replace tactical bridging with fixed bridging.

*Levels of support: V = Vital, C = Critical, E = Essential, N = Necessary.

**Corresponds to the increment levels in each functional area (e.g., C-1 means countermobility tasks, first increment).

S -- Survivability
C -- Countermobility
M -- Mobility
G -- General Engineering

Figure A-11

OFFENSIVE PHASE PRIORITY LIST —
EUROPEAN SCENARIO

Priority	Level of Support*	Priority Increment**	Condensed Description
1	V	M-1	Breach minefields, fortified positions, and enemy strongpoints; destroy enemy bunkers.
2	V	M-2	Maintain MSRs and combat trails; Breach other obstacles to maneuver plan.
3	V	G-1	Construct and repair primary LOCs.
4	C	G-2	Construct and repair secondary LOCs; protect primary facilities.
5	C	M-3	Construct combat trails; support river crossing operations; construct LAPES zones.
6	C	C-1	Execute raids to deny road junctions and key installations.
7	C	S-1	Protect primary positions for TOW, tank, APC, crew-served weapons, FAAR, and DTOC; clear FA fire bases.
8	C	S-2	Protect primary positions for FA FDCs, Vulcan, and alternate TOW, tank, and APC weapon positions.
9	E	M-4	Clear tank ditches and minefields; repair new damage to roads and bridges; retrieve and replace tactical bridging with fixed bridging.

Figure A-12 (Continued on Next Page)

OFFENSIVE PHASE PRIORITY LIST --
EUROPEAN SCENARIO (Continued)

Priority	Level of Support*	Priority Increment**	Condensed Description
10	E	S-3	Protect primary positions for FA howitzers, battalion CPs, BSA, 81-mm and 107-mm mortars, and FARP; protect secondary TOW, tank, and APC weapon positions.
11	E	G-3	Construct and repair tertiary LOCs; protect secondary facilities.
12	N	C-2	Install point targets, minefields, tank ditches, and wire obstacles on the main avenue of approach.
13	N	G-4	Construct and repair other needed LOCs and facilities.
14	N	S-4	Protect primary positions for FA ammunition and BSA generator noise suppression slot/berm.
15	N	C-3	Install point targets, minefields, tank ditches, and wire obstacles on secondary avenues of approach.
16	N	C-4	Complete obstacle plan in depth.

*Levels of support: V = Vital, C = Critical, E = Essential, N = Necessary.

**Corresponds to the increment levels in each functional area (e.g., C-1 means countermobility tasks, first increment).

S -- Survivability
C -- Countermobility
M -- Mobility
G -- General Engineering

Figure A-12

(1) ESC uses realistic values in reference to the scope of the engineer workload. Any engineer task usually has three levels or standards: optimistic, pessimistic, and realistic or average. Invariably, analysts choose the average standard; ESC's experience indicates it is nonproductive to calculate the other two extremes.

(2) Tasks are unconstrained in reference to conditions at the work site (i.e., daytime, trained soldiers, optimal work unit, materials available, and so forth). Most engineer tables and studies are expressed in this way or can be easily converted to this standard. This step of the analysis avoids the common tendency to overestimate a task. Accuracy is regained by degrading capability (see paragraph 6).

d. In summary, detailed engineer tasks are sequentially combined until arranged for the tactical commander in four priority groups. These groups are arranged further by battle phase -- lodgement, offense, and defense -- for the two scenarios (Figure A-13). To arrive at unconstrained but realistic values, the ESC project team analyzed the US Army Combined Arms Combat Development Activities (CACDA's) operational concept and then interviewed the 7th ID(L) unit and staff at Fort Ord, California. This data collection trip also served to validate the scope of engineer tasks and was a principal step in the study methodology.

6. Capability. Engineer capability is calculated using the EFFORT computer model (Annex B). Capability is degraded so when it is compared with on-site unconstrained requirements, an accurate time-phased assessment is produced. Four key aspects of EFFORT were used in this study.

ENGINEER BATTLE TASKS AND RANKING

Mission Area	Tasks	Increments	Ranking
			Four priority groups:
Mobility	14	2-5	Vital Critical
Countermobility	14	3-5	Essential Necessary
			Ranked for three battle phases:
Survivability	13	4-5	Lodgement Offense Defense
General Engineering	26	4-5	
TOTAL	67	16	Three priority lists (with four priority groupings per scenario)

Figure A-13

a. Measurement elements. The study's calculations were based on the eight-man squad size found in the LID divisional engineer battalion. Five classes of dominant equipment were also tracked:

(1) ACE and bulldozer (D-7 size)

(2) SEE and tractor with backhoe and loader attachments (JD 410).

(3) Front-end loader (2.5 cubic yards)

(4) Grader

(5) 5-ton truck (cargo or dump) not dedicated to a squad or a mobility/countermobility piece of equipment (i.e., MICLIC or scatterable mine system).

b. Strength levels. In-theater unit capability is adjusted to represent strengths the Army can realistically field. For this study, the engineer battalion of the notional 17th ID(L) was deployed at 100-percent strength in order to test its forecasted 1988 configuration. Other engineer

EAD units were deployed at levels consistent with available manpower. During deployment, all units are subject to enemy air or sea attacks consistent with the scenario assumptions listed in Volume II of this study.

c. Productive time. After arrival in-theater, unit strength is adjusted for casualties and replacements. The workday of individuals also is assessed. Individuals and their equipment are nonproductive while moving, during sleep, providing security, or while messing, awaiting equipment repair, etc. These standard and nonstandard degradations were averaged for units; the EFFORT model calculates the remaining daily productivity.

d. Exceptions. EFFORT does not calculate capability for bridge manhours, bridge equipment-hours, and explosive and mine Class V items. Bridging capability (manhours and equipment) was computed manually for the EAD structure analysis (Annex J), the scatterable mine Class V items analysis (Annex D), and the Class IV and V supply.

7. Comparison Phase. In the final step of the methodology, total divisional engineer requirements are compared with capability by scenario for each time period and AO (Figure A-1). Those results are summed for the whole division and then expressed as averages per day.

a. The expected result of the base case comparison is an engineer shortfall. Annex J of this document explains the ESC methodology for converting an engineer capability shortfall into an engineer EAD force. When constructing the EAD force, engineer requirements were divided in two catagories: combat-essential and sustainability requirements. If the less likely result of an engineer capability excess had occurred, the engineer EAD force would have been looked at for reductions or relocations.

b. Whether a shortfall existed or not, the divisional engineer battalion is examined for balance by checking the proportion of its capability against corresponding requirement proportions. ESC compared the squad power-to-equipment proportion, as well as the individual equipment mix. For balancing, the battalion's present personnel strength and deployment C-141B sorties were not increased. Changes to the battalion's TOE were recommended where ESC found the unit out of balance in the same category in both the Latin American and European scenarios.

8. Determination of Findings. ESC's conclusions and recommendations pertain to individual scenarios or to both scenarios combined. When scenarios are combined, Latin America is weighted two-thirds, Europe one-third. This weighting scheme was based on the primary and secondary mission and/or expected deployment location of the LID. The weighting scheme above was approved by the SAG at IPR 2 on 9 December, 1986. In moving from conclusions to recommendations, ESC followed these practical guidelines:

a. Any changes recommended to the divisional engineer force structure followed the zero-sum increase rule. The study recommendations do not suggest an increase in the battalion's end-strength, or to the 16 C-141B sorties required to deploy the battalion.

b. Changes must be attainable at low cost. This left some leeway for recommending changes based on long-term development proposals for new types of equipment.

c. ADEA must be able to initiate or influence any action recommended by this study.

d. ESC considered ongoing initiatives of the sponsor and the engineer family, and developed ranked decision tables when significant differences warranted. This allowed all views to be considered, while maintaining ESC's analytical neutrality.

LAST PAGE OF ANNEX A

ANNEX B

ENGINEER CAPABILITY

ANNEX B

ENGINEER CAPABILITY

1. Purpose. This annex describes the process used to determine the engineer support capability of a LID force under a Latin American and European scenario, and identifies the engineer capabilities of the augmentation forces supporting the LID.

2. Scope. The capability estimates made in this annex reflect the engineer strength of the LID as organized under TOE 05-155J800.[1] Estimates were

[1] TOE 05-155J800 (Department of the Army, March 1985).

also made for those EAD engineer organizations most prevalent in the force structure to determine whether the augmentation units can support division requirements.

a. Engineer capability is expressed as net productive manhours (or 8-man squad-hours) and as dominant equipment-hours.

b. The EFFORT model was used to calculate the unit strength, movement, battle casualty, and work delay factors used in this analysis.

3. Methodology. Figure B-1 portrays the process developed and used to determine engineer capability on the battlefield. Five steps were followed to compute engineer capability. The following paragraphs explain each step and highlight the analytic variables that affected the capability computations for each scenario. Figure B-2 is a mathematical sample of the process portrayed in Figure B-1.

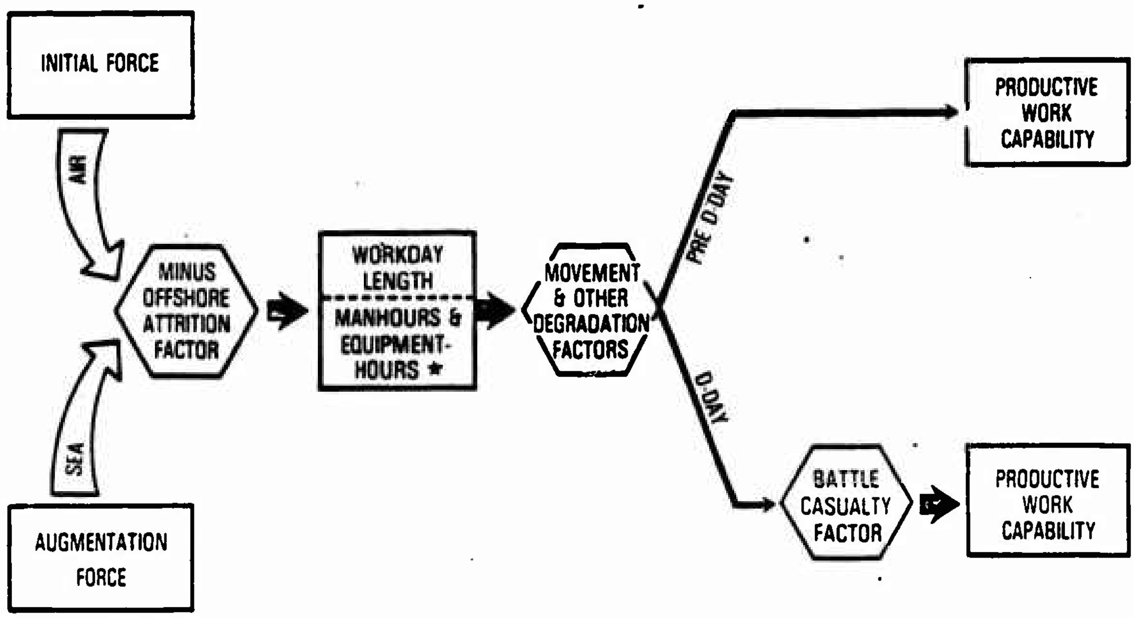
a. Step 1: initial force strength.

(1) In the Latin American scenario, the LID is deployed with only a small augmentation support force (no additional engineer units).

(a) The starting capability of the initial force (the organic engineer battalion of the LID) was based on the assumption that it deploys at 100 percent of its required strength (ALO 1).

(b) The engineers and equipment were simulated on an as-needed basis in regard to positioning. Figure B-3 displays where the company units were located within each time period. AOs Blue and Pink are accessible only by helicopter. Since ACEs cannot be transported with the helicopter assets available in the LID, no ACE capability was calculated for AO Blue or Pink. However, SEE capability is calculated for those AOs, since the SEE can be airlifted.

ENGINEER CAPABILITY MODEL
(MANHOURS AND EQUIPMENT-HOURS)



★ EQUIPMENT WORKDAY SHORTENED FOR MALFUNCTIONS

Figure B-1

SAMPLE ENGINEER CAPABILITY COMPUTATIONS -- EUROPEAN SCENARIO
(Period 2 -- D+8 through D+10)

Number of Personnel/Equipment		Air/Sea Attrition*		In-Country Strength		Work Hours Per Day (Man/Equipment)		Number of Days in Period 2		European Movement & Degradation Factor		Productive Work Capability: Manhours	Productive Work Capability: Squad-hours
LID engineers, C Company													
Productive Personnel**													
50	x	5.0%	=	48	x	18.0	x	3.0	x	45.0%	=	1,410.7	176.3
Equipment***												Equipment-Hours	
2 ACEs	x	5.0%	=	1.8	x	16.0	x	3.0	x	45.0%	=	47.5	
5 SEEs	x	5.0%	=	4.5	x	16.0	x	3.0	x	45.0%	=	118.8	
1 5-ton truck	x	5.0%	=	0.9	x	16.0	x	3.0	x	45.0%	=	23.8	

*Air/sea attrition is assessed for those units arriving after D-day. This figure uses a hypothetical number to portray the mathematical computations. Actual numbers are classified.

**Productive personnel are those whose skills contribute directly to operations at the work site.

***When computing equipment-hours, the EFFORT model rounds up.

Figure B-2

ENGINEER ALIGNMENT WITHIN LATIN AMERICAN SCENARIO
(by Company)

Period	Timeframe From	To	AO* Green	Red	Blue	Pink
1	D+1	D+2	A (+)	—	—	—
	D+2	D+3	B,C, HHC	A	—	—
2	D+3	D+5	C, HHC	A, B	—	—
3	D+5	D+9	C (-), HHC	A	B (+)	—
4	D+9	D+11	—	A, HHC	B (-)	C (+)

*AO green = initial lodgement; AO Red = main avenue of advance; AO Blue = 3d Brigade tactical forward operating base (TFOB); AO Pink = 1st Brigade TFOB.

Figure B-3

(2) In the European scenario, an armored brigade is attached to the LID in addition to an augmentation force. Engineer capability in this scenario includes the LID engineer battalion, the engineer company of the armored brigade, and an in-country engineer combat battalion, corps.

(a) The armored brigade engineer company is gamed at 100 percent of required strength (ALO 1) and the corps engineer battalion is gamed at the authorized level (ALO 2). The corps battalion is assumed in position and effective on D+7, the same day the last units of the LID arrive.

(b) The LID engineer companies are each assigned to a brigade sector and remain in that brigade AO for the entire scenario. The LID engineer companies in the 1st and 2d Brigade are each augmented with a company from the corps engineer battalion. The LID engineer company in the 3d Brigade does not have any augmentation force. In the armored brigade sector, the attached engineer company is augmented with two companies from the corps battalion. The HHC of the LID engineer battalion and the corps engineer battalion are located in the DRA.

b. Step 2: air-sea attrition factors.

(1) In the Latin American scenario, there is no air attrition to the LID because of the scenario's low-intensity conflict and the air superiority of US forces. The engineer battalion of the LID is partially deployed on D+1; all units are in-country by D+2.

(2) In the European scenario, air attrition is computed starting at D-day.

(a) The engineer battalion of the LID is deployed over a period of time from D-10 to D+7. Thus, some air losses are assessed against those units arriving after D-day. The percentage of those losses is dictated by the scenario location and date of deployment as presented in the Army Force Planning Data and Assumptions (AFPDA) document.[2]

(b) Since the corps battalion is an in-country unit, no air/sea attrition is applicable. The engineer company of the armored brigade arrives after D-day and is assessed for air/sea attrition.

c. Step 3: workday length.

(1) Productive personnel are those people whose skills contribute directly to operations at the work site. Therefore, personnel who do primarily overhead tasks (e.g., supply clerks, maintenance mechanics, supervisors, cooks) or those who contribute indirectly to the work site's operations (draftsmen, surveyors, etc.) were not counted by the EFFORT model when calculating squad-hour values. Equipment operators are counted as part of the equipment, not as productive personnel.

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[2] Army Force Planning Data and Assumptions, FY 1986 - 1995 (US Army Concepts Analysis Agency [CAA], August 1985).

(a) In this analysis, the engineer squads are composed of eight productive members. Thus, a squad-hour equates to 8 manhours. Engineer squads in the attached and augmentation force have the same number of productive personnel.

(b) The workday length for productive personnel was calculated based on an 18-hour workday for the duration of both the Latin American and European scenarios.

(2) The dominant items of equipment for the engineers in the LID were six ACEs, 18 SEEs, and three 5-ton cargo trucks. Additional items of equipment that were tracked in the European scenario were dozers, graders, front-end loaders, and 5-ton dump trucks found in the augmentation force of the corps engineer battalion and the engineer company of the armored brigade. Trucks used as squad vehicles were not counted as available and productive pieces of equipment. However, the use of squad vehicles for productive project work is explored as an option in the European scenario. The squad vehicles of the forward-deployed engineer corps battalion are calculated at various levels of availability.

(a) The number of items of dominant equipment is the basis for determining the capability in the equipment-hour category, not the number of personnel who operate the equipment (i.e., equipment operators are counted as part of the equipment).

(b) Equipment-hours were calculated based on a 16-hour workday for both scenarios. The workday was reduced to 16 hours to account for unscheduled maintenance required by equipment breakdown or malfunction.

(c) Before D-day, some personnel and equipment assigned to a combat mission were considered free for other assignments, and were counted as resources available to enhance the engineer's capability. At the start of combat, however, they resumed their original wartime mission. For example, 5-ton trucks dedicated to hauling GEMSS or Volcanos could be used for engineering tasks when the towed equipment is parked, but once combat begins, the trucks must revert to their combat assignment.

(d) Engineer equipment that has a combat mission, such as the CEV, is counted as a percentage of the equivalent dominant equipment item; thus, three CEVs are the equivalent of one D-7 dozer. The latter portion of this annex lists the units which could be used to augment the LID. Oversize equipment in the TOE of those units, such as 20-ton dump trucks, were translated into smaller items of similar capability (e.g., one 20-ton dump truck was equivalent to three 5-ton dump trucks).

(3) Figure B-2 demonstrates the mathematics of Steps 1 through 3 using a productive in-country strength of 50 productive persons for Company C of the LID engineer battalion. The European scenario is used to demonstrate the air attrition factor, which was not computed in the Latin American scenario. The number of productive personnel is multiplied by the number of workhours in the day and by the number of days in the period. The result is an estimate of the unit's gross capability, in manhours and dominant equipment-hours for the period.

d. Step 4: degradation and movement factors.

(1) This analysis assumed that engineer units are effective only for those hours after time for travel to the work site, rest, mess, etc. has been subtracted from the gross available capability. Degradation percentage factors were obtained from AR 570-2, as modified by a 1982 ESC study.[3,4] In

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[3] Organization and Equipment Authorization Tables -- Personnel, Army Regulation [AR] 570-2 (Department of the Army Headquarters, various dates between 1985 and 1986).

[4] Engineer Unit Capabilities (European Environment) (ESC, March 1982).

both the Latin American and European scenarios, the engineer workday of 18 hours was degraded by 25 percent for nonproductive factors such as security, mess, nondelivery of material, change of mission, night operations, and combat disruptions.

(2) Movement percentages for the LID and EAD engineers were developed after examining the scenario, gaming the combat actions, and studying the terrain for movement routes and, in the case of the LID, determining what means of transport were available -- whether vehicle or foot.

(a) Movement in the Latin American scenario was computed as 25 percent of the engineer workday. It was determined that the LID engineers would be walking to and between most of the work sites with very little reliance on vehicle transport.

(b) In the European scenario, the movement factor for the LID engineers was reduced to 20 percent of the workday. Because of the rugged, hilly terrain, the small AOs, and intensity of conflict, the division and its engineers would be restricted in movement and were thus gamed as having limited mobility. Movement for the engineer company of the armored brigade and the corps engineer battalion was computed as 15 percent of the workday. These units, while operating in the same terrain and AOs, were able to use squad vehicles to reduce the amount of time spent moving to work sites.

(3) Productive work time is computed by subtracting the degradation and movement times from the available workday. This process is summarized in Figure B-4, which shows productive workhours and equipment-hours for both scenarios and the units within each scenario. The engineers of the LID are productive for 50 percent of the 18-hour workday in the Latin American scenario, and 55 percent of the workday in the European scenario. The augmentation force is productive 60 percent of the workday in the European scenario.

PRODUCTIVE WORKHOURS PER DAY

	Scenario					
	Latin American		European			
	LID		LID		Attached Units	
	Personnel	Equipment	Personnel	Equipment	Personnel	Equipment
Hours in day	24.0	24.0	24.0	24.0	24.0	24.0
Nonwork time	-6.0	-8.0	-6.0	-8.0	-6.0	-8.0
Workday	18.0	16.0	18.0	16.0	18.0	16.0
Nonproductive time	-4.5	-4.0	-4.5	-4.0	-4.5	-4.0
Movement*	-4.5	-4.0	-3.6	-3.2	-2.7	-2.4
Productive Work Time	9.0	8.0	9.9	8.8	10.8	9.6

*Movement accounts for 25 percent of the workday in the Latin American scenario. In the European scenario, movement is 20 percent for the LID engineers and 15 percent for the engineers in the augmentation force.

Figure B-4

e. Step 5: casualty losses. The final step in computing engineer capability is to apply a casualty factor once combat begins. In the Latin American scenario, no replacements were assumed. In the European scenario, casualties were considered only to the extent that they exceeded replacements. Replacements equal casualties behind the brigade rear boundaries, but casualties exceed replacements forward of those boundaries.

(1) Before any casualty factors can be applied, total engineer casualties for both the Latin American and European scenarios had to be determined. This methodology is shown as a mathematical formula in Figure B-5 and consists of three parts that compute the number of casualties for the combat force, the scenario, and the engineers. The figure compares the two scenarios, showing that the size of the combat force and its attrition rate has a direct cause-and-effect relationship throughout this methodology.

METHODOLOGY FOR DETERMINING CASUALTIES

LATIN AMERICAN CASUALTIES

Combat Force Casualties

Combat Force		Attrition Rate at End of Model Play (%)		Combat Force Casualties
7,386	x	10	=	738.6

Scenario Casualties

Combat Casualties		Scenario Correlation*		Total Scenario Casualties
$\frac{738.6}{x}$	:	$\frac{85}{100}$	=	868.9

Engineer Casualties

Scenario Casualties		Engineer Attrition Rate (%)		Total Engineer Casualties
868.9	x	4	=	34.8

Number of engineers in scenario: 290

Engineer casualty percentage: 34.8/290 = 12.1

EUROPEAN CASUALTIES

Combat Force Casualties

Combat Force		Attrition Rate at End of Model Play (%)		Combat Force Casualties
11,795	x	32	=	3,774.4

Scenario Casualties

Combat Casualties		Scenario Correlation*		Total Scenario Casualties
$\frac{3,774.4}{x}$	:	$\frac{85}{100}$	=	4,440.5

Engineer Casualties

Scenario Casualties		Engineer Attrition Rate (%)		Total Engineer Casualties
4,440.5	x	4	=	177.6

Number of engineers in scenario: 1,174

Engineer casualty percentage: 177.6/1174 = 15.1

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*Based on historical data, the combat force sustains 85 percent of all battle casualties.

Figure B-5

(a) Part one of Figure B-5 calculates the casualties for the combat force. The units that comprise the combat force are listed in Figure B-6 and include the infantry, armor, artillery, and cavalry units of both the division and the EAD support force. The attrition rate for the combat force was derived from the model simulations conducted by the US Army Combined Arms Operational Research Activity of the scenarios presented in Volume II of this study.[5] As shown in Figure B-5, the combat force in the Latin American scenario is attrited 10 percent by the end of the scenario -- 738.6 casualties.

(b) Once the casualties for the combat force have been determined, the casualties for the scenario are calculated. Based on historical data from previous wars, the combat force sustains 85 percent of all casualties. Thus, using a mathematical correlation that 738.6 combat casualties account for 85 percent of all war casualties, the scenario total is 868.9 casualties.

(c) Engineer casualties are included in the 868.9 total scenario casualties. Based on data taken from Army Field Manual (FM) 101-10-1, the engineer casualty rates range from 3.2 percent to 4 percent of the total scenario casualties. ESC selected the 4.0 percent rate based on the type of unit, intensity of combat, and the LID engineers' role in conflict. Multiplying the total casualties by the 4 percent rate results in the total engineer casualties for the scenario.

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[5] Infantry Division (Light) Summary (Combined Arms Operations Research Activity [CAORA], 28 June 1984).

COMBAT FORCE

	Latin American Scenario	European Scenario
LID	309	309
H&H brigade		
9 Infantry brigades	4,869	4,869
1 Field artillery (FA) battalion	1,323	1,323
1 CAB	885	885
Armored brigade		
1 Infantry battalion, mechanized		825
2 Armor battalions		1,104
1 FA battalion		580
1 Cavalry troop		129
Augmentation force		
1 Air assault battalion (TOW)		609
1 FA battalion (8-in. howitzer)		465
1 FA battalion (155-mm self-propelled howitzer)		585
1 Counterbattery radar section (target acquisition battery)		112
TOTAL	7,386	11,795

*The combat force is defined as infantry, armor, artillery, and cavalry units of the deployed force.

Figure B-6

1. As shown in Figure B-5, 34.8 or 35 engineer casualties are sustained in the Latin American scenario. Comparing this number to the total number of engineers available in the scenario (i.e., 290) results in an engineer attrition rate of 12.1 percent.

2. There are 177.6 or 178 engineer casualties in the European scenario. These casualties are distributed over a greater number of engineers in the scenario. As a result, the actual percentage of engineers attrited is only slightly greater than the Latin American scenario (15.1 versus 12.1 percent), even though the European scenario has over five times more casualties.

(2) Engineer casualty rates for each scenario period were developed by analyzing the flow of the battle during each period, the number of casualties sustained by the combat force during the corresponding time period, the amount of engineer work on the various phase lines, and the area covered as the forces advanced or retreated. Using these factors, attrition rates were developed for each period and casualties assessed and accumulated until the count equaled the total engineer casualty number listed in Figure B-5 for each scenario. Figure B-7 lists the combat periods of both the Latin American and the European scenarios, and indicates the casualty rate assigned to each period. Because of the battle flow, a single percentage was not applicable across all AOs within a time period; therefore, different casualty rates were developed for the various AOs.

(a) Engineer casualties in the Latin American scenario are highest when the LID engineers are entering a new AO. Once established, the attrition percentage level drops and remains at a fairly constant level. Casualties in AO Red are sustained as the engineers advance up Axis Sally as the opposing force retreats.

(b) As can be seen from Figure B-7, engineer casualty rates in the European scenario are highest in the armored brigade sector which bears the brunt of the enemy attack throughout most of the scenario. The 3d Brigade is protected by rugged terrain from any direct assaults and sustains a minimal number of casualties. Of the 178 engineer casualties in this scenario, the LID engineers sustain 30 casualties or 10.2 percent of its engineers; the engineer company of the armored brigade is assessed 49 casualties (23.2 percent of its strength) and the engineer corps battalion receives 99 casualties (14.7 percent of its engineers). The armored brigade sector accounts for over

55 percent of the scenario casualties. However, the LID engineers are not in this area and thus have a low attrition rate.

ENGINEER ATTRITION RATES BY TIME PERIOD

Scenario	Period	Timeframe From	Timeframe Through	Sector	Attrition Percentage
Latin America	2	D+3	D+4	AO Green	0.0
				AO Red	8.7
	3	D+5	D+8	AO Green	0.0
				AO Red	7.5
				AO Blue	9.5
	4	D+9	D+10	AO Green	0.0
				AO Red	3.9
				AO Blue	5.5
				AO Pink	4.0
Europe	3	H-Hour	H+23	CAB	0.0
				1st brigade	6.2
				2d brigade	7.8
				3d brigade	3.6
				194th brigade	8.9
				DRA	0.0
	4	H+24	H+47	1st brigade	4.0
				2d brigade	4.6
				3d brigade	5.1
				194th brigade	7.8
				DRA	0.0
	5	H+48	H+95	1st brigade	6.4
				2d brigade	7.1
				3d brigade	4.9
				194th brigade	8.6
				DRA	0.0

Figure B-7

(3) Figure B-8 presents a sample calculation of how casualty rates were computed using the same company shown in Figure B-2. The top portion of the figure shows the casualty rate with regard to numbers of men or end-strength for each period. The lower section shows available capability by

SAMPLE CASUALTY COMPUTATIONS -- EUROPEAN SCENARIO

Unit	Air/Sea Attrition Rate* (%)	In-Country Force	Period 3 D+11 Casualty Rate (%)	Period 3 D+11 End-Strength	Period 4 D+12 Casualty Rate (%)	Period 4 D+12 End-Strength	Period 5 D+13 and D+14 Casualty Rate (%)	Period 5 D+13 and D+14 End-Strength
UNIT STRENGTH								
LID engineers, C Company								
Company strength 64	5.0	61	3.6	59	5.1	56	4.9	53
Productive personnel 50	5.0	48	3.6	46	5.1	43	4.9	41

	Air/Sea Attrition Rate* (%)	Daily Productive Work Capability** (Manhours)	Period 3 D+11 Casualty Rate (%)	Period 3 D+11 Available Capability (Manhours)	Period 4 D+12 Casualty Rate (%)	Period 4 D+12 Available Capability (Manhours)	Period 5 D+13 and D+14 Casualty Rate (%)	Period 5 D+13 and D+14 Available Capability (Manhours)
PRODUCTIVE PERSONNEL CAPABILITY -- AVERAGE PER DAY								
Productive personnel 50	5.0	470.3	3.6	453.3	5.1	430.2	4.9	409.1

*Hypothetical number used to portray mathematical computations.

**Computed as 48 persons working 18 hours per day for one day with an effectiveness factor of 55 percent.

Figure B-8

manhours for each period after casualties are computed. It should be noted that the EFFORT model assesses all casualties at the start of each period, rather than at random or at the end of the period.

4. Engineer Capability.

a. Figures B-9 and B-10 display the results of EFFORT's calculations of the engineer capability of the LID and attached engineer units under both the Latin American and European scenarios. The results are shown by time period and brigade sector in manhours and equipment-hours.

b. The forward-deployed engineer corps battalion has four companies, each containing nine squads with an assigned 5-ton dump truck for a total of 36 squad dump trucks. These trucks have not been counted as productive pieces of equipment since the drivers were counted as productive personnel and part of the squad capability. The rationale is that the truck would transport the squad to a work site and all squad members would then work at the site. In the European scenario, an alternative option is presented where the squad truck would be performing project work and should be counted as equipment capability rather than squad capability.

ENGINEER CAPABILITY — LATIN AMERICAN SCENARIO

	Timeframe				Equipment-Hours				
Period	From	Through	Sector	Manhours	D-7/ ACE	Loader	Grader	5-Ton Truck	SEE/ JD410
1	D+1	D+2	AO Green	1,575	48	0	0	16	168
			AO Red	450	0	0	0	8	24
			TOTAL	2,025	48	0	0	24	172
2	D+3	D+4	AO Green	900	80	0	0	16	128
			AO Red	1,648	15	0	0	29	146
			TOTAL	2,548	95	0	0	45	274
3	D+5	D+8	AO Green	900	64	0	0	32	64
			AO Red	1,526	114	0	0	57	313
			AO Blue	2,306	0	0	0	0	133
			TOTAL	4,732	178	0	0	89	510
4	D+9	D+10	AO Green	0	0	0	0	0	0
			AO Red	732	78	0	0	39	78
			AO Blue	353	0	0	0	0	63
			AO Pink	1,094	0	0	0	0	81
			TOTAL	2,179	78	0	0	39	222
			SCENARIO TOTAL	11,484	399	0	0	197	1,198

Figure B-9

ENGINEER CAPABILITY -- EUROPEAN SCENARIO

	Timeframe				Equipment-Hours				
Period	From	Through	Sector	Manhours	D-7/ ACE	Loader	Grader	5-Ton Truck	SEE/ JD410
1	D-10	D+7	CAB	885	29	19	0	48	29
			1st Brigade	7,310	258	19	0	162	601
			2d Brigade	5,825	205	19	0	136	469
			3d Brigade	3,326	123	0	0	62	308
			194th Brigade	3,985	144	96	0	509	29
			DRA	162	19	19	38	29	26
			TOTAL	21,483	778	172	38	946	1,462
2	D+8	D+10	CAB	2,625	87	58	0	125	87
			1st Brigade	4,110	140	58	0	151	219
			2d Brigade	4,110	140	58	0	151	219
			3d Brigade	1,426	53	0	0	26	132
			194th Brigade	4,958	174	114	0	441	87
			DRA	486	57	58	115	77	79
			TOTAL	17,715	651	346	115	971	823
3	H-hour	H+23	CAB	0	0	0	0	0	0
			1st Brigade	1,285	44	18	0	35	68
			2d Brigade	1,263	43	18	0	35	68
			3d Brigade	458	17	0	0	8	42
			194th Brigade	2,302	78	51	0	131	52
			DRA	162	19	19	38	19	26
			TOTAL	5,470	201	106	38	228	256

Figure B-10 (Continued on Next Page)

ENGINEER CAPABILITY -- EUROPEAN SCENARIO (Continued)

	Timeframe				Equipment-Hours				
Period	From	Through	Sector	Manhours	D-7/ ACE	Loader	Grader	5-Ton Truck	SEE/ JD410
4	H+24	H+47	CAB	0	0	0	0	0	0
			1st Brigade	1,234	42	17	0	34	66
			2d Brigade	1,204	40	17	0	33	64
			3d Brigade	435	16	0	0	8	40
			194th Brigade	2,123	72	49	0	122	48
			DRA	162	19	19	38	19	26
			TOTAL	5,158	189	102	38	216	244
5	H+48	H+95	CAB	0	0	0	0	0	0
			1st Brigade	2,309	79	32	0	64	123
			2d Brigade	2,239	76	31	0	61	119
			3d Brigade	2,225	77	31	0	61	123
			194th Brigade	2,537	88	58	0	177	44
			DRA	324	38	38	77	38	53
			TOTAL	9,634	358	190	77	401	462
			CUMULATIVE TOTAL	59,460	2,177	916	306	2,762	3,247

Figure B-10

(1) Figure B-11 shows the capability in manhours and truck-hours when the squad trucks are counted as 50 percent available and 100 percent available for project work. As can be expected, the manhour capabilility decreases as truck capability increases.

SQUAD VEHICLE ANALYSIS -- EUROPEAN SCENARIO

	50% Trucks Available		100% Trucks Available	
Period	Manhours	Truck-Hours	Manhours	Truck-Hours
2	17,128	1,490	16,544	2,009
3	5,296	388	5,112	547
4	4,992	365	4,824	515
5	9,320	680	9,008	960
TOTAL	36,736	2,923	35,488	4,031

Figure B-11

(2) The capability listed in Figure B-11 when compared with that listed in Figure B-10 (excluding Period 1), results in a manhour decrease of approximately 3 and 7 percent when trucks are counted at 50 and 100 percent, respectively. The increase in truck capability, however, is more dramatic. At 50-percent squad truck availability, there is a 62-percent increase in capability; when all squad trucks are counted, capability increases by almost 225 percent.

(3) In this scenario, the number of engineer trucks are very limited. This accounts for the large increases. The combined number of trucks available, including the LID, the corps battalion, and 194th Engineer Battalion, totals 26 productive trucks. Thus, the addition of 36 squad trucks of the corps battalion to the equipment capability is quite significant.

5. Optional Engineer Units Considered. Although this analysis was primarily directed toward computing the capability of the LID engineers with an augmentation force of an engineer corps battalion, other engineer configurations were considered and their capability computed. These were: a corps battalion, a light equipment company, a combat support equipment (CSE) company, and an airborne battalion.

a. Equipment in engineer units that was larger in size or capability than that contained in standard engineer TOEs was translated to an equivalent size or rate in order to facilitate comparison. Figure B-12 shows each engineer unit used in the analysis that had oversize equipment. The unit is shown with its assigned TOE equipment and equivalent items.

EAD EQUIPMENT CONVERSION TABLE

TOE	Unit	TOE Equipment*	Equivalent Items
5-54L2	Light equipment company (airborne)	D-6 dozers (12)	D-7 dozers (9)
5-58H4	CSE company	20-ton dump trucks (21) 15-ton dump trucks (2) 5-CY scoop loaders (5) 4.5-CY scoop loader (1)	5-ton dump trucks (63) 5-ton dump trucks (5) 2.5-CY scoop loader (10) 2.5-CY scoop loader (2)
5-195L2	Combat battalion, (airborne)	D-6 dozers (5)	D-7 dozers (4)
5-127J4	Engineer company w/ribbon bridge	CEV (3)	D-7 dozer (1)

*Number in inventory.

Figure B-12

b. Figures B-13 and B-14 present the capability of these units by manhours and equipment-hours for each time period of the Latin American and

European scenarios. Capability was computed using the EFFORT model and was based on each unit's authorized strengths and equivalent equipment. The units were gamed as arriving and being effective on the first day of combat. All scenario factors for the base case were used for these units, with the exception of casualties, which where not assessed. Thus, units were assumed to maintain a constant capability after they arrived in-theater. For these units, the capability difference between the two scenarios is primarily a result of the decrease in the movement percentages -- Latin American movement is 20 percent and European movement is 15 percent.

OPTIONAL ENGINEER UNITS AND CAPABILITY -- LATIN AMERICAN SCENARIO
(Without Casualties)

Timeframe		Engineer		Man-	Equipment-Hours				
From	Through	Unit*	TOE	hours	ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD4100
D+3	D+4	Corps bn	5-35	6,772	247	175	70	247	212
		Lt equip co	5-54	0	158	106	158	317	0
		CSE co	5-58	0	141	176	158	1,214	53
		ABN bn	5-195	3,206	318	210	159	246	318
D+5	D+8	Corps bn	5-35	13,545	494	350	140	494	424
		Lt equip co	5-54	0	317	211	317	634	0
		CSE co	5-58	0	282	352	317	2,429	106
		ABN bn	5-195	6,416	633	423	318	492	633
D+9	D+10	Corps bn	5-35	6,772	247	175	70	247	212
		Lt equip co	5-54	0	158	106	158	317	0
		CSE co	5-58	0	141	176	158	1,214	53
		ABN bn	5-195	3,206	318	210	159	246	318

*bn = battalion; co = company; ABN = airborne.

Figure B-13

OPTIONAL ENGINEER UNITS AND CAPABILITY -- EUROPEAN SCENARIO
(Without Casualties)

Timeframe	Engineer Unit	TOE	Man-hours	Equipment Hours: ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD410
D+11	Corps bn	5-35	3,471	126	90	36	126	108
	Lt equip co	5-54	0	86	58	86	173	0
	CSE co	5-58	0	72	90	81	623	36
	ABN bn	5-195	1,731	173	115	86	135	173
D+12	Corps bn	5-35	3,471	126	90	36	126	108
	Lt equip co	5-54	0	86	58	86	173	0
	CSE co	5-58	0	72	90	81	623	36
	ABN bn	5-195	1,731	173	115	86	135	173
D+13 & 14	Corps bn	5-35	6,945	253	180	72	253	217
	Lt equip co	5-54	0	173	115	173	346	0
	CSE co	5-58	0	144	180	162	1,245	72
	ABN bn	5-195	3,463	346	230	173	269	346

Figure B-14

6. Observations. Because the two scenarios are so different with regard to type of conflict, time periods, forces used, duration, and casualty attrition, no direct comparison of engineer capability is possible. Some general observations can be made however.

a. The methodology used for estimating engineer capability under a combat scenario is relatively straightforward. Although ESC used the automated EFFORT model for its calculations, the same methodology can be done manually.

b. Engineer units operating under the European scenario have higher capabilities than those working under the Latin American scenario. The difference can be traced directly to the percentages assigned to movement degradation (20 percent for Latin America versus 15 percent for Europe).

(1) LID engineers have a productive personnel workday of 9.0 hours in the Latin American scenario while in Europe the productive personnel workday is almost 10 hours -- a 10-percent increase.

(2) Productive equipment workhours are also increased by 10 percent in the European scenario as a result of the lower movement percentage.

c. Because the movement and workday factors affect the available engineer capability, they should be carefully developed and take into account the geographic conditions of the area (scenario) under consideration.

LAST PAGE OF ANNEX B

ANNEX C

MOBILITY REQUIREMENTS

ANNEX C

MOBILITY REQUIREMENTS

1. Purpose. This annex identifies and quantifies all the engineer mobility requirements for supporting the LID forward of the brigade rear boundary. The mobility mission area involves the work needed to ensure the movement of forces across the battlefield in accordance with the tactical plan. Figure C-1 groups the major mobility tasks into increments.

MOBILITY PRIORITY INCREMENTS

Increment	Description
M-1	Breach minefields, fortified positions, and enemy strong-points; destroy enemy bunkers.
M-2	Maintain MSRs and combat trails; breach other obstacles to the manuever plan.
M-3	Construct combat trails; support river crossing operations; construct LAPES zones.
M-4	Clear antitank ditches and minefields; repair damage to roads and bridges; retrieve and replace tactical bridging with fixed bridging.

Figure C-1

2. Scope.

a. Requirements calculated in this annex will be limited to mobility tasks in the main battle area (MBA) during the offensive and defensive phases of the study scenarios. Similar requirements which fall behind the brigade rear boundary are classified as general engineering work (Annex F).

b. This annex does not address any haul requirements for Class V items or their implications on mobility tasks.

3. Engineer Mobility Tasks.

a. The threat posture varies significantly between the two scenarios used in this study. It is, therefore, necessary to separately discuss the effect of the enemy posture on the mobility workload for each scenario.

(1) In the Latin American scenario, the threat posture is initially offensive in periods 1 and 2 (D+1 through D+4). In period 3 (D+5 through D+8), the threat changes to a delay and then conducts a retrograde operation. Finally, at the end of period 4 (D+9 through D+10), the enemy transitions to a deliberate type of defense as the scenario ends. Thus,

countermobility work generated by the threat is primarily limited to minefields and obstacles in support of hasty-type strongpoints manned by the threat rear guard.

(2) In the European scenario, the Soviet threat remains in an offensive posture throughout the battle. Thus, even though US forces conduct attacks, they are not engaged against an enemy in a doctrinal hasty or deliberate defense. Soviet countermobility work is generally limited to minefields installed on the flanks of advancing elements by mobile obstacle detachments.

b. For this study, mobility tasks were arranged into four increments, M-1 through M-4. Increment M-1 contains those engineer mobility tasks which were rated most important by the SAG; Increment M-4 contains those tasks of least importance. Figure C-2 shows the mobility tasks and their associated increment group. The order of tasks within each increment group is of no significance.

4. Methodology. Figure C-3 shows how ESC determined engineer mobility requirements. For each scenario, ESC created a set of brigade sectors to support the tactical plan. The scenario chronology and the brigade sectors determined postures of the LID and the threat. Each brigade sector was then analyzed to determine which mobility tasks must be completed. The friendly posture, threat posture, and terrain analysis determined the number of reinforcing obstacles to be overcome. The existing obstacles were derived by examining the terrain. Once the total number of obstacles was established, the engineer requirements to support the tasks in each brigade were quantified. The aggregation of the requirements for all brigades yielded the total manhours and equipment-hours needed to complete each task in a given scenario and time period.

MOBILITY TASKS AND INCREMENT GROUPS

Tasks	Increment Groups M-1	M-2	M-3	M-4
1. Close combat support				
a. Breach fortified positions	X			
b. Destroy enemy bunkers	X			
c. Breach strongpoints	X			
2. Breach obstacles				
a. Breach minefields	X			
b. Breach other obstacles to the maneuver plan				
(1) Breach antitank ditches		X		
(2) Breach road blocks		X		
(3) Breach small gaps		X		
3. Support river crossing operations				
a. Assist the assault force			X	
b. Assist the support force (EAD)			X	
4. Existing roads and bridges				
a. Repair damage				X
b. Retrieve/replace tactical bridging				X
c. Maintain MSRs and combat trails		X		
5. Construct combat trails			X	
6. Clear obstacles (nuisance and safety impact)				
a. Clear minefields				X
b. Clear tank ditches				X
7. Construct LAPES zones			X	

Figure C-2

5. <u>Analysis of Engineer Mobility Tasks</u>. This paragraph describes in detail the analysis of each mobility task by scenario, time period, and brigade sector.

a. Provide close combat support (Increment M-1). Within the context of light infantry operations, close combat was provided by breaching fortified positions, destroying enemy bunkers, and breaching threat strongpoints.

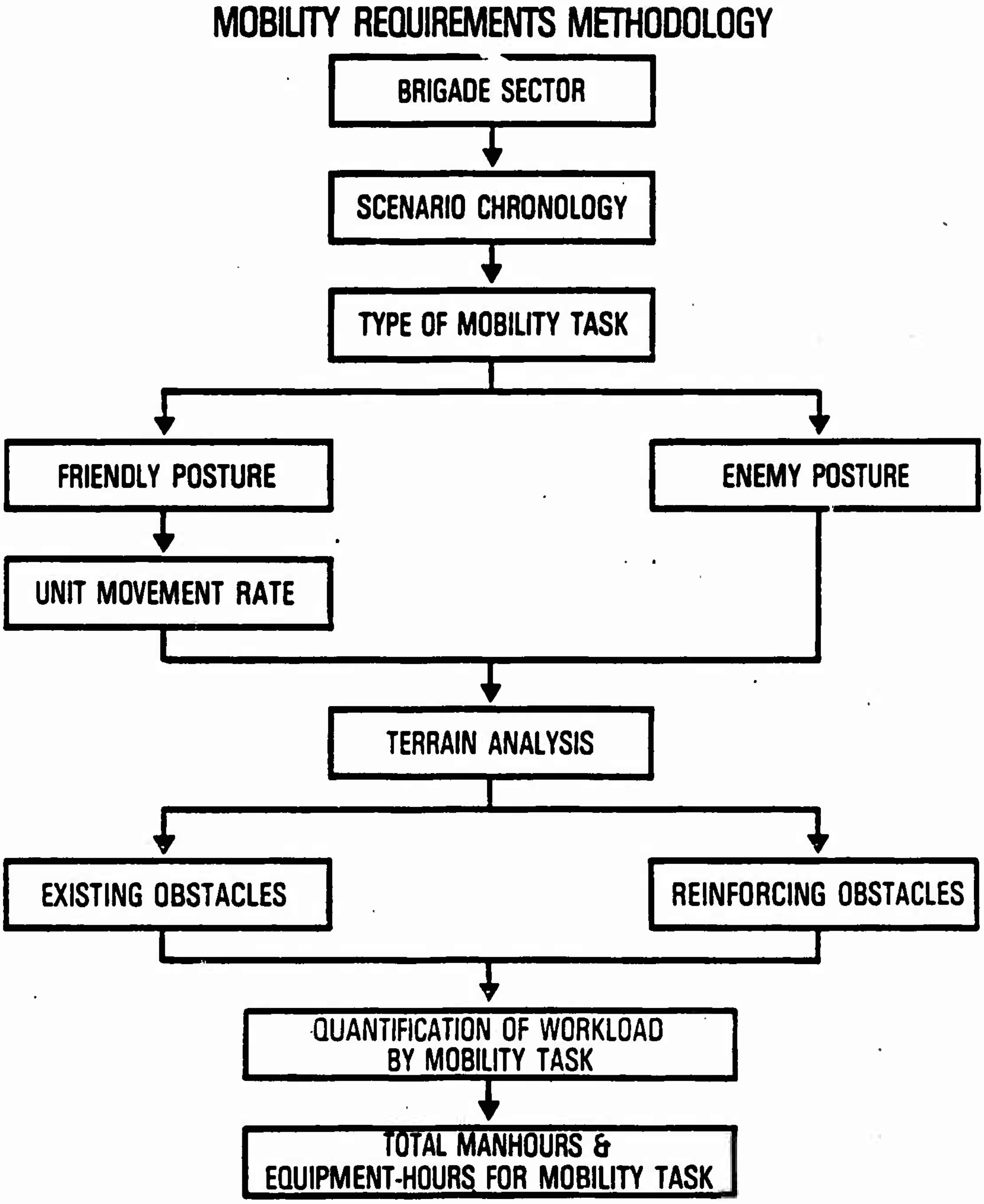
MOBILITY REQUIREMENTS METHODOLOGY
BRIGADE SECTOR
SCENARIO CHRONOLOGY
TYPE OF MOBILITY TASK
FRIENDLY POSTURE
ENEMY POSTURE
UNIT MOVEMENT RATE
TERRAIN ANALYSIS
EXISTING OBSTACLES
REINFORCING OBSTACLES
QUANTIFICATION OF WORKLOAD BY MOBILITY TASK
TOTAL MANHOURS & EQUIPMENT-HOURS FOR MOBILITY TASK

Figure C-3

(1) In the Latin American scenario, close combat support was required only by the 2d Brigade. The threat rear guard facing the 2d Brigade was equivalent to a reinforced motorized rifle battalion. ESC postulated that the rear guard would carry out its mission by occupying a number of company-sized strongpoints along a series of phase lines as the threat main force withdrew. To overcome each such strongpoint, ESC estimated that the supporting LID engineers would be required to breach two dug-in crew-served weapon positions and three protective minefields. Destroying one such company strongpoint required 40 manhours of engineer support. Figure C-4 shows the number of strongpoint breaches.

TOTAL NUMBER OF STRONGPOINT BREACHES

From	Through	2d Brigade*
Latin American Scenario		
D+1	D+2	--
D+3	D+4	--
D+5	D+8	12
D+9	D+10	6
European Scenario		
None		

*Division's main avenue of advance

Figure C-4

(2) In the European scenario, the combination of friendly and enemy postures was such that there was no requirement for close combat support.

b. Breach minefields (Increment M-1).

(1) In the Latin American scenario, again only the 2d Brigade found it necessary to conduct minefield breaching operations. Both friendly

and enemy-emplaced minefields were subject to breaching. ESC estimated that 50 percent of the friendly minefields emplaced during the defensive phase would be neutralized by combat action, and that 50 percent of the remaining friendly minefields would require breaching. During its attack, the 2d Brigade also encountered minefields emplaced by enemy forces. (These minefields are in addition to the protective threat minefields breached by engineers providing close combat support). ESC estimated that one-half of these additional enemy-emplaced minefields would require breaching, and that each footpath-wide breach would require 12 manhours of engineer effort. Figure C-5 shows the number of minefield breaches required by both scenarios.

TOTAL NUMBER OF MINEFIELD BREACHES

		Brigade				
From	Through	1	2	3	Avn	AR*
		Latin American Scenario				
D+1	D+2	--	--	--	--	--
D+3	D+4	--	--	--	--	--
D+5	D+8	--	30	--	--	--
D+9	D+10	--	16	--	--	--
		European Scenario				
D-10	D+7	--	--	--	--	--
D+8	D+10	--	--	--	--	--
H-hour	H+23	--	--	--	--	--
H+24	H+47	2	1	--	--	24
H+48	H+95	--	--	--	--	--

*Attached to the division during the European scenario.

Figure C-5

(2) The primarily defensive posture of the LID in the European scenario generated only a small requirement for minefield breaching. The 1st

and 2d Brigades had a small requirement to breach some of their minefields, in order to allow for the passage of counterattacking friendly forces; this requirement was minimized by intentionally providing lanes when the minefields were initially emplaced. ESC estimated that only 2 percent of each brigade's minefields were breached in this manner. During the armored brigade's counterattack, engineers were required to breach numerous minefields. ESC estimated that each attacking company would encounter two minefields per phase line. Each company requires one vehicle lane per minefield. The counterattack was conducted by two battalions, each with three companies abreast, and crossed two phase lines. Each vehicle lane requires 94 manhours of engineer effort.

c. Breach antitank ditches (Increment M-2).

(1) In the Latin American scenario, there was no requirement for the LID to breach antitank ditches, either friendly or enemy. Due to a combination of the threat, time available, and the remoteness of the battle area from the lodgement area, no antitank ditches were emplaced by the LID. During the attack phases, the threat did not employ antitank ditches because of their marginal effectiveness against the dismounted combat elements of the LID.

(2) The European scenario had no requirement for antitank ditch breaching by the LID for three reasons: First, the terrain occupied by the LID was poorly suited to tanks, thus few antitank ditches were constructed. Second, the LID remained in an essentially defensive posture, so there was no requirement to move forward across the few previously emplaced ditches. Third, the threat forces never assumed a defensive posture in which it would be doctrinally correct for them to emplace antitank ditches. The armored brigade attached to the LID did have a requirement for antitank ditch

breaching during its counterattack. In all cases, these were friendly ditches emplaced during previous periods. For the armored brigade, ESC estimated that the leading battalions would encounter one antitank ditch per phase line, and that the leading companies in each battalion would each require one breached lane. Figure C-6 shows the number of antitank ditch breaches. Each breach requires 90 manhours and 0.5 ACE-hour of engineer effort.

TOTAL NUMBER OF ANTITANK DITCH BREACHES

From	Through	Armored Brigade*
Latin American Scenario		
None		
European Scenario		
D-10	D+7	--
D+8	D+10	--
H-hour	H+23	--
H+24	H+47	12
H+48	H+95	--

*Attached to the division during the European scenario.

Figure C-6

d. Breach roadblocks (Increment M-2).

(1) Road craters were the only type of roadblock encountered by the LID in the Latin American scenario. They were emplaced by both friendly and enemy forces. Road craters themselves are not a significant obstacle to the combat elements of the LID. They do present some difficulties to wheeled direct- and indirect-fire weapons, and are a major obstacle to the LID's wheeled support vehicles. For this reason, all road craters along the MSRs and feeder roads must be breached. Each breach requires 45.6 manhours and 0.25 ACE-hour of effort.

(2) In the European scenario, the 2d Brigade and the attached armored brigade were confronted with roadblocks which required breaching. The 2d Brigade was required to reopen a number of rubble blast emplacements (RBEs) to allow friendly forces to pass through their strongpoint. ESC estimated that one-half the number of RBEs initially emplaced had to be reopened. Each RBE breach consumed 45.6 manhours, 5.3 ACE-hours, and 5.3 loader-hours of engineer effort. During its counterattack, the armored brigade encountered many road craters which had to be breached. The threat was not expected to emplace any new road craters due to its offensive posture, but was expected to reinforce any existing obstacles. ESC estimated that by period 4, one-half the road craters in the armored brigade's sector would have been neutralized by combat action. During the counterattack, ESC estimated that the armored brigade would have to breach 50 percent of the remaining road craters. Each road crater breach requires 45.6 manhours and 0.25 ACE-hour of engineer effort. Figure C-7 shows the total number of roadblocks to be breached.

TOTAL NUMBER OF ROADBLOCK BREACHES

			Brigade				
From	Through	Type	1	2	3	Avn	AR*
		Latin American Scenario					
D+1	D+2		--	--	--	--	--
D+3	D+4		--	--	--	--	--
D+5	D+8	Road crater	--	9	--	--	--
D+9	D+10	Road crater	--	1	--	--	--
		European Scenario					
D-10	D+7		--	--	--	--	--
D+8	D+10	--	--	--	--	--	--
H-hour	H+23	Road crater	--	--	--	--	22
		RBE	--	9	--	--	--
H+48	H+95		--	--	--	--	--

*Attached to the division during the European scenario.

Figure C-7

e. Breach small gaps (Increment M-2). A thorough analysis of the terrain and scenario chronology failed to develop a predictable and quantifiable workload for this mobility task.

f. Maintain MSRs and combat trails (Increment M-2).

(1) In the Latin American scenario, the requirement for MSR maintenance was minimal. MSR maintenance was performed only in the 2d Brigade sector and included the initial effort to sweep the MSR for mines. This was necessary since the MSR was in an area previously controlled by enemy conventional forces, or was subject to intervention by guerrilla forces. The MSR was swept only once after it was secured from enemy control. Maintenance was performed only on that portion of the MSR contained within the brigade sector. The length of the 2d Brigade's MSR shows a large decrease beginning on D+9, when responsibility for much of the MSR is assumed by the division rear. Each kilometer of MSR requires 9.6 manhours and 0.8 truck-hour to sweep; and 0.8 manhour, 0.25 SEE-hour, and 0.5 truck-hour to maintain. Figure C-8 shows the MSR maintenance requirements for both scenarios.

(2) In the European scenario, ESC developed a representative MSR net for each brigade sector. The net is based on actual road distances from the BSA to each battalion train's area, and a number of lateral connector roads. The maintenance factor for Europe is different from Latin American, based on the higher percentage of surfaced roads. Each kilometer of MSR in Europe requires 1.0 manhour, 0.25 grader-hour, and 0.38 truck-hour of engineer effort per day to maintain.

g. Support river crossing operations (Increment M-3).

(1) During the attack phases of the Latin American scenario, the 2d Brigade encountered numerous rivers and streams which had to be crossed.

Through a terrain analysis, ESC identified 12 sites where river crossing support was necessary. In 11 of these cases, support was limited to improving fording sites. Each site was estimated to require 6.5 manhours, 3.5 ACE-hours, and 3.0 SEE-hours. In the one instance where bridging support was required, all work was assumed to be performed by EAD engineer elements.

AVERAGE DAILY MSR MAINTENANCE REQUIREMENTS
(Kilometers)

			Brigade				
From	Through	Task	1	2	3	Avn	AR*
		Latin American Scenario					
D+1	D+2	Clearance	--	15	--	--	--
D+3	D+4	Maintenance	--	30	--	--	--
D+5	D+8	Clearance	--	8	--	--	--
		Maintenance	--	49	--	--	--
D+9	D+10	Clearance	--	10	--	--	--
		Maintenance	--	20	--	--	--
		European Scenario					
D-10	D+7	Maintenance	--	--	--	--	--
D+8	D+10	Maintenance	64	50	53	42	93
H-hour	H+23	Maintenance	64	50	53	42	105
H+24	H+47	Maintenance	64	58	53	42	93
H+48	H+95	Maintenance	85	95	97	21	132

*Attached to division during the European Scenario.

Figure C-8

(2) The European scenario generated a minimal amount of river crossing support requirements. Terrain analysis revealed no need for bridging support and only a few instances where ford improvements were necessary. Figure C-9 shows the number of ford improvements made during both scenarios.

h. Construct combat trails (Increment M-3). Combat trails are constructed to supplement the existing road net. They facilitate the forward, rearward, and lateral movement of the force. Combat trails are frequently associated with activities such as occupying a battle position. They are intended for use by tracked and very high mobility wheeled vehicles. The life span of a combat trail is short, usually measured in hours to at most several days. The fact that combat elements of the LID have few vehicles reduces the division's need for combat trails.

TOTAL NUMBER OF FORD IMPROVEMENTS

		Brigade				
From	Through	1	2	3	Avn	AR*
		Latin American Scenario				
D+1	D+2	--	--	--	--	--
D+3	D+4	--	--	--	--	--
D+5	D+8	--	4	--	--	--
D+9	D+10	--	7	--	--	--
		European Scenario				
D-10	D+7	--	--	--	--	--
D+8	D+10	--	--	--	--	--
H-hour	H+23	--	--	--	--	--
H+24	H+47	--	--	--	--	--
H+48	H+95	--	3	--	--	3

*Attached to the division during the European scenario.

Figure C-9

(1) In the Latin American scenario, ESC estimated that each brigade, infantry battalion, and artillery battalion headquarters would require 100 meters of combat trail to be constructed with every move. Each 100 meters of combat trail required 11.4 manhours and 1.25 ACE-hours of effort. In the TFOBs of the 1st and 3rd Brigades, 2.0 SEE-hours were substituted for the ACE-hours, since the ACE could not be airlifted to these TFOBs.

(2) Europe has a much denser and more highly developed road net, which reduced still further the need for combat trails. In the European

scenario, combat trails were constructed only in support of brigade and infantry or tank battalion headquarters. It was estimated that neither the LID nor the EAD artillery units would need combat trails, given Europe's highly developed road net. Figure C-10 shows, by scenario, the length of combat trails constructed.

TOTAL CONSTRUCTED LENGTH OF COMBAT TRAILS
(100-m segments)

		Brigade				
From	Through	1	2	3	Avn	AR*
		Latin American Scenario				
D+1	D+2	--	2	--	--	--
D+3	D+4	--	--	--	--	--
D+5	D+8	--	6	5	--	--
D+9	D+10	4	4	--	--	--
		European Scenario				
D-10	D+7	--	--	--	--	--
D+8	D+10	4	4	4	2	4
H-hour	H+23	4	8	4	2	8
H+24	H+47	4	4	4	2	4
H+48	H+95	--	--	--	--	--

*Attached to the division during the European scenario.

Figure C-10

i. Construct LAPES zones (Increment M-3). ESC closely examined the need to construct LAPES zones against the available, readily usable sites and determined that both scenarios had only a small requirement to construct LAPES zones. In the Latin American scenario, the 2d Brigade's entire requirement for LAPES zones can be met by using existing airstrips, open areas, and road segments. The 1st and 3d Brigades each have a one-time need for a LAPES zone to be constructed in the BSA of the their respective TFOBs. In Europe, the entire requirement for LAPES zones can be satisfied by using existing airstrips, road segment, and open areas. ESC estimated that each C-130-capable LAPES zone in Latin America would consume about 3.8 SEE-hours of effort. Figure C-11 summarizes LAPES zone construction requirements.

TOTAL NUMBER OF CONSTRUCTED LAPES ZONES

		Brigade				
From	Through	1	2	3	Avn	AR*
		Latin American Scenario				
D+1	D+2	--	--	--	--	--
D+3	D+4	--	--	--	--	--
D+5	D+8	--	--	1	--	--
D+9	D+10	1	--	--	--	--
		European Scenario				
		None				

*Attached to the division during the European scenario.

Figure C-11

j. Clear minefields (Increment M-4).

(1) In the Latin American scenario, each minefield encountered had to be cleared regardless of whether its origin was friendly or enemy. This was to facilitate the movement of friendly forces and to ensure the safety of friendly forces and the civilian population. Minefield clearance took place in those periods and sectors where friendly forces were in an attack posture and after the minefields were definitely under US control. Thus, those minefields cleared in the Latin American scenario fell entirely within the 2d Brigade's sector. The number of minefield clearances was equal to the number of minefield breaches, and each clearance required 252 manhours of engineer work.

(2) In the European scenario, the requirement to clear minefields <u>per se</u> did not exist. There was, however, a need for engineer effort beyond breaching, but short of clearance. During the counterattacks in period 4, engineers were required to locate and mark the boundaries of all friendly and enemy minefields that were breached. This minefield marking was estimated to use 16 manhours per 100 meters of minefield frontage. Figure C-12 shows, by scenario, the number of minefield clearances.

TOTAL NUMBER OF MINEFIELD CLEARANCES
(100-m segments)

From	Through	Brigade 1	Brigade 2	Brigade 3	CAB	AR*
		Latin American Scenario				
D+1	D+2	--	--	--	--	--
D+3	D+4	--	--	--	--	--
D+5	D+8	--	30	--	--	--
D+9	D+10	--	16	--	--	--
		European Scenario				
D-10	D+7	--	--	--	--	--
D+8	D+10	--	--	--	--	--
H-hour	H+23	--	--	--	--	--
H+24	H+47	2	1	--	--	24
H+48	H+95	--	--	--	--	--

*Attached to the division during the European scenario.

Figure C-12

k. Clear antitank ditches (Increment M-4). Since antitank ditches were not employed by either force in the Latin American scenario, there was no requirement to clear them. ESC determined that there was also no requirement to clear antitank ditches in the European scenario. Even though a limited number of antitank ditches were breached during the period 4 counterattacks, they were on ground regained and were required for the defense. Therefore, they did not have to be cleared.

l. Repair damage to roads and bridges (Increment M-4). During combat operations, MSR roads and bridges receive damage from several sources, including combat actions, friendly and enemy countermobilty operations, and guerrilla forces. This damage must be repaired because the MSRs must be kept in operation.

(1) Damage to roads in the Latin American scenario came from three primary sources: air and artillery fires, friendly and enemy countermobility operations, and guerrilla forces. All such damage occurred in the 2d Brigade's sector. ESC estimated the damage due to air and artillery fires was equal to an additional maintenance requirement of 0.5 percent of the brigades MSR. A major portion of damage repair was devoted to clearing any previously breached road craters and any road craters emplaced by guerrilla forces. ESC estimated that guerrilla forces could emplace a maximum of two road craters per day in the brigade sector. Finally, since bridges are likely to sustain some damage, bridge damage was estimated at one span of 20 meters destroyed each day in each brigade sector.

(2) The combat environment in the European scenario is much more intense than in Latin America; therefore, greater levels of bridge and road damage are expected. ESC estimated that air and artillery fires would damage 2.0 percent the MSR road net daily. ESC feels that there is no substantial guerrilla threat in the European scenario. Since any ground gained during the counterattacks was held for a limited period of time, no road craters were cleared or repaired. Bridge damage from all sources was estimated at 12 meters of bridge per brigade sector each day. All bridge repairs were made using Bailey Bridge.

(3) In Latin America, each kilometer of MSR damage required 1.0 manhour, 0.25 SEE-hour, and 0.5 truck-hour to repair. All road craters needed 45.6 manhours, 3.6 ACE-hours, 2.4 SEE-hours, and 2.4 truck-hours to clear and repair. In Europe, each kilometer of MSR repair required 3.0 ACE-hours. Because of the chronology, friendly posture, and road conditions of the European scenario, it was determined that an acceptable level of MSR repair could be acheived by using the ACE only. In both scenarios, bridges were repaired at the rate of 5 manhours per meter of bridge damage. Figure C-13 shows MSR road and bridge damage by scenario.

MSR ROAD AND BRIDGE REPAIR REQUIREMENTS

From	Through	Type Repair	Brigade 1	Brigade 2	Brigade 3	Brigade Avn	Brigade AR*
			Latin American Scenario				
D+1	D+2		--	--	--	--	--
D+3	D+4	Road	--	2	--	--	--
		Crater	--	4	--	--	--
		Bridge	--	2	--	--	--
D+5	D+8	Road	--	2	--	--	--
		Crater	--	17	--	--	--
		Bridge	--	4	--	--	--
D+9	D+10	Road	--	2	--	--	--
		Crater	--	5	--	--	--
		Bridge	--	2	--	--	--
			European Scenario				
D-10	D+7		--	--	--	--	--
D+8	D+10	Road	1.3	1.2	1.1	0.8	1.9
		Bridge	1.5	1.5	1.5	1.5	1.5
H-hour	H+23	Road	1.3	1.0	1.1	0.8	2.1
		Bridge	0.5	0.5	0.5	0.5	0.5
H+24	H+47	Road	1.3	1.2	1.1	0.8	1.9
		Bridge	0.5	0.5	0.5	0.5	0.5
H+47	H+95	Road	1.7	1.9	1.9	0.4	2.6
		Bridge	0.5	0.5	0.5	0.5	0.5

*Attached to the division during the European scenario.

Figure C-13

m. Retrieve and replace tactical bridging (Increment M-4). ESC could quantify no work for the LID engineers within this mobility task. Since the LID contains no organic tactical bridging, it is unlikely that LID engineers would be utilized for this task. Tactical bridging beyond bridge repair tasks was of only minor importance in both scenarios. ESC believes this task is more appropriate for EAD engineers.

6. Results. Figures C-14 through C-17 present the total time-phased mobility support requirements of the LID for the two scenarios studied. The results are shown by mobility Increments M-1 through M-4 and are stratified by brigade in terms of manhour and equipment-hours.

7. Observations.

a. The total mobility workload in both scenarios of this study was smaller than might have ordinarily been expected. It is, however, still representative of the mobility requirements for the LID in the general environment of the study scenarios. Some of the causes of this reduced mobility workload are scenario-related, some are due to the operational concept and tactics of the LID.

(1) In the Latin American scenario, only activity in the 2d Brigade's sector generated any significant level of mobility work. This is reasonable, since the 2d Brigade is conducting conventional operations against the enemy rear guard. The 1st and 3d Brigades are operating somewhat unconventionally from semiclandestine TFOBs, not in prepared defensive positions against an enemy which is in disarray. The 1st and 3d Brigades are concentrating their operations on ambushes and targets of opportunity. These types of operations have little requirement for mobility support. Thus, only the activity of one brigade (the 2d Brigade) effectively contributes to the mobility workload.

ENGINEER MOBILITY REQUIREMENTS -- INCREMENT M-1

From	Through	Effort (Hours)	Brigade 1	2	3	Avn	AR*
			Latin American Scenario				
D+1	D+2	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--
D+3	D+4	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--
D+5	D+8	Man	--	507	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--
D+9	D+10	Man	--	264	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--
			European Scenario				
D-10	D+7	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--
D+8	D+10	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--
H-hour	H+23	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--
H+24	H+47	Man	30	15	--	--	2,256
		ACE	--	48	--	--	--
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--
		Loader	--	98	--	--	--
H+48	H+95	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--

*Attached to the division during the European scenario.

Figure C-14

ENGINEER MOBILITY REQUIREMENTS — INCREMENT M-2

From	Through	Effort (Hours)	Brigade 1	2	3	Avn	AR*
		Latin American Scenario					
D+1	D+2	Man	--	300	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	24	--	--	--
		SEE	--	--	--	--	--
D+3	D+4	Man	--	60	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	30	--	--	--
		SEE	--	15	--	--	--
D+5	D+8	Man	--	926	--	--	--
		ACE	--	2	--	--	--
		5-ton truck	--	124	--	--	--
		SEE	--	49	--	--	--
D+9	D+10	Man	--	286	--	--	--
		ACE	--	1	--	--	--
		5-ton truck	--	36	--	--	--
		SEE	--	10	--	--	--
		European Scenario					
D-10	D+7	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--
D+8	D+10	Man	192	174	159	126	279
		ACE	--	--	--	--	--
		5-ton truck	72	65	60	47	105
		Grader	48	44	40	32	70
H-hour	H+23	Man	64	50	53	42	105
		ACE	--	--	--	--	--
		5-ton truck	24	19	20	16	39
		Grader	16	13	13	11	26
H+24	H+47	Man	64	58	53	42	2,176
		ACE	--	--	--	--	25
		5-ton truck	24	22	20	16	35
		Grader	16	15	13	11	23
H+48	H+95	Man	170	190	194	42	264
		ACE	--	--	--	--	--
		5-ton truck	64	71	73	16	99
		Grader	43	48	49	11	66

*Attached to the division during the European scenario.

Figure C-15

ENGINEER MOBILITY REQUIREMENTS — INCREMENT M-3

From	Through	Effort (Hours)	Brigade 1	Brigade 2	Brigade 3	Avn	AR*
		Latin American Scenario					
D+1	D+2	Man	--	22	--	--	--
		ACE	--	2	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--
D+3	D+4	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--
D+5	D+8	Man	--	71	57	--	--
		ACE	--	19	--	--	--
		5-ton truck	--	36	--	--	--
		SEE	--	12	10	--	--
D+9	D+10	Man	46	98	--	--	--
		ACE	--	33	--	--	--
		5-ton truck	--	72	--	--	--
		SEE	9	24	--	--	--
		European Scenario					
D-10	D+7	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--
D+8	D+10	Man	46	46	46	23	46
		ACE	5	5	5	3	5
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--
H-hour	H+23	Man	46	91	46	23	91
		ACE	5	10	5	3	10
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--
H+24	H+47	Man	46	65	46	23	65
		ACE	5	16	5	3	16
		5-ton truck	--	27	--	--	27
		Grader	--	--	--	--	--
		Loader	--	9	--	--	9
H+48	H+95	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--

*Attached to the division during the European scenario.

Figure C-16

ENGINEER MOBILITY REQUIREMENTS -- INCREMENT M-4

From	Through	Effort (Hours)	Brigade 1	Brigade 2	Brigade 3	Brigade Avn	Brigade AR*
		Latin American Scenario					
D+1	D+2	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--
D+3	D+4	Man	--	184	--	--	--
		ACE	--	14	--	--	--
		5-ton truck	--	11	--	--	--
		SEE	--	10	--	--	--
D+5	D+8	Man	--	8339	--	--	--
		ACE	--	137	--	--	--
		5-ton truck	--	43	--	--	--
		SEE	--	42	--	--	--
D+9	D+10	Man	--	4262	--	--	--
		ACE	--	72	--	--	--
		5-ton truck	--	13	--	--	--
		SEE	--	12	--	--	--
		European Scenario					
D-10	D+7	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--
D+8	D+10	Man	--	--	--	--	--
		ACE	115	104	95	76	167
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--
H-hour	H+23	Man	30	30	30	--	30
		ACE	38	30	32	25	63
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--
H+24	H+47	Man	62	46	30	--	414
		ACE	38	35	32	25	52
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--
H+48	H+95	Man	102	114	116	25	158
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		Grader	--	--	--	--	--

*Attached to the division during the European scenario.

Figure C-17

(2) In Europe, three factors combine to keep the LID's mobility requirements lower than expected: the defensive posture of the LID, the small size of the divisional AO, and the slow rate at which the LID moves. From a mobility standpoint, an attack posture is the most demanding situation due to the extensive requirement for obstacle breaching and the large length of new MSR which is uncovered and must be opened to traffic. Thus, with the exception of the attached armored brigade, the defensive posture of the LID serves to reduce mobility requirements. The LID's AO in the European scenario is quite small, leading to reduced maintenance and repair requirements for MSRs and combat trails. This also reduces the overall mobility requirements. During the European scenario, the LID tended to remain in one AO or to move in small increments. It should be noted that the attached armored brigade, which operates in a larger AO, moves over greater distances in equal periods of time, and conducts an extensive counterattack in period 4, has greater mobility support requirements than the remainder of the division. The armored brigade accounts for 65 percent of the division's mobility support requirements.

b. Both of the scenarios indicate a change in the nature of the type of mobility task performed under the category of river crossing support. Rivers and streams of fordable depth are not major obstacles to the combat elements of the LID. The major support task in this category was the improvement of fords for the crossing of wheeled direct- and indirect-fire weapons and logistical vehicles. Fords were also constructed as a means of bypassing some damaged bridges. Since the LID has no organic tactical bridging, all nonfordable rivers will require EAD engineer support. ESC believes that it is most appropriate to delay all but the most urgent bridge repairs and the retrieval and replacement of tactical bridging by fixed bridging to EAD engineers. Due to equipment and training, the EAD force is better suited to these tasks.

c. Minefield breaching and clearing are the source of a major portion of the mobility manhour support requirements. This includes the minefields associated with road craters, bridge demolitions, and other targets.

(1) In the area of minefield breaching, the LID enjoys an advantage over heavier mechanized forces. The majority of the LID's breaching requirements are for footpaths only; thus, there is a reduced requirement for time-consuming vehicle lane breaching. The primary means of breaching footpaths is still the bangalore torpedo. Because of its size, weight, and bulk, the cumbersome bangalore torpedo will be unsuitable for LID engineers in many situations.

(2) The armored brigade is the unit which generates a significant breaching requirement in the European scenario. The brigade could save manhours by using the MICLIC. By substituting MICLIC for the 24 minefield breaches in Figure C-5, the brigade could save 2,232 manhours (279 squad-hours). There is, however, an additional resource requirement for vehicles to transport this heavy munition. The advantages and disadvantages of MICLIC when used by mechanized forces are well documented.[1,2] ESC believes MICLIC is not well suited to the needs and tactical requirements of the LID.

(3) Minefield clearing, when required, consumes huge quantities of manhours and can easily become an overwhelming task. In the Latin American scenario, it is by far the dominant mobility task, though it is placed in one of the lower priority increments. Except for extreme emergencies, ESC feels that this task is best deferred or accomplished by EAD engineers.

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[1] Engineer Analysis of the 9th Infantry Division (Motorized), Volumes I and II (US Army Engineer Studies Center [ESC], December 1985).

[2] III Corps Engineer Assessment (ESC, March 1981).

LAST PAGE OF ANNEX C

ANNEX D

COUNTERMOBILITY REQUIREMENTS

ANNEX D

COUNTERMOBILITY REQUIREMENTS

1. Purpose. This annex describes the methodology ESC used to estimate LID countermobility requirements under two scenario variations. It also identifies countermobility tasks and increments and summarizes the resulting countermobility requirements.

2. Scope. The scenarios considered in this analysis varied widely in the countermobility demands placed on the divisional engineer battalion. The Latin American scenario is a low- to mid-intensity conflict with a one-third/two-thirds split between defensive and offensive operations, respectively. In the European scenario, the LID was involved in a high-intensity, predominantly defensive operation. Therefore, throughout this annex it will be necessary to separately address the application of ESC's countermobility methodology to each scenario. The primary focus of ESC's methodology is to determine the effect of the obstacles listed in Figure D-1 on the LID's countermobility mission. This annex will not discuss the divisional engineer battalion's capability to haul countermobility materials (mines, demolitions, and barrier materials); that issue is addressed by Annex G.

3. Assumptions and Their Significance. A number of assumptions were required before developing personnel and equipment work factors for the LID's countermobility mission. These assumptions were arrived at by reviewing current doctrine, and by consulting representatives of the 7th ID(L) and the

staff and instructors at the US Training and Doctrine Command's (TRADOC) Field Artillery School, US Army Engineer School, and Fort Rucker Aviation Center.

COUNTERMOBILITY INCREMENTS

Increment	Description
C-1	Execute raids to deny road junctions and key installations.
C-2	Install point targets, minefields, tank ditches, and wire obstacles on the main avenue of approach.
C-3	Install point targets, minefields, tank ditches, and wire obstacles on secondary avenues of approach.
C-4	Complete the obstacle plan in depth.

Figure D-1

a. ASSUMPTION: Engineers will transport obstacle material from the brigade support area (BSA) to the work site. SIGNIFICANCE: Squad and transportation resources as well as travel time to and from the BSA were incorporated into the overall study methodology. Failure of the division transportation and logistical systems to deliver engineer material to the BSA will greatly reduce the number of squad-hours that can be directly expended on engineer support tasks, and will place more demands on engineer transportation assets.

b. ASSUMPTION: Countermobility requirements calculated in this annex are limited to countermobility tasks located forward of the brigade rear boundary or within a brigade's assigned AO. SIGNIFICANCE: Similiar tasks occurring outside these areas are considered general engineering tasks, and are discussed in Annex F.

c. ASSUMPTION: Conventional mines and mining techniques are used as the base case for all countermobility tasks involving mine warfare. SIGNIFICANCE: Dynamic mining is unavailable to the LID in the Latin American scenario, and is of limited availability in the European scenario. Scatterable mine systems will be evaluated in both scenarios as an excursion. Their use could substantially reduce requirements for engineer resources and place a smaller burden on the logistics system.

d. ASSUMPTION: All linear and point obstacles are supplemented with minefields wherever appropriate. SIGNIFICANCE: The total engineer requirement would be less than predicted by this analysis if this supplemental mining were not employed.

4. Definitions.

a. Obstacle density. A factor expressed as the number of obstacle targets per square kilometer in the defensive sector. It is based on terrain features that affect the cross country mobility (CCM) of enemy formations. Terrain with high CCM values usually requires greater obstacle densities than terrain with low values of CCM.

b. Obstacle mix. Obstacle mix is the mix of point targets (road craters, abatis, bridge demolitions, etc.) and linear targets (minefields, tank ditches, etc.) (see Figure D-2). Like obstacle density, it is based on terrain features that affect the CCM of enemy formations. High CCMs generally favor a more even ratio of linear-to-point targets than do low values of CCM.

c. Obstacle target priority. The priority of obstacle targets is estimated by considering the risk expected on the avenues of approach into the defensive sector and the distance of the target from the FEBA.

OBSTACLE MIX FOR THE EUROPEAN SCENARIO
(Percentage)

Posture	Linear Targets	Point Targets
Counterattack	100	—
Delay	25	75
Defend		
CCM >30	50	50
CCM <30*	35	65

*Applicable to LID AOs only.

Figure D-2

d. Minefield modules. These modules are planning factors used for conventional and scatterable minefields. Conventional minefields are quantified in terms of mines per meter of front. Scatterable minefields, on the other hand, are measured by the number of mines per square meter of area. For planning purposes, it is assumed that each scatterable mine system will emplace a standard-size module. This module is characterized by a specific density and a particular set of dimensions. The module can be adjusted by varying its size and delivery system. For example, the density of a minefield may be increased by decelerating the prime mover to slower than normal speed, thus increasing the number of mines in a specific area. Each minefield can be assigned an appropriate measure of effort, reflecting the manhours and equipment-hours required to emplace and mark the minefield module. (Marking is not possible in enemy-held territory, especially for artillery- or air-delivered mine systems). Figure D-3 lists the minefield modules used in this analysis and their associated characteristics.

e. Point targets. Point targets are classified based on their ease of bypass. Those that are impossible or difficult to bypass are excellent candidates for effective point targets. Engineer effort was not generally expended on targets where bypass was easy.

MINEFIELD MODULES

Type	Size (Meters)	Number of of Mines*	Density**
Conventional	100 x 100	122 AT 25 AP	1 AT 0.2 AP
ICOM	100 x 100	50 AT 25 AP	0.5 AT 0.2 AP
RAAM	400 x 400	405 AT (45 rounds)	0.0025
ADAM	400 x 400	160 AP (5 rounds)	0.001
Air Volcano	800 x 150	670 AT 134 AP	0.006
Ground Volcano	1,000 x 120	800 AT 160 AP	0.007
Conventional Point	30 x 70	30 AT 3 AP	NA
MOPMS	semicircle (radius = 35)	17 AT 4 AP	0.035
ICOM point	30 x 70	17 AT 4 AP	NA

*AT = antitank; AP = anitpersonnel.
**Conventional minefields measured in mines per meter of minefield frontage. Scatterable minefields measured as mines per square meter.

Figure D-3

5. Increment Groups. Since this annex quantifies those LID countermobility requirements which must ultimately be measured against limited engineer resources, ESC developed a system of increments for engineer tasks within all of the engineer functional areas. These increments were used by the SAG to rank all engineer tasks throughout the battlefield. For this study, countermobility tasks were arranged into four increments, C-1 through C-4. Increment

C-1 contains those engineer countermobility tasks which were rated most important by the SAG; Increment C-4 contains those tasks of least importance. Figure D-4 shows the countermobility tasks and the associated increment group. The order of tasks within each increment group is of no signficance. In the Latin American scenario, the allocation of a target to an increment group was based on site-specific conditions. In the European scenario, ESC apportioned the targets among the increment groups as shown in Figure D-4, task 5.

COUNTERMOBILITY TASKS AND PRIORITY INCREMENTS

Task	Increment Group C-1	C-2	C-3	C-4
1. Countermobility raid				
a. Deny road or road junction	X			
b. Deny key installation	X			
2. Install obstacles on main avenue of approach				
a. Point targets*		X		
b. Minefields		X		
c. Tank ditches		X		
d. Wire		X		
3. Install obstacles on secondary avenues of approach				
a. Point targets*		X		
b. Minefields		X		
c. Tank ditches		X		
d. Wire		X		
4. Complete the obstacle plan in depth				
a. Point targets*				X
b. Minefields				X
c. Tank ditches				X
d. Wire				X
5. European scenario increment allocation	(0%**)	40%	30%	30%

*Includes obstacles made with local or expedient materials.
**Site-specific.

Figure D-4

6. Methodology.

a. General. ESC quantified the LID's engineer requirements in terms of manhours and critical equipment-hours by scenario, increment, time period and brigade. Figure D-5 diagrams ESC's methodology for engineer countermobility requirements in both the Latin American and European scenarios.

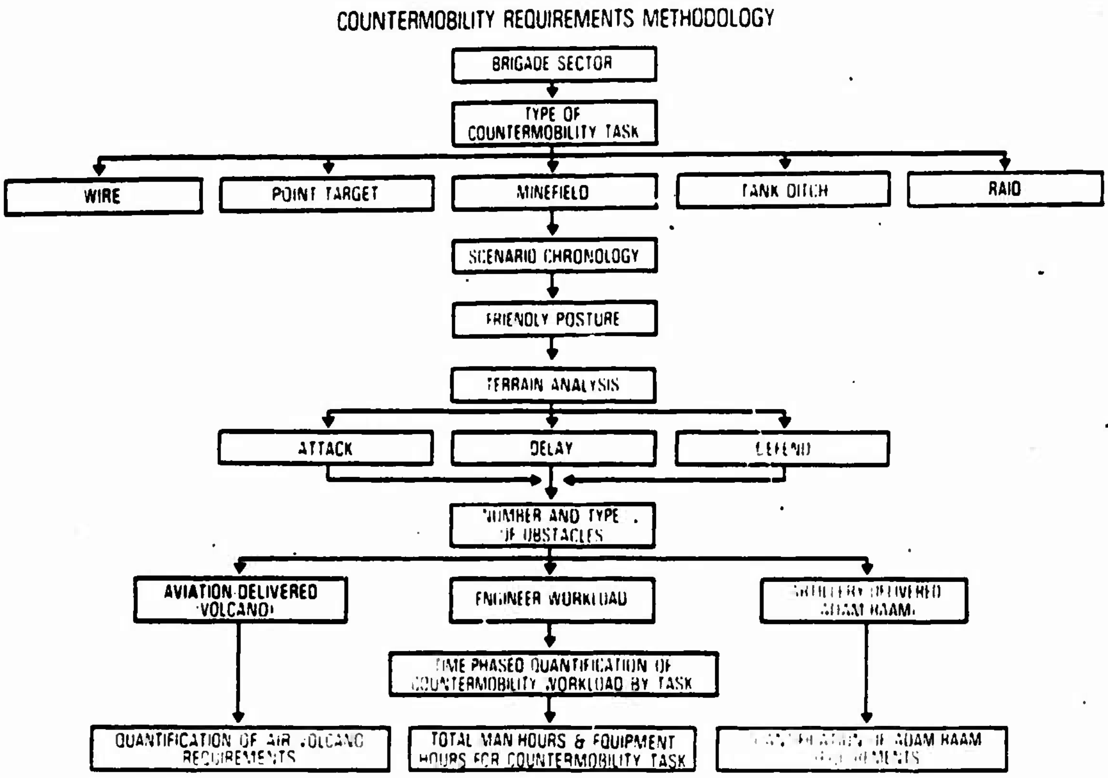

Figure D-5

(1) The scenario chronology generated the friendly postures, shown in Figure D-6, against which the nature of the battlefield terrain and its effect on the CCM of each of the division's brigades and the threat were analyzed. The CCM percentages (i.e., the percentage of the battlefield on which the enemy force can move relatively freely) are listed in Figure D-7 for the European scenario. Since obstacle planning for the Latin American

scenario was done on a site-specific basis, CCM percentages were not used to generate of obstacle requirements and are therefore not listed here.

FRIENDLY UNIT POSTURES

From	Through	Brigade 1	2	3	Avn	AR*
		Latin American Scenario				
D+1	D+2	—	—	—	--	NA
D+3	D+4	—	Defend	—	Delay	NA
D+5	D+8	—	Attack	Attack	—	NA
D+9	D+10	Attack	Attack	Attack	--	NA
		European Scenario				
D-10	D+7	—	—	—	--	--
D+8	D+10**	Defend	Defend	Defend	Defend	Defend
H-hour	H+23	Defend	Defend	Defend	Defend	Defend
H+24	H+47	Defend	Attack	Defend	Defend	Attack
H+48	H+95	Delay	Delay	Delay	Delay	Delay

*Attached to division during European scenario.
**Obstacle preparations before contact.

Figure D-6

(2) Target density factors were developed for a particular range of CCM percentages based on historical obstacle data and recent trends in European general defense plans (GDPs). The obstacle density factor for the LID in the European scenario was doubled based on the recent experience of the 13th Engineer Battalion in a light environment, and the belief that countermobility operations will be how the LID will mitigate any mobility advantages of the threat. Figure D-8 lists the target density factors for the European scenario.

CCM IN THE EUROPEAN SCENARIO

Unit	Area (km^2)	CCM (Percentage)
Combat Aviation Brigade (CAB)	49	43
1st Brigade	106	24
2d Brigade	69	10
3d Brigade	78	--
Subtotal	302	17*
AR Brigade	148	53
Maneuver Subtotal	450	29*
DRA	410	36
TOTAL	860	33*

*These averages not used in methodology.

Figure D-7

OBSTACLE DENSITY FACTORS

CCM Factor	Obstacles per km^2 LID	Obstacles per km^2 AR Brigade*
0.00 - 0.29	1.33	0.67
0.30 - 0.44	2.00	1.00
0.45 - 0.54	2.67	1.33
0.55 - 0.69	3.33	1.67
0.70 - 0.77	4.00	2.00
0.78 - 0.82	4.67	2.33
0.83 - 0.88	5.33	2.67
0.89 - 0.93	6.00	3.00
0.94 - 1.00	6.67	3.33

*Derived from analysis of the World War II European Campaign and current NATO GDPs.

Figure D-8

(3) The actual number and mix of targets for the Latin American scenario was generated by creating an actual site-specific, time-phased obstacle plan for each brigade AO. This is shown in Figure D-9.

LATIN AMERICAN SCENARIO OBSTACLE WORKLOAD

From	Through	Obstacle Type*	Brigade 1	Brigade 2	Brigade 3	Brigade Avn	AR
D+1	D+2	Minefields	—	—	—	—	NA
		Road craters					
		<25 ft	—	—	—	—	NA
		>25 ft	—	—	—	3	NA
		Bridges	—	—	—	3	NA
D+3	D+4	Minefields	—	54	—	9	NA
		Road craters					
		<25 ft	—	2	—	—	NA
		>25 ft	—	4	—	3	NA
		Bridges	—	6	—	6	NA
D+5	D+8	Minefields	—	—	20	—	NA
		Road craters					
		<25 ft	—	—	4	—	NA
		>25 ft	—	—	6	—	NA
		Bridges	—	—	2	3	NA
D+9	D+10	Minefields	52	—	8	—	NA
		Road craters					
		<25 ft	5	—	6	—	NA
		>25 ft	1	—	2	—	NA
		Bridges	5	—	1	—	NA

*Minefields are conventional 100-m modules. Road craters are shown for travelled-way width of greater than and less than 25 ft.

Figure D-9

(4) Manhours and equipment-hours were calculated for all engineer-emplaced obstacles. Wherever an air- or artillery-delivered minefield was emplaced, the requirement was documented but no engineer effort was calculated. Figure D-10 shows the engineer effort required to emplace the various types of linear and point targets considered by this analysis. Figure D-11 shows the number of antitank (AT) and antipersonnel (AP) mines required for each target.

(5) Figure D-12 lists the target mix, as a percentage, by posture and type for the European scenario. Due to the extremely poor CCM of the infantry brigade AOs, it was necessary to alter the historical point-to-linear

target mix. ESC believes that the low values of CCM in these areas will cause the target mix ratio to distinctly favor point targets. This is reflected in Figure D-12, which shows a greater proportion of point targets for the infantry brigades than for the CAB and armored brigade which operate in more open terrain.

COUNTERMOBILITY PLANNING FACTORS

Obstacle/System*	Manhours	Equipment-Hours 5-Ton Truck	Equipment-Hours ACE	Equipment-Hours SEE
Conventional minefield				
Density 1.0 - 1.0	48.1	2.3	—	—
Density 1.0 - 0.2	35.9	2.3	—	—
Ground volcano minefield	4.5	1.4	—	—
Tank Ditch (100 m)	7.0	0.34	2.8	—
Rubble Blast Emplacement (100 ft)	63.0	5.7	—	—
Road Crater				
<25 ft wide	12.9	0.25	—	—
>25 ft wide	25.8	0.25	—	—
Bridges (non-prechambered)	57.8	0.5	—	—
Abatis (75 m)	23.6	1.0	—	0.4
Guiding battalion through lines	8.0	—	—	—

*Planning factors are estimates based on information contained in Engineer Field Data, FM 5-34 (DA HQ, 24 September 1976); Countermobility, FM 5-102 (DA HQ, March 1985); Combat Developments Engineer Family of Systems Study (E-FOSS) (US Army Engineer School [USAES], February 1979); and TSM — Mine Warfare Systems' Handbook of Employment Concepts for Mine Warfare Systems (US Army Engineer Center and School, November 1985).

Figure D-10

MINEFIELD DENSITIES

Type Obstacle	Minefield Density (mines) AT	AP	Measurement Base
Conventional minefield			
Closed terrain	1.0	1.0	Per meter of front
Open terrain	1.0	0.2	Per meter of front
Antitank ditch	23.8	5.6	Per 100 m of ditch
Rubble blast			
Emplacement (100 ft)	30	3	Per emplacement
Road Craters			
<25 ft wide	30	3	Per crater
>25 ft wide	60	6	Per crater
Bridge demolition	60	6	Per bridge
Abatis (75 m)	30	3	Per abatis

Figure D-11

EUROPEAN SCENARIO TARGET COMPOSITION
(Percentages)

	Friendly Posture				
			Defense		
Obstacle System*	Counter-attack	Delay	Infantry Brigade	CAB	AR Brigade
Conventional minefield	--	--	33	48	30
ADAM/RAAM	100	25	--	--	--
Antitank ditch	--	*	2	2	20
Road crater	--	70	50	40	45
Bridge Demolition	--	5	5	5	5
Abatis	--	--	10	5	--
TOTALS	100	100	100	100	100

*Sidehill cuts on railroads are executed in the attached AR brigade zone where the terrain permits (1.5 to 12% of base total).

Figure D-12

(6) In the Latin American scenario, the engineer countermobility effort was arrived at by mutiplying the time-phased distribution of targets (Figure D-9) by the appropriate planning factor (Figure D-10) and summing the results for each type of target within each AO and time period. The algorithm in Figure D-13 was used to calculate the engineer countermobility effort in the European scenario.

COUNTERMOBILITY REQUIREMENTS ALGORITHM

Engineer Requirements (hours by type obstacle) =

Area of Brigade AO (km^2) (Figure D-7)		Target Density (obstacle per km^2) (Figure D-8)		Target Mix (% of type Obstacle) (Figure D-12)		Resource Requirements (manhours and equipment-hours by obstacle type) (Figure D-10)
	x		x		x	

Figure D-13

b. Attack.

(1) Additional countermobility work is performed during the attack phases of the Latin American scenario. The engineers supporting brigades in the isolated TFOBs protect their operating bases and support the offensive operations, especially raids and ambushes. This support is primarily in the form of bridge demolitions, road craters, and small minefields.

(2) Some engineer countermobility effort was expended to support various categories of counterattack in the European scenario, but that support was limited based on the dynamic situation inherent in counterattacks and ESC's interpretation of the doctrine given in FM 5-102, Countermobility.

(a) ADAM/RAAM requirements were tracked for each maneuver battalion attack. Three RAAM artillery modules and one volley of ADAM were used per battalion counterattack to disrupt movement and prevent the commitment of threat second-echelon forces.

(b) During the division counterattack in period 4, rubble blast emplacements (RBEs) were emplaced as part of Increment C-1; (this was the only time RBEs were used during this scenario). The number of RBEs required were calculated based on closing all routes leading in from the perimeter of the city located in front of the 2d Brigade.

(c) To accommodate the forward (attack) passage of lines in period 4, 10 percent of the obstacles in the 1st and 2d Brigade areas were opened and used as gaps and lanes; the engineer effort required to open those obstacles was calculated under mobility tasks (Annex C). When these same obstacles were closed during the latter part of period 4, the engineer effort to close them was calculated as a requirement under countermobility Increments C-2 through C-4.

c. Defend.

(1) Within the defensive phase of the Latin American scenario, the countermobility workload was generated on a site-specific basis. This was done by combining knowledge of the threat's doctrine regarding the width of various unit-sized avenues of approach with information on the terrain in the AO. An unconstrained obstacle plan was developed for all avenues of approach into the LID's defensive sector. Obstacles were selected based on terrain, weapons characteristics, and LID tactics.

(2) For the European scenario, the algorithm in Figure D-13 was used to generate the countermobility workload. Since the brigade rear boundaries were shallow (8 to 20 kilometers deep), each brigade AO constituted the initial defensive belt. Within these defensive belts, obstacles were executed

along likely enemy avenues of approach. To accommodate the rearward (withdrawal) passage of lines in period 3, 10 percent of the obstacles in period 2 were left open as gaps and lanes. These were then closed during the latter part of period 3 under countermobility task Increments C-2 through C-4.

d. Delay. In the Latin American scenario, targets for the single brigade delay phase were the same as those for the attack phase. For the European scenario, the algorithm shown in Figure D-13 was again used to generate the countermobility workload. The major difference between ESC's defend and delay methodologies for the European scenario was in the target mix (see Figure D-12). This mix emphasizes stopping the enemy in the armored brigade zone, which contains the high-speed avenue of approach into the divisional AO. The delay zone was estimated to be equivalent to the initial DRA (see Figure D-7). Additional sidehill cuts were executed as antitank obstacles on existing railroads in the attached armored brigade zone. These sidehill cuts were calculated based on planning factors for an antitank ditch and were 1.5 to 12 percent of the base total.

7. Base Case Results. The total timed-phased requirements for engineer manhours and equipment-hours needed to perform the LID's countermobility mission are shown in Figures D-14 through D-17. This information is displayed by scenario, increment group, time period, and brigade. The number of minefield modules, road craters, bridge demolitions, abatis, and meters of tank ditches required by scenario, time period, and brigade area are listed in Figures D-18 through D-20.

COUNTERMOBILITY REQUIREMENTS -- INCREMENT C-1

From	Through	Effort (Hours)	Brigade 1	Brigade 2	Brigade 3	Avn	AR*
		Latin American Scenario					
D+1	D+2	Man	--	--	--	250	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	--	--	--	NA
		SEE	--	--	--	--	NA
D+3	D+4	Man	--	--	--	574	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	--	--	--	NA
		SEE	--	--	--	--	NA
D+5	D+8	Man	--	--	--	174	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	--	--	--	NA
		SEE	--	--	--	--	NA
D+9	D+10	Man	--	--	--	--	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	--	--	--	NA
		SEE	--	--	--	--	NA
		European Scenario					
D-10	D+7	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--
D+8	D+10	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--
H-hour	H+23	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--
H+24	H+47	Man	--	1,134	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	103	--	--	--
		SEE	--	--	--	--	--
H+48	H+95	Man	--	--	--	--	216
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--

*Attached to the division during the European scenario.

Figure D-14

COUNTERMOBILITY REQUIREMENTS -- INCREMENT C-2

From	Through	Effort (Hours)	Brigade 1	2	3	Avn	AR*
		Latin American Scenario					
D+1	D+2	Man	--	--	--	--	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	--	--	--	NA
		SEE	--	--	--	--	NA
D+3	D+4	Man	--	720	--	--	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	35	--	--	NA
		SEE	--	--	--	--	NA
D+5	D+8	Man	--	--	567	--	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	--	--	--	NA
		SEE	--	--	--	--	NA
D+9	D+10	Man	878	--	--	--	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	--	--	--	NA
		SEE	--	--	--	--	NA
		European Scenario					
D-10	D+7	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--
D+8	D+10	Man	1,955	1,272	1,438	1,449	2,167
		ACE	3	2	2	2	40
		5-ton truck	52	34	38	45	63
		SEE	2	1	1	1	--
H-hour	H+23	Man	217	141	160	161	241
		ACE	1	1	1	1	4
		5-ton truck	6	4	4	5	7
		SEE	1	1	1	1	--
H+24	H+47	Man	46	603	--	--	683
		ACE	1	1	--	--	13
		5-ton truck	1	16	--	--	20
		SEE	1	1	--	--	--
H+48	H+95	Man	2,206	2,228	2,215	--	1,149
		ACE	--	--	3	--	14
		5-ton truck	16	16	17	--	10
		SEE	--	--	--	--	--

*Attached to the division during the European scenario.

Figure D-15

COUNTERMOBILITY REQUIREMENTS -- INCREMENT C-3

From	Through	Effort (Hours)	Brigade 1	2	3	Avn	AR*
		Latin American Scenario					
D+1	D+2	Man	--	--	--	--	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	--	--	--	NA
		SEE	--	--	--	--	NA
D+3	D+4	Man	--	846	--	--	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	43	--	--	NA
		SEE	--	--	--	--	NA
D+5	D+8	Man	--	--	322	--	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	--	--	--	NA
		SEE	--	--	--	--	NA
D+9	D+10	Man	1,311	--	231	--	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	--	--	--	NA
		SEE	--	--	--	--	NA
		European Scenario					
D-10	D+7	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--
D+8	D+10	Man	1,466	954	1,078	1,087	1,625
		ACE	2	1	2	1	30
		5-ton truck	39	25	28	34	48
		SEE	2	1	1	1	--
H-hour	H+23	Man	163	106	120	121	181
		ACE	1	1	1	1	3
		5-ton truck	4	3	3	4	5
		SEE	1	1	1	1	--
H+24	H+47	Man	34	453	--	--	512
		ACE	1	1	--	--	9
		5-ton truck	1	12	--	--	15
		SEE	1	1	--	--	--
H+48	H+95	Man	1,655	1,671	1,661	--	861
		ACE	--	--	3	--	10
		5-ton truck	12	12	13	--	7
		SEE	--	--	--	--	--

*Attached to the division during the European scenario.

Figure D-16

COUNTERMOBILITY REQUIREMENTS -- INCREMENT C-4

			Brigade				
From	Through	Effort (Hours)	1	2	3	Avn	AR*
		Latin American Scenario					
D+1	D+2	Man	--	--	--	--	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	--	--	--	NA
		SEE	--	--	--	--	NA
D+3	D+4	Man	--	850	--	--	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	50	--	--	NA
		SEE	--	--	--	--	NA
D+5	D+8	Man	--	--	151	--	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	--	--	--	NA
		SEE	--	--	--	--	NA
D+9	D+10	Man	58	--	203	--	NA
		ACE	--	--	--	--	NA
		5-ton truck	--	--	--	--	NA
		SEE	--	--	--	--	NA
		European Scenario					
D-10	D+7	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		5-ton truck	--	--	--	--	--
		SEE	--	--	--	--	--
D+8	D+10	Man	1,446	954	1,079	1,087	1,625
		ACE	2	1	2	1	30
		5-ton truck	39	25	28	34	48
		SEE	2	1	1	1	--
H-hour	H+23	Man	163	106	120	121	181
		ACE	1	1	1	1	3
		5-ton truck	4	3	3	4	5
		SEE	1	1	1	1	--
H+24	H+47	Man	34	452	--	--	513
		ACE	1	1	--	--	9
		5-ton truck	1	12	--	--	15
		SEE	1	1	--	--	--
H+48	H+95	Man	1,655	1,671	1,661	--	861
		ACE	--	--	3	--	10
		5-ton truck	12	12	13	--	7
		SEE	--	--	--	--	--

*Attached to the division during the European scenario.

Figure D-17

NUMBER OF MINEFIELD MODULES -- ALL INCREMENTS

			Brigade				
From	Through	Type	1	2	3	Avn	AR*
			Latin American Scenario				
D+1	D+2	Conventional	--	--	--	--	NA
D+3	D+4	Conventional	--	--	--	9	NA
D+5	D+8	Conventional	--	--	20	--	NA
D+9	D+10	Conventional	52	--	8	--	NA
			European Scenario				
D-10	D+7	None	--	--	--	--	--
D+8	D+10	Conventional	42	27	31	42	53
H-hour	H+23	Conventional	5	3	3	5	6
H+24	H+47	Conventional	1	13	--	--	17
H+48	H+95	Conventional	--	--	--	--	--

*Attached to the division during the European scenario.

Figure D-18

NUMBER OF POINT TARGETS -- ALL INCREMENTS

			Brigade				
From	Through	Type	1	2	3	Avn	AR*
		Latin American Scenario					
D+1	D+2	Road crater	--	--	--	3	NA
		Bridge	--	--	--	3	NA
D+3	D+4	Road crater	--	6	--	3	NA
		Bridge	--	6	--	3	NA
D+5	D+8	Road crater	--	--	10	--	NA
		Bridge	--	--	2	3	NA
D+9	D+10	Road crater	6	--	8	--	NA
			5	--	1	--	NA
		European Scenario					
D-10	D+7	None	--	--	--	--	--
D+8	D+10	Road crater	63	41	47	35	80
		Bridge	6	4	5	4	9
		Abatis	13	8	9	4	--
H-hour	H+23	Road crater	7	5	5	4	9
		Bridge	1	1	1	1	1
		Abatis	1	1	1	1	--
H+24	4+47	Road crater	1	20	--	--	25
		Bridge	--	2	--	--	3
		Abatis	--	4	--	--	--
		RBE	--	18	--	--	--
H+48	H+95	Road crater	143	144	143	--	72
		Bridge	10	10	10	--	5
		Abatis	--	--	--	--	--

*Attached to the division during the European scenario.

Figure D-19

NUMBER OF TANK DITCH TARGETS -- ALL INCREMENTS
(100 m per target)

From	Through	Type	Brigade 1	2	3	Avn	AR*
		Latin American Scenario					
		NONE					
		European Scenario					
D-10	D+7	None	--	--	--	--	--
D+8	D+10	Antitank ditch	3	2	2	2	35
H-hour	H+23	Antitank ditch	1	1	1	1	4
H+24	H+47	Antitank ditch	--	1	--	--	11
H+48	H+95	Antitank ditch	--	--	3	--	13

*Attached to the division during the European scenario.

Figure D-20

8. Scatterable Mine Excursion. As part of the countermobility analysis, ESC conducted an excursion to determine what effect the employment of scatterable and improved conventional mines (ICOM) would have on the total engineer workload for countermobility. Under this excursion ESC established a base case for mining in each scenario, then developed a new explosive excursion by substituting a scatterable mine system or an improved conventional mine into the base case wherever possible. The engineer effort required to support both cases was then compared. The excursion deals only with the engineer effort associated with scatterable and improved conventional mines; the logistical aspects of these mines are discussed in Annex G.

a. Base case.

(1) Planning factors. ESC used the minefield planning factors in Figure D-21 to estimate the engineer effort required under the mine

excursion's base case. The factors shown are the requirements to emplace one of the appropriate modules described in Figure D-3. These times do not include any marking requirements, as they are a constant.

MINEFIELD MODULE PLANNING FACTORS -- BASE CASE

Type Minefield	Effort (Hours) Man	Effort (Hours) 5-Ton Truck	Elasped Time (Hours)
Conventional linear	39.7	0.2	1.4
Conventional point	8.8	0.2	1.4

Figure D-21

(2) Minefield modules. The base case for each scenario was established by determining the number of minefield modules required. Figure D-22 shows this information for both scenarios. The point minefields are generally those emplaced to reinforce obstacles such as road craters, bridge demolitions, and abatis. The base case for the Latin American scenario consisted entirely of hand-emplaced conventional mines. The European scenario's base case also included the use of the artillery-delivered RAAM and ADAM mines. Since artillery-delivered mines require no engineer effort, the RAAM and ADAM requirements have not been listed here. A partial estimate of their logistics requirements is included in Annnex G.

(3) Effort. The numbers of minefield modules in Figure D-22 were multiplied by the appropriate planning factors from Figure D-21 to determine the engineer effort required by the base case. The result is shown in Figure D-23.

MINEFIELD MODULE REQUIREMENTS -- BASE CASE

Type Module	Brigade 1	2	3	Avn	AR*
	Latin American Scenario				
Conventional linear	52	54	28	9	NA
Conventional point	22	22	32	24	NA
	European Scenario				
Conventional linear	48	43	34	47	76
Conventional point	482	366	341	77	378

*Attached to the division during the European scenario.

Figure D-22

ENGINEER EFFORT REQUIRED FOR MINING -- BASE CASE

Type Minefield	Effort (Hours)	Brigade 1	2	3	Avn	AR*
		Latin American Scenario				
Conventional linear	Man	1,747	1,814	941	302	NA
	5-ton truck	—	108	—	—	NA
Conventional point	Man	194	194	282	211	NA
	5-ton truck	—	4	—	—	NA
Total	Man	1,941	2,008	1,223	513	NA
	5-ton truck	—	112	—	—	NA
		European Scenario				
Conventional linear	Man	1,906	1,707	1,350	1,866	3,017
	5-ton truck	96	86	68	94	152
Conventional point	Man	4,242	3,221	3,001	678	3,226
	5-ton truck	96	73	68	15	76
Total	Man	6,148	4,928	4,351	2,544	6,243
	5-ton truck	192	159	136	109	228

*Attached to the division during the European scenario.

Figure D-23

b. New explosive excursion. The new explosive excursion for the Latin American and European scenarios examines the use of artillery-delivered RAAM and ADAM mines, the Air and Ground Volcano systems, and a generic improved conventional mine.[1]

(1) Planning factors. The planning factors for the new explosive excursion are shown Figure D-24. They are based on the modules shown in Figure D-3 and contain no allowance for marking.

MINEFIELD MODULE PLANNING FACTORS -- NEW EXPLOSIVE EXCURSION

Type Minefield	Effort (Hours) Man	Effort (Hours) 5-Ton Truck	Elasped Time (Hours)
Linear			
ICOM	8.0	0.1	0.4
Ground Volcano	1.6	0.4	0.4
Air Volcano	—	—	varies
RAAM-ADAM	—	—	0.2
Point			
MOPMS	0.8	0.1	0.5
ICOM	2.8	0.2	1.1

Figure D-24

(2) Minefield modules. Wherever possible, scatterable mines (RAAM-ADAM or the Volcano systems) were substituted for the conventional mines of the base case. In many instances it was still necessary to install hand emplaced minefields. This was due to requirements for underwater mining at ford sites, security at clandestine TFOBs, and for use with point minefields. In such situations, ICOMs were substituted for the conventional mines.

[1]There is very little difference in the effort required to install the improved conventional mines examined in this study. More information on improved conventional mines is contained in Annex G.

(a) In the Latin American scenario, the mine systems were selected based on the specific conditions surrounding each obstacle. Ground Volcano and RAAM-ADAM were used extensively by the 2d Brigade during the defensive period. Air Volcano was used to support offensive operations by the 1st and 3d Brigades. Hand-emplaced minefields were used to protect the TFOBs of the 1st and 3d Brigades. Overall, minefield emplacement was about 60 percent Air Volcano, 20 percent Ground Volcano, and 20 percent hand-emplaced mines.

(b) In the European scenario, ESC conducted a terrain survey which indicated that the Ground Volcano system could meet 60 percent of the linear minefield requirements. Because of the substantial air threat, internal competition for helicopter assets, and terrain characteristics, it was estimated that the Air Volcano could provide 15 percent of the mining requirement. The remaining 25 percent was satisfied by hand-emplaced minefields. Figure D-25 shows minefield module requirements for the new explosive excursion.

(3) Effort. Figure D-26 shows the engineer effort required by the new explosive excursion. No values have been shown for RAAM-ADAM or Air Volcano since these systems place no demands on engineer resources. The new explosive excursion examined two means of installing point minefields -- using the MOPMS or using ICOMs. The results are shown in Figure D-26 as variations of the new explosive excursion.

c. Results. Figure D-27 shows the results of the scatterable mine excursion for the Latin American and European scenarios. Figure D-28 shows the same information as a percentage of the total countermobility effort. There are significant manhour savings in both scenarios. The extensive use of

Air Volcano results in the very high percentage savings shown in Figure D-28 for the Latin American scenario. This is because the Air Volcano system makes no demands on engineer resources. The MOPMS variation results in slightly higher manhour and truck-hour savings than does the ICOM variation.

MINEFIELD MODULE REQUIREMENTS -- NEW EXPLOSIVE EXCURSION

Type Module	Brigade 1	2	3	Avn	AR*
Latin American Scenario					
Linear					
ICOM	18	—	11	--	NA
Air Volcano	4.2	1.5	2.0	1.1	NA
Ground Volcano	—	3.0	—	—	NA
Point					
MOPMS or ICOM	22	22	32	24	NA
European Scenario					
Linear					
ICOM	12	11	9	12	19.0
Air Volcano	0.9	0.8	0.6	0.9	1.4
Ground Volcano	2.9	2.6	2.0	2.8	4.6
Point					
MOPMS or ICOM	482	366	341	77	378

*Attached to the division during the European scenario.

Figure D-25

ENGINEER EFFORT REQUIRED FOR MINING — NEW EXPLOSIVE EXCURSION

Type Minefield	Effort (Hours)	Brigade 1	2	3	Avn	AR*
Latin American Scenario						
Linear						
ICOM	Man	144	--	88	--	NA
	5-ton truck	--	--	--	--	NA
Ground Volcano	Man	--	5	--	--	NA
	5-ton truck	--	1	--	--	NA
Point						
MOPMS variation	Man	18	18	26	19	NA
	5-ton truck	--	2	--	--	NA
ICOM variation	Man	62	62	90	67	NA
	5-ton truck	--	4	--	--	NA
Total						
MOPMS variation	Man	162	23	114	19	NA
	5-ton truck	--	3	--	--	NA
ICOM variation	Man	206	67	178	67	NA
	5-ton truck	--	5	--	--	NA
European Scenario						
Linear						
ICOM	Man	96	88	72	96	152
	5-ton truck	1	1	1	1	2
Ground Volcano	Man	6	4	3	4	7
	5-ton truck	1	1	1	1	1
Point						
MOPMS variation	Man	386	293	273	62	302
	5-ton truck	48	37	34	8	38
ICOM variation	Man	1,350	1,025	955	216	1,058
	5-ton truck	96	73	68	15	77
Total						
MOPMS variation	Man	488	385	348	162	461
	5-ton truck	50	39	36	10	42
ICOM variation	Man	1,452	1,117	1,030	316	1,217
	5-ton truck	98	75	70	17	81

*Attached to the division during the European scenario.

Figure D-26

SAVINGS IN ENGINEER EFFORT DUE TO THE EMPLOYMENT OF SCATTERABLE MINES

Type Minefield	Effort (Hours)	Brigade 1	2	3	Avn	AR*
		Scenario				
MOPMS variation	Man	1,779	1,985	1,109	494	NA
	5-ton truck	—	109	—	—	NA
ICOM variation	Man	1,735	1,941	1,045	446	NA
	5-ton truck	—	107	—	—	NA
		European Scenario				
MOPMS variation	Man	5,660	4,543	4,003	2,382	5,782
	5-ton truck	142	120	100	99	186
ICOM variation	Man	4,696	3,811	3,321	2,228	5,026
	5-ton truck	94	84	66	92	147

*Attached to the division during the European scenario.

Figure D-27

SCENARIO SAVINGS IN COUNTERMOBILITY EFFORT
DUE TO THE EMPLOYMENT OF SCATTERABLE MINES
(Percentage)

Type Minefield	Effort (Hours)	Scenario: Latin America	Scenario: Europe
MOPMS variation	Man	75	47
	5-ton truck	84	65
ICOM variation	Man	72	40
	5-ton truck	83	49

Figure D-28

9. Observations.

a. When the LID is employed in suitable terrain, the nature of countermobility work changes considerably from that generally associated with heavier forces. LID operations favor terrain with very low CCM, extensive cover, and the forested concealment typical of the difficult terrain of both the Latin American and European scenarios. This difficult terrain, combined with the low mobility of the LID and the substantial threat capabilities in Europe, have led to the LID's assignment to an AO in the European scenario that is less than half the size of the AO assigned to a mechanized force. Obstacle density is also reduced for LID operations in Europe, as low CCM areas of less than 30 percent require that only 1.33 obstacles be emplaced per square kilometer. Mechanized forces in Europe normally operate in AOs with 60 percent CCM that need 1.67 obstacles per square kilometer -- 25 percent more than a LID force's AO.[2]

(1) The LID's smaller AO and lower obstacle density reduce the total LID obstacle level which in turn lowers the obstacle-related engineer effort. The level of engineer effort required under a given scenario can also be affected by changing the obstacle mix in a scenario.

(2) The effect of linear targets can be changed in two ways: linear targets can be made less numerous and smaller in size, or the ratio of point-to-linear targets -- the target mix -- can be increased. The potential impact of mix changes on engineer requirements lends new significance to the value of point targets and tends to reduce the importance of linear targets. Linear targets consume about 2.5 times more engineer resources than point targets; therefore, the obstacle mix in the study's two scenarios can also reduce engineer effort. The total combined effect of all terrain factors in these scenarios reduces the engineer countermobility effort by 65 percent or more from the effort required by a similar, division-sized heavy force operating in less rigorous terrain.

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[2]This 25-percent difference would have been even more pronounced if the obstacle density for the LID had not been doubled for the European portion of this analysis, as explained in paragraph 6a(2).

b. Minefield emplacement. Mining accounts for about 80 and 50 percent of the total countermobility manhours in the Latin American and European scenarios, respectively. This includes the effort devoted to installing linear minefields and the effort dedicated to reinforcing other obstacles with mines. Thus, improvements in mining can significantly affect the total countermobility manhour requirement. When taken in the aggregate, the integrated use of scatterable and improved conventional mines reduce the countermobility manhour requirement by 70 percent for the Latin American scenario, and by 40 percent for the European scenarios, as shown in Figure D-28.

(1) RAAM-ADAM. Artillery-delivered mines did not have much effect on the countermobility requirements in the Latin American scenario. This was due to a combination of terrain, the threat, and the tactics used by the LID. RAAM-ADAM support was unavailable to those brigades operating well forward in clandestine TFOBs. The LID lacks the transportation needed to move the 155-mm howitzer to such bases, and it may not be operationally sound to tie them to such an immobile weapon in this situation. In the European scenario, the RAAM-ADAM mines make a major contribution to countermobility. Even though RAAM-ADAM contributions were not tracked separately, ESC believes that in LID operations, especially defensive ones, artillery-delivered mines will supplement and compliment the primary engineer countermobility effort. But because they are not likely to substitute for engineer emplaced obstacles, their integration into the study scenarios did not significantly reduce engineer requirements. Artillery-delivered mines are well suited for such missions as attacking targets of opportunity, reinforcing obstacles, and covering gaps and lanes in the obstacle system. They may be effectively employed in the covering force area (CFA) to channelize and disrupt the enemy, thus saving

scarce and vulnerable engineer forces for work in the main battle area (MBA). As such, artillery-delivered mines represent an economy of force only if they are emplaced after the enemy is committed to an anvenue of approach.

(2) Air Volcano. The Air Volcano is a very important system in the Latin American scenario. It was substituted for about 60 percent of all hand-emplaced minefields. It was especially useful to the brigades operating in the clandestine TFOBs because of the low air defense artillery (ADA) threat. In Europe, Air Volcano was used to satisfy only 15 percent of all minefield requirements, since its use was restricted by the high ADA threat. In both scenarios, three Air Volcano systems were sufficient to meet the LID's needs. The Air Volcano is especially attractive because it is responsive and makes no demands on engineer resources. It can quickly emplace minefields against new threats or reinforce friendly forces as needed. Once the enemy is committed to an avenue of approach, Air Volcano can rapidly emplace minefields a terrain feature or two in front of the enemy's lead elements. It can also move above the difficult terrain favored by the LID to provide mining support with a timeliness not possible with ground-based systems. Thus, in spite of any ADA threat, Air Volcano should remain an important LID system.

(3) Ground Volcano. The Ground Volcano was used for 20 percent of the Latin American scenario's minefield requirements. Its use was restricted by two factors. First, as presently configured on a 5-ton truck, the system is not air transportable to the TFOBs, and it may be operationally unsound to use them there. Second, Ground Volcano can cause off-road mobility problems for a 5-ton truck during the rainy season. Ground Volcano was used extensively in the European scenario, where it accounted for 60 percent of all emplaced linear minefields. In the LID brigade AOs, the anticipated small

size of minefields and their difficult sites (steep, forested or rocky slopes) may tend to restrict the use of the Ground Volcano. A smaller version of the Ground Volcano may be required to meet the transportability and operational requirements of the LID. The armored brigade's AO provided excellent opportunities to use the Ground Volcano system.

(4) Hand-emplaced minefields were widely used in both scenarios for a number of reasons. Some sites were not supportable by scatterable mine systems because of their remoteness. In other cases, the tactical situation and the desire to maintain security and retain surprise favored hand emplacement. In the Latin American scenario excursions, the inability to transport the Ground Volcano, and the extended distances between AOs and the limited availability of 155-mm howitzers greatly restricted the use of Ground Volcano and ADAM-RAAM mine systems. Finally, minefields associated with point targets were hand emplaced. Hand-emplaced minefields accounted for 20 percent and 25 percent of all minefields in Latin American and the European scenarios, respectively. The use of improved conventional mines offered important payoffs in faster emplacement rates and a requirement for fewer mines because of the full-width attack capability of these mines.

(5) MOPMS can also lead to significant savings in the countermobility manhour requirement. It is especially suitable for the minefields associated with point targets, or for closing gaps and lanes in linear obstacles. For a conventional road crater, mining accounts for 45 percent of the required manhours. MOPMS can reduce this to less then 10 percent and shorten the total time required to emplace the road crater. The use of MOPMS saves a minimum of 10 percent of the countermobility manhour requirements in both scenarios.

(6) Figure D-29 summarizes the application, by scenario, of scatterable and improved conventional mining.

SCENARIO APPLICATION OF SCATTERABLE AND ICOM MINES

	Scenario	
System	Latin America	Europe
RAAM-ADAM	Low	Moderate[a]
Air Volcano	High	Low
Ground Volcano[b]	Moderate	High
MOPMS[c]	Moderate	Moderate
ICOM	Moderate	Moderate[d]

[a]Not specifically tracked in the European scenario.
[b]Smaller prime mover may enhance use by the LID.
[c]Best suited for use with point targets and lane closing.
[d]Changes to high if used as a replacement for MOPMS.

Figure D-29

c. Antitank ditches. Due to the combination of time, terrain, threat, and site, antitank ditches were not employed in the Latin American scenario. In Europe, antitank ditches were primarily used in the armored brigade's AO, where the terrain was more favorable to mechanized operations. Antitank ditches were not used to any significant degree in the LID brigade AOs. In this analysis, antitank ditches were emplaced by excavation. Although not captured by this analysis, ESC believes that antitank ditches will remain important to the LID at the tactical level. These ditches are likely to be short in nature (<200 meter) and explosively emplaced so that tactical security and surprise are retained. They may well be employed in tank ambush operations where the goal is to deny the enemy high-speed movement through close terrain. This forces the enemy to dismount and fight a slow-paced infantry battle, thus disrupting his plans and slowing the tempo of his attack.

d. Point targets.

(1) Road craters make up to 65 percent of the total obstacle load in the European scenario. Thus, improvements in road crater emplacement times could lead to substantial savings in countermobility manhour requirements. Figure D-30 shows some alternative methods for emplacing road craters. Only the first two are currently recognized procedures. The M-180 offers important manhour savings of 15 percent in the countermobility requirements in Europe, but has very high logistics requirements (see Annex G). Methods 4 and 5 are suggestions by the US Army Waterways Experiment Station (WES) and ESC.

(2) ESC believes that much work needs to be done to develop efficient road crater geometry based on the capabilities of the SEE and the unique properties of liquid explosives. For example, a boom-mounted compactor plate on the SEE might be used to drive a small diameter steel pipe and mandrel. The mandrel could be withdrawn and liquid explosives poured into the pipe. Such a road crater could be emplaced by a crew with fewer members than a squad. Research could determine the best number, spacing, and depth for the boreholes and the quantity of liquid explosive to be used. Until such information for various alternatives is known, it will be impossible to confidently estimate the manhour savings offered by the SEE and liquid explosives.

COMPARISION OF ROAD CRATERING ALTERNATIVES

Method*		Surface	Effort (Hours) Man	Effort (Hours) Truck	Effort (Hours) SEE	Elapsed Time (Hours)
1.	Conventional	Paved or Unpaved	1.4	0.2	--	1.4
2.	M-180	Paved or Unpaved	0.4	0.2	--	0.8
3.	SEE w/auger & Standard A explosive	Paved	0.8	0.2	1.5	1.8
		Unpaved	0.5	0.2	1.0	1.3
4.	SEE w/auger & liquid explosive	Paved	0.8	0.2	2.0	2.5
		Unpaved	0.5	0.2	1.5	2.0
5.	15-lb shaped charge and liquid explosive	Paved or Unpaved	0.9	0.2	--	1.5

*Method 1 is a hasty road crater, per Countermobility, Army Field Manual (FM) 5-102 (Department of the Army, Headqarters, March 1985). Method 3 is also a hasty road crater; the SEE removes pavement as necessary, then augers five boreholes. Method 4 used three boreholes; each are 10-ft deep and are loaded with 85 lb of XM 268. Method 5 uses 50 pounds of nitromethane per each of five boreholes.

Figure D-30

LAST PAGE OF ANNEX D

ANNEX E

SURVIVABILITY REQUIREMENTS

ANNEX E

SURVIVABILITY REQUIREMENTS

1. Purpose. This annex discusses the assumptions and limitations of the methodology used to evaluate survivability tasks for the LID under Latin American and European scenarios, and lists the division's survivability requirements for each scenario.

2. Scope. Survivability tasks provide protective positions for critical weapons and support systems within the division area, including protective

positions for all field artillery (FA) and air defense artillery (ADA) units. Protective construction requirements for the main division command post (CP) and division support command (DISCOM) activities located to the rear of the brigade rear boundaries are considered general engineering tasks; their requirements are calculated separately in Annex F.

a. Figure E-1 groups the major survivability tasks into four increments. The highest priority tasks are listed under Increment S-1 and the lowest under Increment S-4.

SURVIVABILITY TASKS BY INCREMENT

Increment	Description
S-1	Protect primary positions for TOW, tank, APC, crew-served weapons, FAAR, and DTOC; clear FA fire bases.
S-2	Protect primary positions for FA FDCs, Vulcan, and alternate TOW, tank, and APC weapon positions.
S-3	Protect primary positions for FA howitzers, battalion CPs, BSA, 81-mm and 107-mm mortars, and FARP; protect secondary TOW, tank, and APC weapon positions.
S-4	Protect primary positions for FA ammunition and BSA generator noise suppression slot/berms.

Figure E-1

b. Figure E-2 ranks each survivability task by increment group. The left column indicates which systems are to be protected, and the right four columns indicate the priority of those tasks during the battle. The importance of each task and its placement into a specific increment group was decided by the SAG.

3. Methodology. The method for generating survivability requirements for the Latin American and European scenarios is outlined in Figure E-3. Of

SURVIVABILITY TASKS AND INCREMENT GROUPS

Tasks (Weapon/Equipment to Be Dug In)	Increment Groups* S-1	S-2	S-3	S-4
1. Direct-fire weapons				
a. TOW	P**	A**	S**	
b. TOW -- EAD	P	A	S	
c. Crew-served weapon		P		
d. Tank***	P	A	S	
e. APC***	P	A	S	
f. 2-man perimeter foxhole			P	
2. Air defense weapons				
a. Vulcan		P		
b. FAAR	P			
3. Indirect-fire weapons				
a. FA -- division				
(1) Clear fire base	P			
(2) FDC		P		
(3) 105/155-mm towed howitzer			P	
(4) Howitzer personnel shelter			P	
(5) Ammunition carrier				P
b. Field artillery -- EAD				
(1) Clear fire base	P			
(2) FDC		P		
(3) 155/203-mm self-propelled howitzer			P	
(4) Howitzer personnel shelter			P	
(5) Ammunition carrier				P
c. 107-mm mortar			P	
d. 81-mm mortar***			P	
4. Command and support centers				
a. DTOC	P			
b. Battalion CPs			P	
c. Battalion helipads			P	
d. BSA				
(1) Helicopter revetments			P	
(2) ATP hardstand			P	
(3) Medical bunker			P	
(4) BSA generators				P
5. Forward logistics protection				
a. FARP			P	
b. Brigade petroleum, oil, and lubricant (POL) berms			P	

*Position may not be dug in if occupancy is less than 12 hours.
**P = primary position; A = alternate position; S = supplementary position.
***Used only for the attached armored brigade in the European scenario.

Figure E-2

the five factors included in this methodology, only the second factor (number of protectable items per unit TOE) was a constant across both scenarios. The third factor (cover availability) was a constant for all AOs in Latin America. A different cover availability constant was computed for the European scenario because of the different types of forests and built-up areas found in Europe, and the deep narrow valleys and irregularities in high hills and mountains, etc., that are typical of European terrain. The percentage of unit strength and position construction frequency are variable from one period to another within each scenario. However, equipment- and squad-hour factors were fairly stable in the scenarios.

SURVIVABILITY REQUIREMENTS METHODOLOGY

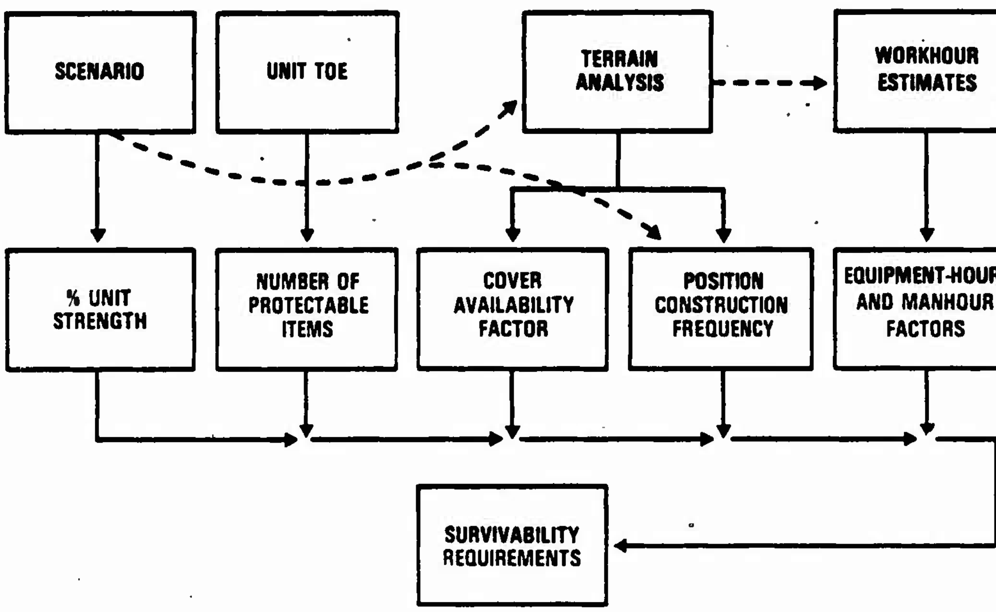


Figure E-3

a. The initial number of items to be protected are as listed in the unit TOEs. As each scenario proceeded, the number of items to be protected was reduced by an attrition rate derived from the scenario results. A terrain analysis conducted by ESC determined the percentage of natural cover available in each brigade area and the DRA for both scenarios.

b. The number of survivability positions to be dug and the frequency of moves to supplementary or alternate positions were determined from interviews with 7th ID(L) personnel, unit concepts of operation, Army field manuals, and other standard sources. Standard engineer workhour estimates were then applied to the equation to obtain the overall survivability requirements. The estimates for each scenario were finally summed into the four increments, as displayed in Figures E-1 and E-2, for each area of the division (brigade and DRA) and for each scenario time period.

c. The remainder of this annex is a detailed discussion of each step in ESC's survivability methodology.

4. <u>Generating Survivability Requirements</u>. Figure E-4, derived from the methodology diagram shown in Figure E-3, was used to generate engineer survivability requirements under both study scenarios.

SURVIVABILITY REQUIREMENTS ALGORITHM

Engineer Requirements (Equipment-Hours/Manhours) =

Items to Be Protected	X	% Unit Strength	X	% Without Natural Cover	X	Number of Moves	X	Hours Per Item

Figure E-4

a. Items to be protected. ESC and the SAG jointly determined which items to protect. Their decision, reflected in Figure E-2, is based on the TOE for the LID and EAD for both the Latin American and European scenarios, as well as on the concept of operations for the LID. These data are constant throughout the battle and do not vary from one scenario to another. EAD units were used sparingly in Latin America, but in Europe the armored brigade was added to the LID along with a TOW and two artillery battalions.

b. Percentage of unit strength. The scenarios drive the percentage of unit strength in each period of the battle. These data are derived from scenario wargaming results and are factored into the equation to give the total number of weapon and equipment systems requiring protection for a given period of the battle. As the battle progresses and units are attrited, fewer items are required to be dug in. The attrition rates for the different weapon systems were also derived from the scenario results.

c. Percentage without natural cover. Not all weapon systems and equipment require the same degree of protection on the battlefield. The opportunity that various units will have to use available natural cover is a function of the terrain available in a specific scenario. A t_ -ain analysis was conducted by ESC for both the Latin American and European battle areas. Figure E-5 shows the set of algorithms and factors used by ESC in estimating the relative nonavailability of natural cover for specific weapon and equipment systems. These factors were developed by ESC and are based on the natural cover availability overlays for flat-trajectory fire weapon systems. In Latin America, the available cover ranged from 15 to 70 percent; in Europe, it ranged from 22 to 78 percent. The percentage of positions without cover under the Latin American scenario (Variable C1) was not adjusted, since the minimal air threat allowed all systems to use cover equally. For Europe, the percentage of positions without natural cover (Variables C2 through C11) was applied differently within the survivability requirements algorithm (Figure E-4).

(1) Systems which were dug in 100 percent of the time were the FAAR (Variable C2), all TOWs (Variable C4), crew-served weapons in the LID

POSITIONS WITHOUT NATURAL COVER
(Percentage)

Equipment/weapon system	Algorithm Used for Specific Terrain Area*
I. Latin America	
All systems	100 - (A x 1.0** = B1) = C1
II. Europe	
FAAR	100 - (A x 0.0** = B2) = C2
Vulcan	100 - (A x 0.5** = B3) = C3
Direct-fire weapons:	
All TOWs	100 - (A x 0.0** = B4) = C4
Crew-served	
LID defense	100 - (A x 0.0** = B5) = C5
LID delay	100 - (A x 1.0** = B6) = C6
Armored brigade	100 - (A x 1.0** = B7) = C7
FA:	
LID 155-mm towed howitzers	100 - (A x 0.0** = B8) = C8
155-mm/203-mm self-propelled howitzers	100 - (A x 1.5** = B9) = C9
Mortars	100 - (A x 2.0** = B10) = C10
Command and support centers	100 - (A x 2.0** = B11) = C11

*The variables used in these algorithms are defined as follows:

Variable A: percentage of natural cover available for flat-trajectory fire weapon vehicles.

**: this factor is used to account for the different percentages of cover usually available for weapon or equipment systems that are not flat-trajectory systems.

Variable B: adjusted percentage of natural cover availability.

Variable C: percentage of positions without natural cover (i.e., the percentage of positions to be dug in). Variables C2, C4, C5, and C8 will always be 100 percent for FAAR, TOW, and crew-served weapons in the LID defense, and for LID 155-mm towed howitzers.

Figure E-5

defensive role (Variable C5), and LID 155-mm towed howitzers (Variable C8). Because the FAAR services rotary-wing aircraft, it cannot use natural cover and must be dug in. All TOWs and towed FA were dug in to provide maximum protection in the European threat environment; therefore, the cover factor used was 0.0, which resulted in a 100-percent emplacement requirement.

(2) The Vulcan air defense system (Variable C3) was assumed to be able to find and use half of the available protective cover in the scenarios A0; its cover factor is 0.5.

(3) A cover factor of 1.0 was used for crew-served, direct-fire weapons in the delay role (Variable C6) and for direct-fire weapons in the armored brigade (Variable C7). This means that the cover is directly related to the percentage of weapon systems dug in. If the natural protective cover was 100 percent, none were dug in. At the other extreme, if the natural protective cover was 0 percent, then all systems were dug in.

(4) The 155- and 203-mm self-propelled howitzers (Variable C9) were assumed to have a cover factor of 1.5, based on their opportunity to find natural cover protection. This is because of their greater mobility, distance from the FEBA, and their greater ability to locate firing batteries behind masking terrain. Self-propelled howitzers were only used in the European scenario. In the Latin American scenario, the cover factor of the towed 105-mm howitzer was 1.0 because of the minimal air threat.

(5) Mortars (Variable C10) and command and support centers (Variable C11) were assumed to have a cover factor of 2.0 based on their opportunity for finding natural cover protection. This factor was based on the smaller area required to conceal and relocate mortars and the additional time available to site command and support centers. There is also more freedom of choice in locating a command and support center.

d. Number of moves. The frequency of moves required for each brigade during different periods of battle was derived from the combination of terrain and threat conditions depicted in the scenarios. This frequency was used to determine the approximate locations of a weapon throughout the scenarios, to identify which equipment systems needed protection, and determine the relocation criteria of weapon or equipment systems.

(1) The movement criteria for the BSAs (including POL sites, ammunition transfer points [ATPs], etc.), FAARs, and Vulcans were the same for both scenarios. BSAs were established for each brigade AO and were reestablished when the brigade moved significantly, either forward (when the offense was successful) or to the rear (when the enemy was stronger). The FAAR and the Vulcans, on the other hand, were moved every 12 hours.

(2) In Latin America, movement stopped once a TFOB was established. Figure E-6 depicts a typical battalion CP used for a TFOB in the Latin American scenario. The systems shown in this schematic -- a battalion tactical operations center (TOC), an artillery FDC, a helipad, an ammunition bunker, howitzers, and two-man perimeter foxholes -- were not relocated until the TFOB was abandoned for a new TFOB.

(3) In Europe, most systems moved when the maneuver force relocated to a new position of a phase line advance or retreat. These phase lines occur, on the average, every 3 kilometers for the LID brigades and every 6 kilometers for the armored brigade. The systems that move when a phase line relocates are the crew-served weapon positions, TOWs, mortars, battalion CPs, tanks, and APCs. FAARs and all FA howitzers move every 24 hours, depending on the enemy's radar tracking capability.

e. Hours per item. Figures E-7 and E-8 show the data ESC used to determine, in manhours and equipment-hours, how long it would take to protect

BATTALION TOC SCHEMATIC*

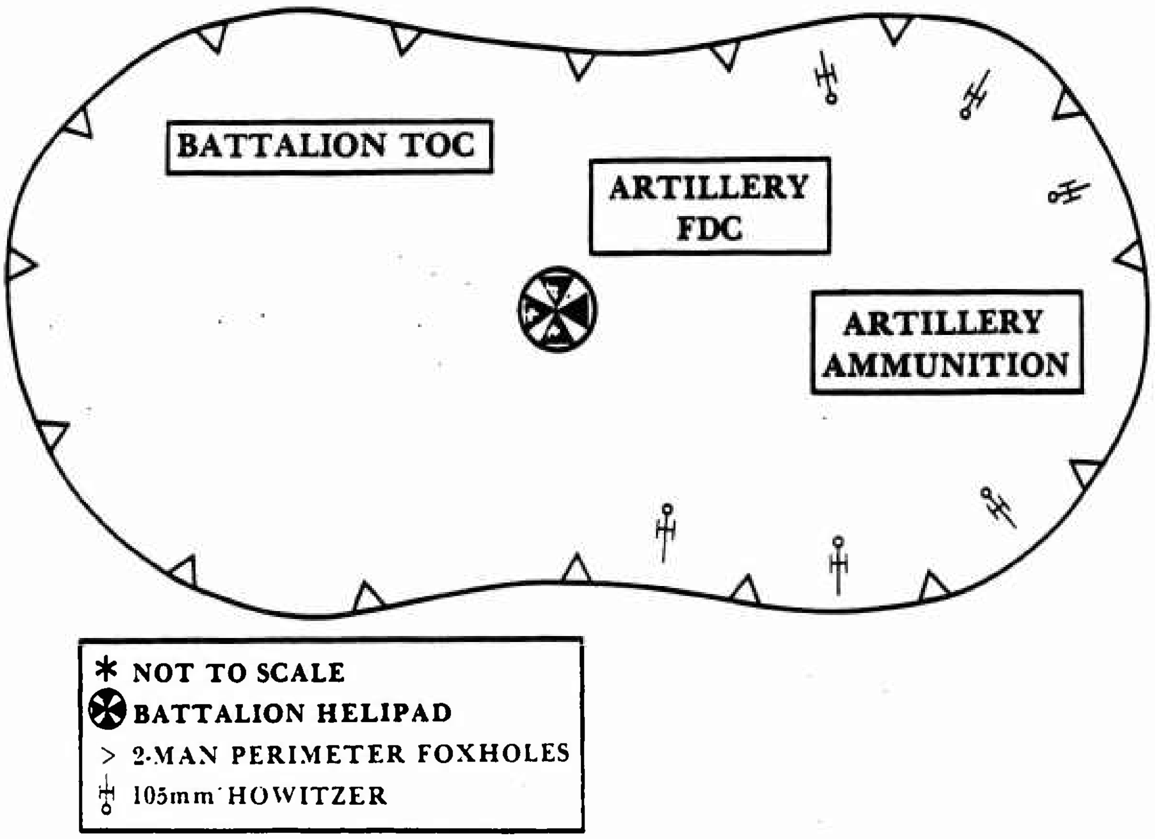


Figure E-6

ENGINEER PLANNING FACTORS FOR SURVIVABILITY -- LATIN AMERICA

Tasks	Technique*	Man hours	Equipment Hours ACE/ Dozer	Equipment Hours JD410/ SEE	Loader	Reference
Construct berm for FAAR (13.1 x 10.8 x 2.7 m) (453.2 loose cubic yards [LCY])**	A	0.08	1.28	--	1.36	a
Construct berm for Vulcan (radius = 7 m; height = 0.75 m) (56.7 LCY)	A	0.08	0.29	--	0.20	a
Construct berm for 105-mm towed howitzer (radius = 7 m; height = 0.75 m) (56.7 LCY)	A	0.08	0.29	--	0.20	a
	B	0.08	--	1.04	--	--
Construct berm for 155-mm towed howitzer (radius = 9 m; height = 0.75 m) (92.0 LCY)	A	0.08	0.42	--	0.32	a
	B	0.08	--	1.68	--	--
Construct hole/berm for 81-mm/107-mm mortars (radius 2.4 m; diameter = 0.9 m) (5.6 bank cubic yards [BCY])	B	0.08	--	0.30	--	a
Construct berm for POL storage, (240.0 LCY) (11.5 x 11.5 x 1.8 m)	A	0.80	4.00	--	--	b
	B	1.00	--	5.40	--	--
Construct BSA helicopter revetment (11.3 x 7.6 x 1.9 m) (185.0 LCY)	A	0.08	2.50	--	--	b
	B	0.08	--	4.60	--	--

Figure E-7 (Continued on Next Page)

ENGINEER PLANNING FACTORS FOR SURVIVABILITY — LATIN AMERICA (Continued)

Tasks	Technique*	Man hours	Equipment Hours ACE/ Dozer	Equipment Hours JD410/ SEE	Loader	Reference
Construct slot trench (10.5 x 3 x 1.5 m) (72.1 BCY); medical and battalion CP bunkers, FDC, and howitzer personnel shelters	A	0.08	0.28	--	0.42	b
	B	0.10	--	1.50	--	--
Construct trench for BSA generators (2.1 x 0.6 x 1m) (1.6 BCY)	B	--	--	0.10	--	b
Construct trench for DTOC (13 x 6.1 x 1.2 m) (124.5 BCY)	A	0.08	0.35	--	0.55	b
	B	0.08	--	2.57	--	--
Construct trench for crew-served position/2-man perimeter foxhole (2.2 x 0.6 x 1.5 m) (2.6 BCY)	B	--	--	0.13	--	b
Clear area for battalion helipad (46 x 46 m); level pad (15 x 15 m)	A	1.26	0.26	--	--	--
	B	2.33	--	1.92	--	b
Clear, level, and drain area for ATP hardstand (15 x 15 m)	A	0.33	0.67	--	--	b
	B	0.33	--	2.00	--	--

[a]Workload Estimate for Combat Engineers in the Desert (US Army Engineer Studies Center [ESC], July 1986), Estimate was modified by 10%; SEE estimates based on data provided to ESC by the Mercedes-Benz UNIMOG representative.

[b]Combat Developments Engineer Family of Systems Study (E-FOSS) (US Army Engineer School [USAES] February 1979), SEE estimate based on data provided to ESC by the Mercedes-Benz UNIMOG representative.

*A = ACE available; B = ACE not available or SEE more efficient than ACE.
**LCY = 1.3 bank cubic yards (BCY).

Figure E-7

ENGINEER PLANNING FACTORS FOR SURVIVABILITY -- EUROPE

Tasks	Man-hours	ACE Dozer	JD410/SEE	Loader	Reference
Construct berm for FAAR (13.1 x 10.8 x 2.7 m) (453.2 LCY)	0.08	0.90	--	0.90	a
Construct berm for towed Vulcan (radius 7 m; height = 0.75 m) (56.7 LCY)	0.08	0.28	--	0.20	a
Dig in self-propelled Vulcan	--	0.45	--	--	a
Construct berm for 105-mm towed howitzer (roads = 7 m; height = 0.75 m) (56.7 LCY)	0.08	0.29	--	0.20	b
Construct berm for 155-mm towed howitzer (radius 9 m; height = 1 m) (92.0 LCY)	0.08	0.42	--	0.32	b
Construct berm for 155-mm/203-mm self-propelled howitzer	--	0.82	--	0.82	b
Construct hole/berm for 81-mm/107-mm mortars (radius 2.4 m; diameter = 0.9 m) (5.6 BCY)	0.08	--	0.55	--	c
Construct FAAR berm for POL storage (11.5 x 11.5 x 1.8 m) (240 LCY)	0.80	4.00	--	--	d
Construct helicopter revetment (11.5 x 7.6 x 1.9 m) (185 LCY)	0.08	2.50	--	--	d
Construct slot trench (10.5 x 3 x 1.5 m) (72.1 BCY); medical and battalion CP bunkers, FDC, and howitzer personnel shelters	0.08	0.28	--	0.42	d

Figure E-8 (Continued on Next Page)

ENGINEER PLANNING FACTORS FOR SURVIVABILITY — EUROPE (Continued)

Tasks	Man-hours	ACE Dozer	JD410/SEE	Loader	Reference
Construct trench for BSA generators (2.1 x 0.6 x 1 m) (1.6 BCY)	--	--	0.10	—	d
Construct trench for DTOC (13 x 6.1 x 1.2 m) (124.5 BCY)	0.08	0.35	—	0.55	d
Construct trench for crew-served weapon (2.2 x 0.6 x 1.5 m) (2.6 BCY)	--	--	0.17	--	d
Clear, level, and drain area for ATP hardstand (15 x 15 m)	0.33	0.67	--	--	d
Construct berm for dismounted TOW (1.5 x 1.7 x 0.6 m) (2.04 BCY)	—	—	0.15	—	d
Dig in carriers: tank, APC, TOW, CP, mortar	--	0.45	--	--	a
Dig in artillery ammunition carrier	--	0.16	--	0.16	a

[a]Analysis of V Corps Combat Engineer Wartime Requirements (ESC, December 1983).

[b]Workload Estimates for Combat Engineers in the Desert (ESC, July 1986). SEE estimate based on data provided to ESC by the Mercedes-Benz UNIMOG representative.

[c]Workload Estimates for Combat Engineers in the Desert, Annex E, "European Workload Factors" (ESC, July 1986).

[d]Combat Developments Engineer Family of Systems Study (E-FOSS) (USAES, February 1979). SEE estimates based on data provided to ESC by the Mercedes-Benz UNIMOG representative.

Figure E-8

each weapon or equipment system used during the study scenarios. These data are based on the results of ESC's field questionnaire and interviews, previous research, published and draft ESC reports, projected estimates, and standard engineer references.

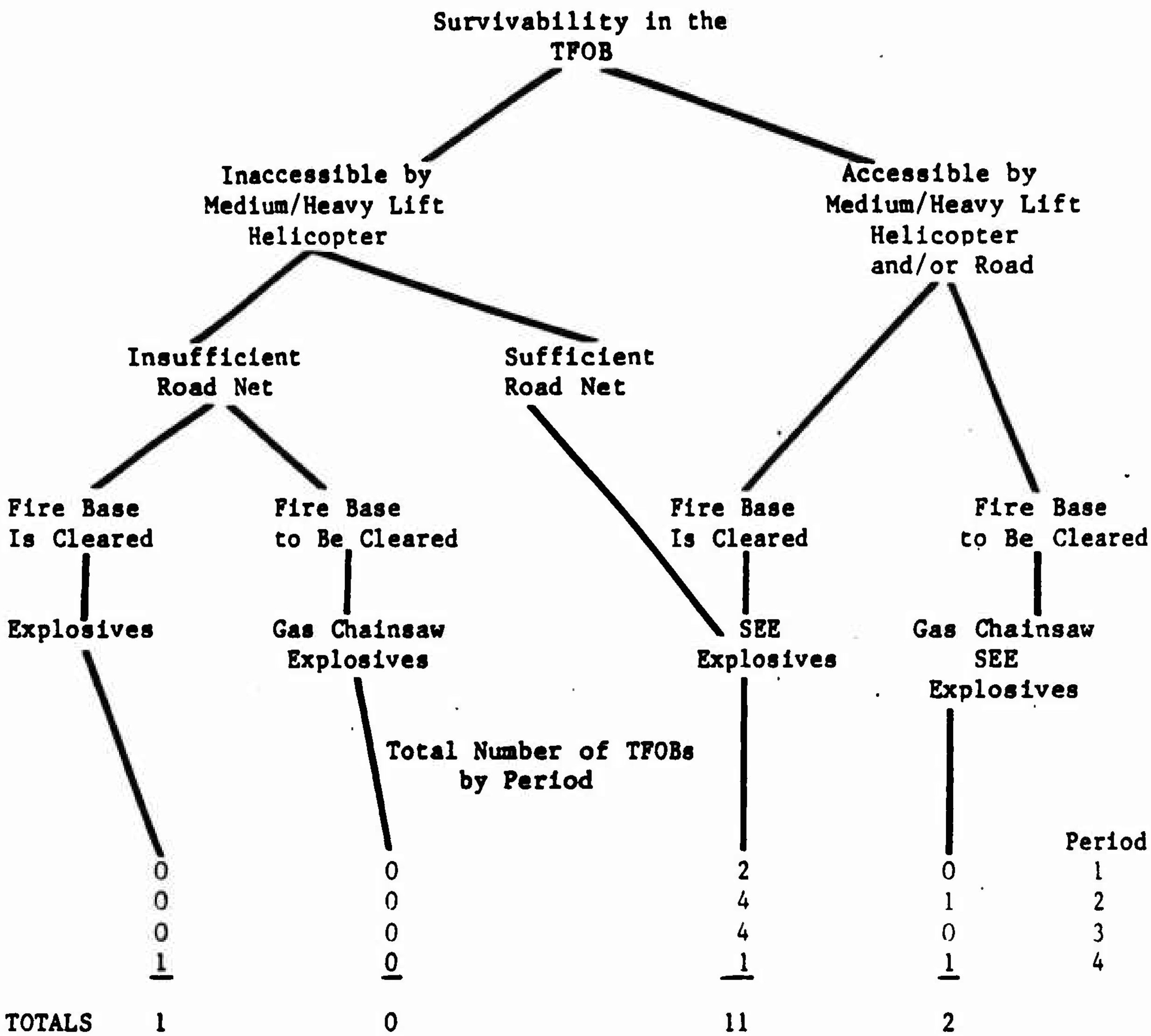
(1) These data will vary depending on the tactical situation and an analysis of the local terrain. However, terrain and soil types were considered in the selection of the data listed in Figures E-7 and E-8.

(2) The figures also list two equipment systems for digging in a position -- the SEE and the ACE. In Latin America, the SEE may be driven over a road system or could be deployed by helicopter into an AO lacking an adequate road network, but the ACE is too heavy to airlift to remote areas by helicopter. Therefore, the Latin American scenario sometimes required that the SEE be used instead of the ACE, as indicated by entry B in the second column of Figure E-7.

(3) Figure E-9 shows survivability tasks in a typical TFOB under the Latin American scenario; a TFOB could also include the BSA or a separate artillery fire base. Note that only once was a fire base constructed without the aid of a SEE; on two occasions, a fire base needed a small helicopter landing pad cleared by hand-held gas chainsaws in order to airland a SEE. In most cases, both the SEE chainsaws and hand auger attachments were heavily utilized. The hand auger was used to dig small holes for the explosive-assisted excavation of the two-man perimeter foxhole positions.

f. Figure E-10 is an example of a calculation using the survivability algorithm shown in Figure E-4. The example illustrates the requirements in the 1st Brigade area during time period 3 of the European scenario: 18 howitzers in the unit TOE, minus 4-percent attrition (i.e., 96 percent of

SURVIVABILITY TASKS IN THE TFOB



Number of TFOBs Per Period & Brigade AO

Period:	Brigade AO 1	2	3
1	2	—	—
2	—	5	—
3	—	—	4
4	3	—	—

Figure E-9

unit strength), in an open area, during one move, using a 0.08 manhour factor. Thus, the total requirement is 1.38 manhours.

SURVIVABILITY REQUIREMENTS ALGORITHM EXAMPLE

Engineer Requirements (Equipment-Hours/Manhours) =

Howitzers to Be Protected	x	% Unit Strength	x	% Without Natural Cover	x	Number of Moves	x	Man-hours per Item	=	
18	x	96	x	100	x	1	x	0.08	=	1.38

Figure E-10

5. Results. There are no survivability requirements for certain scenarios, as shown in Figure E-11. In the Latin America scenario EAD, FA and TOW forces were not on the force list because of the character of the threat environment and the LID's organization and operation (O&O) concept.[1] In addition, ESC's interviews with the staff of the 7th ID(L) indicated that the following systems would not be dug in under a Latin American scenario: 107-mm mortars, the TOW, and crew-served weapons. Under the European scenario, the 81-mm mortars were organic only to the armored brigade, which was only used in Europe. The requirement for the battalion two-man perimeter foxholes in Europe was eliminated based on the LID's O&O concept and the threat; however, this loss is offset by the use of company crew-served weapons. No engineer requirement was calculated for the support of helicopter revetments and battalion helipads under a European scenario, because ESC's analysis of the European terrain indicated there were many adequate landing areas, and because

[1]US Army Operational Concept: The Light Infantry Division, (US Army Combined Arms Combat Developments Activity [CACDA], 15 March 1984).

UNREQUIRED SURVIVABILITY TASKS

Systems Not Protected	Increment	Reason: O&O Concept	Reason: Interview*	Reason: Terrain	Reason: Threat
Latin American Scenario					
FA -- EAD	S3	X	--	--	X
107-mm mortars	S3	--	X	--	X
81-mm mortars -- EAD	S3	X	--	--	X
TOW	S1-3	--	X	--	--
Crew-served weapons	S3	X	X	X	X
203-mm self-propelled howitzers -- EAD	S3	X	--	--	X
European Scenario					
2-man perimeter foxholes	S3	X	--	--	X
203-mm self-propelled howitzers -- EAD	S3	X	--	X	--
BSA helicopter revetments	S3	--	--	X	--
Battalion helipads	S3	--	--	X	--
Brigade POL berms	S3	--	--	X	--

*Interviews conducted by ESC with members of the 7th ID(L) at Fort Ord, California, 7-11 October 1985.

Figure E-11

the LID's O&O concept is to relocate rather than dig in. The engineer requirement for supporting brigade POL was also eliminated in Europe because of the abundance of natural available cover and the time which should be available to the brigade to find and use that cover.

a. Figures E-12 through E-15 summarize the engineer effort in each survivability increment of each scenario, and in unit areas and periods of battle. These data were derived from Figure 4, the survivability requirements algorithm. Note that the survivability effort for the division main CPs, DISCOM, and other units and equipment located in the DRA is not listed in this annex, but is included under the discussion of the requirements and effort necessary to fulfill general engineering tasks (Annex F).

b. The survivability workload (tasks accomplished) is shown in Figures E-16 and E-17 for Latin America and Europe. The EAD effort is shown in Figure E-18 for survivability Increments S1 through S4 by time period for Latin America and Europe. There were no EAD survivability requirements in the Latin American scenario, because the LID's O&O concept and the character of the threat required few EAD forces.

6. Observations. The calculation of survivability requirements (and the engineer effort necessary to fulfill those requirements) was profoundly affected by two factors: the LID's operational concept and the amount of natural cover available under each scenario. There was also an indication that the type of SEE attachment chosen for a task could affect the overall generation of equipment-hour requirements.

a. Operational concept. The LID operational concept generated significantly different requirements for survivability protection per scenario for the division's direct-fire weapons. These differences resulted in a

SURVIVABILITY REQUIREMENTS -- INCREMENT S-1

From	Through	Effort (Hours)	Brigade 1	2	3	Avn	AR*	DRA
			Latin American Scenario					
D+1	D+2	Man	--	--	--	--	NA	1
		ACE	--	--	--	--	NA	5
		SEE	--	--	--	--	NA	--
		Loader	--	--	--	--	NA	6
D+3	D+4	Man	--	6	--	--	NA	--
		ACE	--	4	--	--	NA	--
		SEE	--	4	--	--	NA	--
		Loader	--	4	--	--	NA	--
D+5	D+8	Man	--	--	--	--	NA	--
		ACE	--	--	--	--	NA	--
		SEE	--	--	--	--	NA	--
		Loader	--	--	--	--	NA	--
D+9	D+10	Man	4	--	--	--	NA	--
		ACE	--	--	--	--	NA	1
		SEE	3	--	--	--	NA	--
		Loader	--	--	--	--	NA	--
			European Scenario					
D-10	D+7	--	--	--	--	--	--	--
D+8	D+10	Man	--	--	--	--	1	2
		ACE	11	11	11	--	124	3
		SEE	20	20	20	3	13	--
		Loader	--	--	--	--	1	3
H-hour	H+23	Man	--	--	--	--	1	4
		ACE	--	16	5	--	62	5
		SEE	--	29	2	--	6	--
		Loader	--	--	--	--	2	5
H+24	H+47	Man	--	--	--	--	1	4
		ACE	--	10	5	--	60	5
		SEE	--	3	2	--	--	--
		Loader	--	--	--	--	2	5
H+48	H+95	Man	--	--	--	--	2	7
		ACE	24	15	15	--	130	10
		SEE	18	12	11	--	12	--
		Loader	--	--	--	--	3	10

*Attached to the division during the European scenario.

Figure E-12

SURVIVABILITY REQUIREMENTS -- INCREMENT S-2

From	Through	Effort (Hours)	Brigade 1	Brigade 2	Brigade 3	Avn	AR*	DRA
		Latin American Scenario						
D+1	D+2	Man	--	--	--	--	NA	2
		ACE	1	--	--	--	NA	9
		SEE	--	--	--	--	NA	--
		Loader	--	--	--	--	NA	6
D+3	D+4	Man	--	2	--	--	NA	2
		ACE	1	5	--	--	NA	4
		SEE	--	--	--	--	NA	--
		Loader	2	4	--	--	NA	3
D+5	D+8	Man	1	2	3	--	NA	--
		ACE	3	2	--	--	NA	--
		SEE	--	--	--	--	NA	--
		Loader	4	4	--	--	NA	--
D+9	D+10	Man	--	--	--	--	NA	--
		ACE	--	1	--	--	NA	--
		SEE	1	--	--	--	NA	--
		Loader	--	2	--	--	NA	--
		European Scenario						
D-10	D+7	--	--	--	--	--	--	--
D+8	D+10	Man	2	2	2	--	6	5
		ACE	12	12	12	--	125	2
		SEE	4	4	4	2	--	--
		Loader	1	1	1	--	3	2
H-hour	H+23	Man	2	2	2	--	9	10
		ACE	1	17	6	--	64	4
		SEE	--	5	2	--	--	--
		Loader	1	1	1	--	4	3
H+24	H+47	Man	2	2	2	--	9	10
		ACE	1	11	6	--	62	4
		SEE	--	3	2	--	--	--
		Loader	1	1	1	--	4	3
H+48	H+95	Man	4	4	4	--	14	19
		ACE	26	16	16	--	133	8
		SEE	8	5	5	--	--	--
		Loader	2	2	2	--	5	6

*Attached to the division during the European scenario.

Figure E-13

SURVIVABILITY REQUIREMENTS -- INCREMENT S-3

From	Through	Effort (Hours)	Brigade 1	Brigade 2	Brigade 3	Brigade Avn	Brigade AR*	Brigade DRA
		Latin American Scenario						
D+1	D+2	Man	7	--	--	--	NA	2
		ACE	27	--	--	--	NA	38
		See	10	--	--	--	NA	--
		Loader	14	--	--	--	NA	6
D+3	D+4	Man	6	6	--	--	NA	--
		ACE	17	21	--	--	NA	--
		SEE	--	21	--	--	NA	--
		Loader	13	12	--	--	NA	--
D+5	D+8	Man	10	9	46	--	NA	--
		ACE	26	52	--	--	NA	--
		SEE	--	--	27	--	NA	--
		Loader	25	20	--	--	NA	--
D+9	D+10	Man	2	4	--	--	NA	1
		ACE	--	10	--	--	NA	30
		SEE	20	--	--	--	NA	--
		Loader	--	10	--	--	NA	--
		European Scenario						
D-10	D+7	--	--	--	--	--	--	--
D+8	D+10	Man	12	12	12	6	22	--
		ACE	18	18	18	4	152	--
		SEE	4	4	4	2	13	--
		Loader	6	6	6	1	22	--
H-hour	H+23	Man	11	11	11	11	14	--
		ACE	7	23	13	7	90	--
		SEE	--	5	2	--	6	--
		Loader	6	6	6	--	22	--
H+24	H+47	Man	11	11	11	22	11	--
		ACE	7	18	12	14	86	--
		SEE	--	3	2	--	6	--
		Loader	6	6	6	--	19	--
H+48	H+95	Man	21	21	21	--	7	--
		ACE	38	29	29	--	154	--
		SEE	8	5	5	--	4	--
		Loader	11	11	11	--	19	--

*Attached to the division during the European scenario.

Figure E-14

SURVIVABILITY REQUIREMENTS -- INCREMENT S-4

From	Through	Effort (Hours)	Brigade 1	2	3	Avn	AR*	DRA
			Latin American Scenario					
D+1	D+2	Man	1	--	--	--	NA	--
		ACE	3	--	--	--	NA	--
		See	1	--	--	--	NA	--
		Loader	4	--	--	--	NA	--
D+3	D+4	Man	--	--	--	--	NA	--
		ACE	--	2	--	--	NA	--
		SEE	--	1	--	--	NA	--
		Loader	--	4	--	--	NA	--
D+5	D+8	Man	2	2	6	--	NA	--
		ACE	6	5	--	--	NA	--
		SEE	--	--	1	--	NA	--
		Loader	9	7	--	--	NA	--
D+9	D+10	Man	--	--	--	--	NA	--
		ACE	--	2	--	--	NA	--
		SEE	3	--	--	--	NA	--
		Loader	--	3	--	--	NA	--
			European Scenario					
D-10	D+7	--	--	--	--	--	--	--
D+8	D+10	Man	12	12	12	--	15	--
		ACE	8	8	8	--	11	--
		SEE	--	--	--	--	--	--
		Loader	10	10	10	--	14	--
H-hour	H+23	Man	11	11	11	--	15	--
		ACE	8	8	8	--	10	--
		SEE	--	--	--	--	1	--
		Loader	10	10	10	--	14	--
H+24	H+47	Man	11	11	11	--	15	--
		ACE	8	8	8	--	10	--
		SEE	--	--	--	--	1	--
		Loader	10	10	10	--	13	--
H+48	H+95	Man	36	36	36	--	14	--
		ACE	15	15	15	--	10	--
		SEE	--	--	--	--	1	--
		Loader	19	19	19	--	13	--

*Attached to the division during the European scenario.

Figure E-15

SURVIVABILITY WORKLOAD -- LATIN AMERICA

From	Through	Effort By Task	Brigade Area 1st	2nd	3rd	DRA
Increment S-1:						
D+1	D+2	Berm for FAAR	--	--	--	3
		Trench for DTOC	--	--	--	3
D+3	D+4	Berm for FAAR	--	3	--	--
		Clear fire base	--	2	--	--
D+5	D+8	--	--	--	--	--
D+9	D+10	Clear fire base	2	--	--	--
		Trench for DTOC	--	--	--	2
Increment S-2:						
D+1	D+2	Berm for Vulcan	--	--	--	31
		Artillery FDC (division)	5	--	--	--
D+3	D+4	Berm for Vulcan	--	13	--	15
		Artillery FDC (division)	5	4	--	--
D+5	D+8	Artillery FDC (division)	10	8	1	--
D+9	D+10	Artillery FDC (division)	1	4	--	--
Increment S-3:						
D+1	D+2	Berm for 155-mm towed howitzers	31	--	--	--
		Howitzer personnel shelters	31	--	--	--
		Battalion CPs	2	--	--	--
		BSA helicopter revetments	--	--	--	15
		ATP hardstand in BSA	1	--	--	--
		Medical bunker in BSA	1	--	--	--
		Brigade POL berms	3	--	--	--
		2-man perimeter foxholes	77	--	--	--
D+3	D+4	Berm for 155-mm towed howitzers	31	26	--	--
		Howitzer personnel shelters	31	26	--	--
		Battalion CPs	--	4	--	--
		ATP hardstand in BSA	--	1	--	--
		Medical bunker in BSA	--	1	--	--
		Brigade POL berms	1	2	--	--
		2-man perimeter foxholes	--	160	--	--

Figure E-16 (Continued on Next Page)

SURVIVABILITY WORKLOAD — LATIN AMERICA (Continued)

From	Through	Effort By Task	Brigade Area 1st	2nd	3rd	DRA
D+5	D+8	Berm for 155-mm towed howitzers	61	50	6	--
		Howitzer personnel shelters	61	50	6	--
		Battalion CPs	--	--	2	--
		BSA helicopter revetments	--	12	--	--
		Battalion helipads	--	--	1	--
		ATP hardstand in BSA	--	--	1	--
		Medical bunker in BSA	--	--	1	--
		Brigade POL berms	--	--	2	--
		2-man perimeter foxholes	--	--	68	--
D+9	D+10	Berm for 155-mm towed howitzers	5	24	--	--
		Howitzer personnel shelters	5	24	--	--
		Battalion CPs	1	--	--	--
		BSA helicopter revetments	--	--	--	12
		Battalion helipads	1	--	--	--
		ATP hardstand in BSA	1	--	--	--
		Medical bunker in BSA	1	--	--	--
		Brigade POL berms	2	--	--	--
		2-man perimeter foxholes	36	--	--	--
Increment S-4:						
D+1	D+2	Ammunition carrier	10	--	--	--
		BSA generators	5	--	--	--
D+3	D+4	Ammunition carrier	10	9	--	--
		BSA generators	--	11	--	--
D+5	D+8	Ammunition carrier	20	17	2	--
		BSA generators	--	--	6	--
D+9	D+10	Ammunition carrier	2	8	--	--
		BSA generators	2	--	--	--

Figure E-16

SURVIVABILITY WORKLOAD -- EUROPE

From	Through	Effort By Task	Brigade Area 1st	2nd	3rd	Avn	AR*	DRA
Increment S-1:								
D-10	D+7	--	--	--	--	--	--	--
D+8	D+10	TOW	24	24	24	16	--	--
		TOW (EAD)	24	24	24	--	48	--
		Crew-served weapon	96	96	96	--	75	--
		Tank	--	--	--	--	169	--
		APC	--	--	--	--	56	--
		FAAR	--	--	--	--	1	3
H-hour	H+23	TOW	--	35	12	--	--	--
		TOW (EAD)	--	35	12	--	24	--
		Crew-served weapon	--	141	--	--	37	--
		Tank	--	--	--	--	83	--
		APC	--	--	--	--	28	--
		FAAR	--	--	--	--	2	6
H+24	H+47	TOW	--	23	12	--	--	--
		TOW (EAD)	--	23	12	--	23	--
		Crew-served weapon	--	--	--	--	--	--
		Tank	--	--	--	--	80	--
		APC	--	--	--	--	27	--
		FAAR	--	--	--	--	2	6
H+48	H+95	TOW	54	33	33	--	--	--
		TOW (EAD)	54	33	33	--	65	--
		Crew-served weapon	61	44	36	--	72	--
		Tank	--	--	--	--	163	--
		APC	--	--	--	--	54	--
		FAAR	--	--	--	--	4	11
Increment S-2:								
D-10	D+7	--	--	--	--	--	--	--
D+8	D+10	TOW	24	24	24	16	--	--
		TOW (EAD)	24	24	24	--	48	--
		Tank	--	--	--	--	169	--
		APC	--	--	--	--	56	--
		Vulcan	--	--	--	--	5	8

Figure E-17 (Continued on Next Page)

SURVIVABILITY WORKLOAD — EUROPE (Continued)

From	Through	Effort By Task	Brigade Area 1st	2nd	3rd	Avn	AR*	DRA
		Artillery FDC (division)	3	3	3	--	--	--
		Artillery FDC (EAD)	--	--	--	--	4	--
H-hour	H+23	TOW	--	35	12	--	--	--
		TOW (EAD)	--	35	12	--	24	--
		Tank	--	--	--	--	83	--
		APC	--	--	--	--	28	--
		Vulcan	--	--	--	--	11	16
		Artillery FDC (division)	3	3	3	--	--	--
		Artillery FDC (EAD)	--	--	--	--	4	--
H+24	H+47	TOW	--	23	12	--	--	--
		TOW (EAD)	--	23	12	--	23	--
		Tank	--	--	--	--	80	--
		APC	--	--	--	--	27	--
		Vulcan	--	--	--	--	10	16
		Artillery FDC (division)	3	3	3	--	--	--
		Artillery FDC (EAD)	--	--	--	--	4	--
H+48	H+95	TOW	54	33	33	--	--	--
		TOW (EAD)	54	33	33	--	65	--
		Tank	--	--	--	--	163	--
		APC	--	--	--	--	54	--
		Vulcan	--	--	--	--	18	30
		Artillery FDC (division)	6	6	6	--	--	--
		Artillery FDC (EAD)	--	--	--	--	4	--
Increment S-3:								
D-10	D+7	--	--	--	--	--	--	--
D+8	D+10	TOW	24	24	24	16	--	--
		TOW (EAD)	24	24	24	--	48	--
		Tank	--	--	--	--	169	--
		APC	--	--	--	--	56	--
		155-mm towed howitzers	18	18	18	--	--	--
		155-mm self-propelled howitzers	--	--	--	--	24	--
		107-mm mortars (EAD)	--	--	--	--	13	--

Figure E-17 (Continued on Next Page)

SURVIVABILITY WORKLOAD -- EUROPE (Continued)

From	Through	Effort By Task	Brigade Area					
			1st	2nd	3rd	Avn	AR*	DRA
		81-mm mortars (EAD)	--	--	--	--	10	--
		Battalion CPs	--	--	--	1	5	--
		ATP hardstand	--	--	--	--	1	--
		Medical bunker	--	--	--	--	1	--
		FARP	--	--	--	1	--	--
		Brigade POL berms	--	--	--	--	2	--
H-hour	H+23	TOW	--	35	12	--	--	--
		TOW (EAD)	--	35	12	--	24	--
		Tank	--	--	--	--	83	--
		APC	--	--	--	--	28	--
		155-mm towed howitzers	18	18	18	--	--	--
		155-mm self-propelled howitzers	--	--	--	--	24	--
		107-mm mortars (EAD)	--	--	--	--	7	--
		81-mm mortars (EAD)	--	--	--	--	5	--
		Battalion CPs	--	--	--	--	5	--
		ATP hardstand	--	--	--	--	1	--
		Medical bunker	--	--	--	--	1	--
		FARP	--	--	--	2	--	--
		Brigade POL berms	--	--	--	--	2	--
H+24	H+47	TOW	--	23	11	--	--	--
		TOW (EAD)	--	23	11	--	23	--
		Tank	--	--	--	--	80	--
		APC	--	--	--	--	27	--
		155-towed howitzers	17	17	17	--	--	--
		155-mm self-propelled howitzers	--	--	--	--	23	--
		107-mm mortars (EAD)	--	--	--	--	7	--
		81-mm mortars (EAD)	--	--	--	--	5	--
		Battalion CPs	--	--	--	--	--	--
		ATP hardstand	--	--	--	--	1	--
		Medical bunker	--	--	--	--	1	--
		FARP	--	--	--	3	--	--
		Brigade POL berms	--	--	--	--	2	--

Figure E-17 (Continued on Next Page)

SURVIVABILITY WORKLOAD — EUROPE (Continued)

From	Through	Effort By Task	Brigade Area 1st	2nd	3rd	Avn	AR*	DRA
H+48	H+95	TOW	54	33	33	--	--	--
		TOW (EAD)	54	33	33	--	65	--
		Tank	--	--	--	--	163	--
		APC	--	--	--	--	54	--
		155-mm towed howitzers	33	33	33	--	--	--
		155-mm self-propelled howitzers	--	--	--	--	22	--
		107-mm mortars (EAD)	--	--	--	--	4	--
		81-mm mortars (EAD)	--	--	--	--	3	--
		Battalion CPs	--	--	--	--	1	--
		ATP hardstand	--	--	--	--	1	--
		Medical bunker	--	--	--	--	1	--
		Brigade POL berms	--	--	--	--	2	--
Increment S-4:								
D-10	D+7	--	--	--	--	--	--	--
D+8	D+10	Ammunition carrier (division)	18	18	18	--	--	--
		Howitzer personnel shelter (division)	18	18	18	--	--	--
		Ammunition carrier (EAD)	--	--	--	--	24	--
		Howitzer personnel shelter (EAD)	--	--	--	--	24	--
		BSA generators	--	--	--	--	5	--
H-hour	H+23	Ammunition carrier (division)	18	18	18	--	--	--
		Howitzer personnel shelter (division)	18	18	18	--	--	--
		Ammunition carrier (EAD)	--	--	--	--	24	--
		Howitzer personnel shelter (EAD)	--	--	--	--	24	--
		BSA generators	--	--	--	--	5	--

Figure E-17 (Continued on Next Page)

SURVIVABILITY WORKLOAD — EUROPE (Continued)

From	Through	Effort By Task	Brigade Area 1st	2nd	3rd	Avn	AR*	DRA
H+24	H+47	Ammunition carrier (division)	17	17	17	--	--	--
		Howitzer personnel shelter (division)	17	17	17	--	--	--
		Ammunition carrier (EAD)	--	--	--	--	23	--
		Howitzer personnel shelter (EAD)	--	--	--	--	23	--
		BSA generators	--	--	--	--	5	--
H+48	H+95	Ammunition carrier (division)	33	33	33	--	--	--
		Howitzer personnel shelter (division)	33	33	33	--	--	--
		Ammunition carrier (EAD)	--	--	--	--	22	--
		Howitzer personnel shelter (EAD)	--	--	--	--	22	--
		BSA generators	--	--	--	--	1	--

Figure E-17

EAD SURVIVABILITY REQUIREMENTS -- ALL INCREMENTS

From	Through	Effort (Hours)	Brigade 1	2	3	Avn	AR*	DRA
			Latin American Scenario					
D+1	D+2	--	--	--	--	--	NA	--
D+3	D+4	--	--	--	--	--	NA	--
D+5	D+8	--	--	--	--	--	NA	--
D+9	D+10	--	--	--	--	--	NA	--
			European Scenario					
D-10	D+7	Man	--	--	--	--	--	--
		ACE	--	--	--	--	--	--
		SEE	--	--	--	--	--	--
		Loader	--	--	--	--	--	--
D+8	D+10	Man	--	--	--	--	3	--
		ACE	11	11	11	--	53	--
		SEE	--	--	--	--	7	--
		Loader	--	--	--	--	35	--
H-hour	H+23	Man	--	--	--	--	3	--
		ACE	--	16	5	--	42	--
		SEE	--	--	--	--	4	--
		Loader	--	--	--	--	35	--
H+24	H+47	Man	--	--	--	--	3	--
		ACE	--	10	5	--	41	--
		SEE	--	--	--	--	4	--
		Loader	--	--	--	--	34	--
H+48	H+95	Man	--	--	--	--	2	--
		ACE	24	15	15	--	58	--
		SEE	--	--	--	--	2	--
		Loader	--	--	--	--	33	--

*Attached to the division during the European scenario.

Figure E-18

considerably higher requirement for SEE equipment-hours under the European scenario than under the Latin American scenario.

(1) Under the Latin American scenario, each brigade operated in a TFOB where each maneuver battalion typically established a hilltop fire base for its headquarters. This hilltop base included one artillery battery. Engineers helped each battalion establish a hilltop perimeter defense by assisting in the construction of two-man perimeter foxholes. The battalion's companies operated from the fire base in a detached mode, and did not require engineer support for their direct-fire weapons.

(2) In Europe, the scenario required a positional defense. Therefore, all three of each manuever battalion's companies dug in. Two phase line defenses were initially constructed and the engineers always kept a fall-back position constructed as the enemy forced the battalions to pull back. The battalion headquarters was not protected with direct-fire weapon positions, since the battalion's dug-in companies provided the equivalent of this protection.

b. Availability of natural cover. The availability of natural cover had a significant effect on the survivability-related workload generated for engineers for each scenario.

(1) Under the Latin American scenario, available cover ranged from 15 to 70 percent of the battlefield, depending on the brigade AO being considered. Since there was little air threat in this scenario, most weapon and equipment systems could be protected using available natural cover. For example, one ammunition transfer point (ATP) hardstand per LID brigade required engineer help to dig in. However, the overall requirement which was generated for this task using ESC's survivability requirements algorithm

(Figure 4) was reduced by 15 to 70 percent, depending on the AO where the brigade under consideration was located.

(2) Under the European scenario, no ATP hardstands were constructed for the LID brigades, but one was dug in for the attached armored brigade. Since the LID's AOs in Europe offered more than 50 percent natural cover, this task generated no measurable engineer survivability requirement. This is because ESC adjusted its methodology to account for the high percentage of available natural cover. Specifically, each command and support facility was assumed to require twice the normal amount of available cover to allow the LID to safely locate and use natural terrain to protect those facilities. For example, the natural available cover in the armored brigade AO was 22 percent. Therefore, 100 - (2 x 22)= 56 percent. For all the other AOs with greater than 50 percent cover the equation becomes for example, 100- (2 x 67) = -34 percent. The 56 percent factor would require construction of a ATP hardstand and the negative -34 percent factor would not require construction. ESC was acutely aware of the effect of cover and adjusted the standard methodology as described in paragraph 3c to ensure LID systems were properly protected in Europe.

c. Effect of SEE attachments on equipment-hour totals. Most direct-fire weapon positions were dug using the SEE backhoe attachment, which is the SEE's main trenching tool. However, some of the SEE equipment-hours listed for these trenches included the time needed to remove soil with the SEE front-end loader. For tasks that required the construction of berms, the front-end loader attachment was used more often than the backhoe, although the backhoe was required to break the soil initially at the berm site. Since ESC could only calculate the use of one attachment at a time, the total hours required for a task are assigned to the equipment configuration usually preferred for that task. The analysis did not attempt to determine the exact ratio of use between the backhoe and front-end loader for any particular task. It was assumed that both attachments were generally needed for each task for which SEE equipment-hours were required.

LAST PAGE OF ANNEX E

ANNEX F

GENERAL ENGINEERING REQUIREMENTS

ANNEX F

GENERAL ENGINEERING REQUIREMENTS

1. Purpose. This annex discusses the assumptions and limitations of the methodology used to evaluate general engineering tasks under the Latin American and European scenarios, and lists the division's general engineering requirements for each scenario.

2. Scope. General engineering covers those engineering tasks in the BSA and behind the brigade rear boundaries (or within the rear portion of each TFOB) which are required for the tactical and logistical support of maneuver

units. This includes support to the LOC system and critical combat service support, communication, and CP facilities.

a. Figure F-1 groups the 26 general engineering tasks into four increments, G-1 through G-4. Increment G-1 contains those general engineering tasks which were rated most important by the SAG; Increment G-4 contains those tasks of least importance. Tasks in the same increment have the same relative priority. Figure F-2 lists the generic definitions for those tasks included in the general engineering priority increments.

GENERAL ENGINEERING TASKS AND INCREMENT GROUPS

Task Number	Description	Increment G-1	G-2	G-3	G-4
1	Repair MSRs	X			
2	Repair forward area airfields -- division support area (DSA)* 0.5 craters 6.8 spalls unexploded ordnance (UXO) Clear debris	X			
3	Construct pioneer roads -- division	X			
4	Maintain MSRs	X			
5	Repair MSR bridges -- construct bypass		X		
6	Maintain forward area airfield -- DSA* Repair 2.3 craters Repair 33.8 spalls Repair 0.8 UXO Clear debris		X		
7	Construct pioneer roads -- EAD		X		
8	Repair ammunition sites -- EAD		X		
9	Repair POL sites		X		
10	Construct water points		X		

Figure 1 (Continued on Next Page)

GENERAL ENGINEERING TASKS AND INCREMENT GROUPS (Continued)

Task Number	Description	Increment G-1	G-2	G-3	G-4
11	Maintain MSR bridges			X	
12	Construct forward area airfield -- DSA			X	
13	Repair battle area airfields -- BSA* 0.5 craters 6.8 spalls UXO Clear debris			X	
14	Maintain pioneer roads -- division		X		
15	Maintain pioneer roads -- EAD		X		
16	Repair CP & support centers Shelters (4.9 x 3.4 x 2.1 m) Slots (3.5 x 50 x 2 m) Berms (1.8 x 4.3 x 48.8 m)		X		
17	Construct ammunition sites -- EAD		X		
18	Repair maintenance unit sites -- EAD		X		
19	Repair general supply sites -- EAD		X		
20	Construct general supply sites -- EAD		X		
21	Construct POL sites		X		
22	Construct battle area airfield -- BSA		X		
23	Maintain battle area airfield -- BSA* Repair 2.3 craters Repair 33.8 spalls Repair 0.8 UXO Clear debris		X		
24	Construct CP & support centers Shelters (4.9 x 3.4 x 2.1 m) Slots (3.5 x 50 x 2 m) Berms (1.8 x 4.3 x 48.8 m)		X		
25	Construct maintenance unit sites -- EAD		X		
26	Construct corps support hospital (CSH)		X		

*Per air attack.

Figure F-1

GENERAL ENGINEERING INCREMENT SUMMARY

Increment	Description
G-1	Construct or repair primary LOCs.
G-2	Construct or repair secondary LOCs; protect primary facilities.
G-3	Construct and repair tertiary LOCs; protect secondary facilities.
G-4	Construct and repair other needed LOCs and facilities.

Figure F-2

b. Figure F-3 distributes the 26 general engineering tasks among 13 functional areas and three engineer work categories. The engineer work category Damage Repair (column 1) covers both enemy bomb damage and sabotage. Expedient Construction (column 2) involves such work as protective construction, site clearance, and access road construction. Maintenance Repair (column 3) work is important to sustaining the combat force; it consists of building MSRs and pioneer access roads, and maintaining airfields.

GENERAL ENGINEERING FUNCTIONAL AREAS AND TASK NUMBERS

	Engineer Work Category		
Functional Area	Damage Repair	Expedient Construction	Maintenance Repair
MSRs	1	--	4
MSR bridges	5	--	11
Forward area airfields -- DSA	2	12	6
Battle area airfields -- BSA	13	22	23
Pioneer roads -- division	--	3	14
Pioneer roads -- EAD	--	7	15
CP and support centers -- division	16	24	--
Ammunition sites -- EAD	8	17	--
Maintenance units sites -- EAD	18	25	--
General supply sites -- EAD	19	20	--
POL sites	9	21	--
Water points	--	10	--
CSH	--	26	--

Figure F-3

3. Methodology. The method ESC used to generate general engineering requirements in the Latin American and European scenarios is outlined in Figure F-4. The variable which most significantly influenced the general engineering requirement was the initial battlefield situation and subsequent unit movements, as defined by the scenarios. The second most influential variable was the battlefield terrain. Among the most important terrain features were soil condition (especially during the rainy season), slope, and availability of natural cover.

a. ESC quantitatively estimated the engineer effort required to complete the tasks within each engineer work category, based on both a terrain analysis of the scenario battlefield and the battlefield situation encountered during each scenario period. Each of these three engineer work categories is defined below.

(1) Damage repair. Before the engineer effort needed to complete damage repair tasks could be assessed, the amount of damage expected to result from bombing, strafing, and sabotage against the LID's command and support facilities was estimated.

(a) To generate estimates of bomb damage for the European scenario, ESC used a method developed for its 1985 assessment of the combat engineer requirements of a high technology motorized division.[1]

(b) ESC postulated a sabotage threat to the LID for both scenarios and generated estimates for sabotage damage repair. These estimates were based on the number of enemy agent teams expected to be operating in the scenario AOs, and the frequency and type of targets presumably being attacked by those teams during each scenario.

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[1] Engineering Analysis of the 9th Infantry Division (Motorized) (9ID [MTZ]), Volume I (Engineer Studies Center [ESC], December 1985).

GENERAL ENGINEERING REQUIREMENTS METHODOLOGY

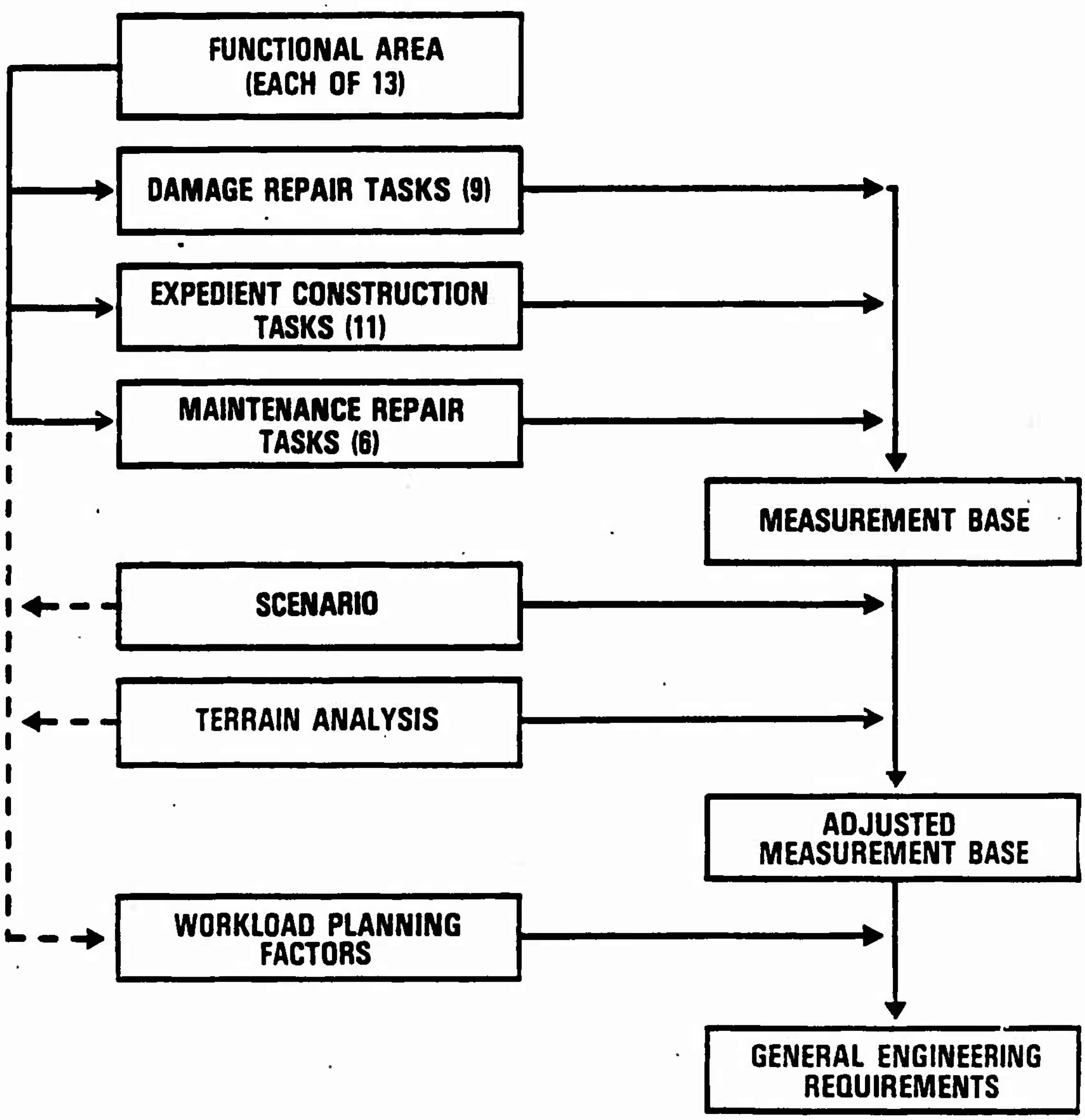

Figure F-4

(2) Expedient construction. ESC determined the scope of each expedient construction task based primarily on the dimensions of the tactical zones, frequency of unit relocations, LID strength, and the amount of host nation and US forward deployed support available.

(a) The dimensions of the tactical zones vary by period for each scenario. Since the work requirements of many tasks were based on these dimensions, ESC calculated the rear area dimensions for each period of each scenario.

(b) Expedient construction was required each time divisional headquarters, CPs, and support commands were relocated. The frequency of unit relocation was determined by the battlefield situation during each period of each scenario. These frequencies were used to calculate work requirements for each general engineering task.

(c) The attrited LID unit strength was scenario-driven and was determined for each period of each scenario. These data determined required stockage levels of POL, ammunition, and other supplies. These stockage levels were used to calculate protective construction requirements.

(d) ESC determined what percentage of each expedient construction task could be met with existing host nation and US forward deployed facilities. The remaining percentage was the amount of the task which had to be completed by engineers supporting the LID in each base case scenario.

(3) Maintenance repair. Road networks and airfield surfaces deteriorate over time. This deterioration process is accelerated by constant daily use, damage repair limited to keeping the surface at the minimum usable standard, and by adverse weather conditions. During both scenarios, maintenance repair was required after a time to keep the LOCs and facilities open.

For airfields, the minimum air operating surface (MAOS) was opened to full air operating surface (AOS). Workload estimates were based on the original expedient construction planning factor or the percentage of road net in use. This percentage was usually low (1 to 3 percent) and never exceeded 10 percent.

b. The measurement base (see Figure F-4) was modified to fit the variables of the scenarios and terrain analyses outlined above. Workload planning factors (equipment-hours and manhours) were derived from interviews with the staff of the 7th ID(L) at Ford Ord, California, and from standard engineer references, such as the US Army Engineer School's 1979 Combat Developments Engineer Family of Systems Study (E-FOSS). These planning factors were then applied to the adjusted measurement base for the final calculation of general engineering requirements. The general engineering planning factors in Figures F-5 and F-6 were used to generate all the general engineering requirements listed in this annex.

4. Results.

a. Figure F-7 lists those general engineering tasks that this analysis determined were not required under the study scenarios; these tasks are therefore omitted from the overall requirements listed in Figures F-8 through F-13.

(1) Under the Latin American scenario, none of the systems listed under the Damage Repair engineer work category were dug-in because there was no air or sabotage threat. No forward area or battle area airfields were built because there were enough host nation airfields available to meet the division's needs. Although some engineer effort was devoted to constructing maintenance unit sites and ammunition sites under this scenario, that effort was not large enough to calculate separately. Since the threat from air

GENERAL ENGINEERING PLANNING FACTORS -- LATIN AMERICA

		Equipment-Hours				
	Manhours	ACE/ Dozer	Truck	JD410/ SEE	Grader	Loader
Repair 10 m of MSR (dirt/gravel repair)[a]		0.28	1.28			0.32
Construct bridge bypass within 1 km of bridge[b]		1.80	2.10			
Construct 1 km of pioneer road[b]	11.40	11.40				
Construct CP/support shelter[b]						
Slot trench (12 x 3.5 x 1.5 m)	0.08	0.45				0.20
Berm around trench (14 x 6 x 1 m)						
Construct ammunition storage berm[b] (14.5 x 14.5 x 1.5 m)	0.70	5.40				
Construct general supply site berm[b] (14.5 x 14.5 x 1.5 m)	0.70	5.40				
Construct maintenance unit site berm[b] (14 x 14 x 1 m)	0.70	5.20				
Construct POL berm (11.5 x 11.5 x 1.8 m)		0.80	4.00			
Construct CSH facility (54,500 m^2)[b]		16.10	19.50	15.30	15.30	4.10
Site drainage (800 m = 291 BCY)		0.80	13.80			
Sanitation pits		15.30	5.70	15.30	15.30	4.10
Construct water point[d]		4.28	2.28		1.00	
Turnout (200 m)		2.28	2.28			
Baffle dam (3 x 3 x 1 m)		2.00			1.00	
Maintain MSR (per 1 km)[c]		1.00		0.20		0.20
Maintain MSR bridge (per 100 km)[c] (per 100 m)		0.50		0.10		0.10
Maintain pioneer roads[c] (per 1 km per day)	1.00		0.30		0.30	0.10
Lay airfield M-19 matting[e] (per 250 sq ft)	1.00					

[a] 10 x 8 m x 1.5 m) = 120 BCY x 1.3 = 157 LCY: ESC estimate based on Caterpillar Performance Handbook (Caterpillar Tractor Company, October 1984).

[b] Engineer Analysis of the 9th Infantry Division (Motorized) (9th ID[MTZ]) (ESC, December 1985).

[c] Combat Developments Engineer Family of Systems Study (E-FOSS), Volume VII, Appendix N (USAES, February 1979).

[d] Field Water Supply, Army Technical Manual (TM) 5-700 (Department of the Army, Headquarters [DA HQ], July 1967); an ESC-modified estimate.

[e] Planning and Design of Roads, Airbases, and Helipads in Theater of Operations, TM 5-330 (DA HQ, September 1968); an ESC-modified estimate.

Figure F-5

GENERAL ENGINEERING PLANNING FACTORS -- EUROPE

		Equipment-Hours				
	Manhours	ACE/ Dozer	Truck	JD410/ SEE	Grader	Loader
Repair 30.48 m of MSR (Clear 2-lane -- RBE)[a]		5.30				5.30
Repair airfield (MAOS/air attack)[b]						
0.5 crater	5.40	1.70	1.10		0.30	1.10
6.8 spalls	5.40		0.20			
UXO	0.10					
Clear debris	0.10		2.10			
Repair CP & support centers -- division[b]						
21 shelters (4.9 x 3.4 x 2.1 m)	558.60		88.20			29.40
42 slots (3.5 x 50 x 2 m)		4.20				8.40
21 berms (1.8 x 4.3 x 48.8 m)		8.40				
Repair CP & support centers -- BSA[b]						
5 shelters (4.9 x 3.4 x 2.1 m)	133.00		21.00			7.00
8 slots (3.5 x 50 x 2 m)	0.80				1.60	
5 berms (1.8 x 4.3 x 48.8 m)		2.00				
Repair POL sites[b]	0.40	5.00				
Construct bridge bypass within 1 km of bridge[a]	6.50	3.25	9.75			3.25
Construct 1-km pioneer road[b]	11.40	11.40				
Construct CP/support shelter -- division[b]						
21 shelters (4.9 x 3.4 x 2.1 m)	5,586.00		882.00			294.00
42 slots (3.5 x 50 x 2 m)		33.60				71.40
21 berms (1.8 x 4.3 x 48.8 m)		84.00				
Construct CP/support shelter -- BSA[b]						
5 shelters (4.9 x 3.4 x 2.1 m)	1,330.00		210.00			70.00
8 slots (3.5 x 50 x 2 m)		6.40				13.60
5 berms (1.8 x 4.3 x 48.8 m)		20.00				
Construct POL berm (11.5 x 11.5 x 1.8 m)[a]	0.80	4.00				
Maintain MSR per 1 km[a]	1.00		0.20		0.20	
Maintain MSR bridge (per meter per day)[b]	1.00		0.20		0.20	
Maintain pioneer roads (per 1 km per day)[a]	1.00		0.30		0.30	0.10
Maintain airfield (AOS/air attack)[b]						
Repair 2.3 craters/air attack	27.60	8.70	5.60		1.50	5.60
Repair 33.8 spalls/air attack	26.80		1.00			
Repair 0.8 UXO/air attack	0.80					
Clear debris	0.50				2.10	

[a] Combat Developments Engineer Family of Systems Study (E-FOSS), Volume VII, Appendix N (USAES, February 1979).

[b] Engineer Analysis of the 9th Infantry Division (Motorized) (9th ID[MTZ]) (ESC, December 1985).

Figure F-6

UNREQUIRED GENERAL ENGINEERING TASKS

		Reason			
Task	Increment	O&O Concept	Host Nation & US Forces	Host Nation & US Facility	Threat
Latin American Scenario					
Damage Repair:					
Forward Area Airfields (DSA)	G1				X
Battle Area Airfields (BSA)	G3				X
CP & Support Centers (Div)	G3				X
Ammunition Sites (EAD)	G2				X
Maintenance Unit Sites (EAD)	G3				X
General Supply Sites (EAD)	G3				X
POL Sites	G2				X
Expedient Construction:					
Forward Area Airfields (DSA)	G3			X	
Battle Area Airfields (BSA)	G4	X			X
Maintenance Unit Sites (EAD)	G4			X	
Ammunition Sites (EAD)	G3			X	
Maintenance Repair:					
Forward Area Airfields (DSA)	G2				X
Battle Area Airfields (BSA)	G4				X
European Scenario					
Damage Repair:					
Ammunition Sites (EAD)	G2		X		
Maintenance Unit Sites (EAD)	G3		X		
General Supply Sites (EAD)	G3		X		
Expedient Construction:					
Forward Area Airfields (DSA)	G3			X	
Battle Area Airfields (BSA)	G4			X	
Pioneer Roads (EAD)	G2			X	
Ammunition Sites (EAD)	G3		X		
General Supply Sites (EAD)	G3		X		
Water Points	G2			X	
Maintenance Unit Sites (EAD)	G4		X		
CSH Facility (EAD)	G4	X			
Maintenance Repair:					
Pioneer Roads (EAD)	G3		X		

Figure F-7

attacks and sabotage was negligible, no requirement for the major repair of these facilities was calculated.

(2) Under the European scenario, EAD units were not required for ammunition sites, maintenance unit sites, and general supply sites since either existing host-nation facilities or US forward deployed facilities were available. A forward area airfield and battle area airfield already existed in the AO and access to them was granted by the host nation. The host nation road network was sufficient to support all of the EAD units' required movements. Since water was readily available throughout the European AO, no forward water points were required. According to doctrine, no CSH facility was assigned to the divisional AO under the European scenario; in Europe, the CSH was located in the corps rear area.

b. Figures F-8 to F-11 summarize the overall general engineering requirements for each scenario by unit area and period of battle. The survivability requirements, not included in Annex E for the division main CP, DISCOM, and other units located to the rear of the brigade rear boundary, are listed in Figures F-12 and F-13.

c. The general engineering workloads (tasks accomplished) for Latin America and Europe are shown in Figures F-12 and F-13.

d. The EAD requirements listed by time period in Figure F-14 are for all G-1 through G-4 increments under both the Latin American and European scenarios. These requirements were extracted from the total effort listed in Figures F-8 through F-11. There were no general engineering EAD requirements under the European scenario because of the LID's operational concept, which used available host nation and US forward deployed force facilities whenever possible.

GENERAL ENGINEERING REQUIREMENTS -- INCREMENT G-1

From	Through	Effort (Hours)	Brigade Area 1	2	3	AR*	DRA
		Latin American Scenario					
D+1	D+2	Man	--	--	--	NA	17
		ACE	--	--	--	NA	17
		Loader	--	--	--	NA	1
		Grader	--	--	--	NA	--
		Truck	--	--	--	NA	--
		SEE	--	--	--	NA	--
D+3	D+4	Man	--	--	--	NA	4
		ACE	--	--	--	NA	4
		Loader	--	--	--	NA	--
		Grader	--	--	--	NA	--
		Truck	--	--	--	NA	--
		SEE	--	--	--	NA	--
D+5	D+8	Man	--	--	--	NA	--
		ACE	--	--	--	NA	1
		Loader	--	--	--	NA	1
		Grader	--	--	--	NA	--
		Truck	--	--	--	NA	1
		SEE	--	--	--	NA	--
D+9	D+10	Man	--	--	--	NA	42
		ACE	--	--	--	NA	43
		Loader	--	--	--	NA	1
		Grader	--	--	--	NA	--
		Truck	--	--	--	NA	1
		SEE	--	--	--	NA	--
		European Scenario					
D-10	D+7	Man	--	--	--	--	57
		ACE	--	--	--	--	61
		Loader	--	--	--	--	4
		Grader	--	--	--	--	--
		Truck	--	--	--	--	--

Figure F-8 (Continued on Next Page)

GENERAL ENGINEERING REQUIREMENTS -- INCREMENT G-1 (Continued)

From	Through	Efforc (Hours)	Brigade Area 1	2	3	AR*	DRA
		European Scenario (Continued)					
D+8	D+10	Man	--	--	--	--	57
		ACE	--	--	--	--	61
		Loader	--	--	--	--	4
		Grader	--	--	--	--	--
		Truck	--	--	--	--	--
H-hour	H+23	Man	--	--	--	--	11
		ACE	--	--	--	--	5
		Loader	--	--	--	--	4
		Grader	--	--	--	--	1
		Truck	--	--	--	--	3
H+24	H+47	Man	--	--	--	--	--
		ACE	--	--	--	--	4
		Loader	--	--	--	--	4
		Grader	--	--	--	--	--
		Truck	--	--	--	--	--
H+48	H+95	Man	--	--	--	--	68
		ACE	--	--	--	--	62
		Loader	--	--	--	--	5
		Grader	--	--	--	--	1
		Truck	--	--	--	--	3

*Attached to the division during the European scenario.

Figure F-8

GENERAL ENGINEERING REQUIREMENTS -- INCREMENT G-2

From	Through	Effort (Hours)	Brigade Area 1	2	3	AR*	DRA
		Latin American Scenario					
D+1	D+2	Man	--	--	--	NA	10
		ACE	--	--	--	NA	5
		Loader	--	--	--	NA	--
		Grader	--	--	--	NA	1
		Truck	--	--	--	NA	1
		SEE	--	--	--	NA	1
D+3	D+4	Man	--	--	--	NA	25
		ACE	--	--	--	NA	7
		Loader	--	--	--	NA	--
		Grader	--	--	--	NA	3
		Truck	--	--	--	NA	--
		SEE	--	--	--	NA	13
D+5	D+8	Man	--	--	--	NA	33
		ACE	--	--	--	NA	--
		Loader	--	--	--	NA	7
		Grader	--	--	--	NA	7
		Truck	--	--	--	NA	--
		SEE	--	--	--	NA	14
D+9	D+10	Man	--	--	--	NA	98
		ACE	--	--	--	NA	19
		Loader	--	--	--	NA	--
		Grader	--	--	--	NA	16
		Truck	--	--	--	NA	16
		SEE	--	--	--	NA	--
		European Scenario					
D-10	D+7	Man	--	--	--	--	58
		ACE	--	--	--	--	3
		Loader	--	--	--	--	3
		Grader	--	--	--	--	10
		Truck	--	--	--	--	20

Figure F-9 (Continued on Next Page)

GENERAL ENGINEERING REQUIREMENTS -- INCREMENT G-2 (Continued)

From	Through	Effort (Hours)	Brigade Area 1	2	3	AR*	DRA
		European Scenario (Continued)					
D+8	D+10	Man	--	--	--	--	58
		ACE	--	--	--	--	3
		Loader	--	--	--	--	3
		Grader	--	--	--	--	10
		Truck	--	--	--	--	20
H-hour	H+23	Man	--	--	--	--	150
		ACE	--	--	--	--	17
		Loader	--	--	--	--	9
		Grader	--	--	--	--	21
		Truck	--	--	--	--	24
H+24	H+47	Man	--	--	--	--	210
		ACE	--	--	--	--	8
		Loader	--	--	--	--	3
		Grader	--	--	--	--	41
		Truck	--	--	--	--	50
H+48	H+95	Man	--	--	--	--	274
		ACE	--	--	--	--	17
		Loader	--	--	--	--	9
		Grader	--	--	--	--	46
		Truck	--	--	--	--	59

*Attached to the division during the European scenario.

Figure F-9

GENERAL ENGINEERING REQUIREMENTS -- INCREMENT G-3

From	Through	Effort (Hours)	Brigade Area 1	2	3	AR*	DRA
		Latin American Scenario					
D+1	D+2	Man	--	--	--	NA	7
		ACE	--	--	--	NA	3
		Loader	--	--	--	NA	--
		Grader	--	--	--	NA	2
		Truck	--	--	--	NA	2
		SEE	--	--	--	NA	--
D+3	D+4	Man	--	--	--	NA	13
		ACE	--	--	--	NA	11
		Loader	--	--	--	NA	--
		Grader	--	--	--	NA	3
		Truck	--	--	--	NA	3
		SEE	--	--	--	NA	--
D+5	D+8	Man	--	--	--	NA	13
		ACE	--	--	--	NA	3
		Loader	--	--	--	NA	--
		Grader	--	--	--	NA	3
		Truck	--	--	--	NA	3
		SEE	--	--	--	NA	--
D+9	D+10	Man	--	--	--	NA	18
		ACE	--	--	--	NA	6
		Loader	--	--	--	NA	4
		Grader	--	--	--	NA	--
		Truck	--	--	--	NA	4
		SEE	--	--	--	NA	--
		European Scenario					
D-10	D+7	Man	--	--	--	--	6
		ACE	--	--	--	--	12
		Loader	--	--	--	--	--
		Grader	--	--	--	--	1
		Truck	--	--	--	--	1

Figure F-10 (Continued on Next Page)

GENERAL ENGINEERING REQUIREMENTS -- INCREMENT G-3 (Continued)

From	Through	Effort (Hours)	Brigade Area 1	2	3	AR*	DRA
		European Scenario (Continued)					
D+8	D+10	Man	--	--	--	--	70
		ACE	--	--	--	--	13
		Loader	--	--	--	--	5
		Grader	--	--	--	--	10
		Truck	--	--	--	--	15
H-hour	H+23	Man	--	--	--	--	50
		ACE	--	--	--	--	1
		Loader	--	--	--	--	3
		Grader	--	--	--	--	4
		Truck	--	--	--	--	10
H+24	H+47	Man	--	--	--	11	57
		ACE	--	--	--	2	1
		Loader	--	--	--	1	3
		Grader	--	--	--	1	5
		Truck	--	--	--	3	11
H+48	H+95	Man	--	--	--	11	66
		ACE	--	--	--	2	13
		Loader	--	--	--	1	4
		Grader	--	--	--	1	8
		Truck	--	--	--	3	13

*Attached to the division during the European scenario.

Figure F-10

GENERAL ENGINEERING REQUIREMENTS -- INCREMENT G-4

From	Through	Effort (Hours)	Brigade Area 1	2	3	AR*	DRA
		Latin American Scenario					
D+1	D+2	Man	--	--	--	NA	2
		ACE	--	--	--	NA	10
		Loader	--	--	--	NA	--
		Grader	--	--	--	NA	--
		Truck	--	--	--	NA	--
		SEE	--	--	--	NA	--
D+3	D+4	Man	--	--	--	NA	2
		ACE	--	--	--	NA	18
		Loader	--	--	--	NA	--
		Grader	--	--	--	NA	--
		Truck	--	--	--	NA	--
		SEE	--	--	--	NA	--
D+5	D+8	Man	--	--	--	NA	1
		ACE	--	--	--	NA	7
		Loader	--	--	--	NA	--
		Grader	--	--	--	NA	--
		Truck	--	--	--	NA	--
		SEE	--	--	--	NA	--
D+9	D+10	Man	--	--	--	NA	16
		ACE	--	--	--	NA	20
		Loader	--	--	--	NA	--
		Grader	--	--	--	NA	4
		Truck	--	--	--	NA	15
		SEE	--	--	--	NA	15
		European Scenario					
D-10	D+7	Man	--	--	--	--	--
		ACE	--	--	--	--	--
		Loader	--	--	--	--	--
		Grader	--	--	--	--	--
		Truck	--	--	--	--	--

Figure F-11 (Continued on Next Page)

GENERAL ENGINEERING REQUIREMENTS -- INCREMENT G-4 (Continued)

From	Through	Effort (Hours)	Brigade Area 1	2	3	AR*	DRA
		European Scenario (Continued)					
D+8	D+10	Man	1,320	1,320	1,320	1,320	2,793
		ACE	26	26	26	26	59
		Loader	84	84	84	84	183
		Grader	--	--	--	--	--
		Truck	210	210	210	210	441
H-hour	H+23	Man	--	1,320	--	1,320	--
		ACE	--	26	--	26	--
		Loader	--	84	--	84	--
		Grader	--	--	--	--	--
		Truck	--	210	--	210	--
H+24	H+47	Man	--	--	--	7	--
		ACE	--	--	--	9	--
		Loader	--	--	--	6	--
		Grader	--	--	--	4	--
		Truck	--	--	--	7	--
H+48	H+95	Man	1,320	1,320	1,320	1,386	2,793
		ACE	26	26	26	35	59
		Loader	84	84	84	89	189
		Grader	--	--	--	4	--
		Truck	210	210	210	217	441

*Attached to the division during the European scenario.

Figure F-11

GENERAL ENGINEERING WORKLOAD -- LATIN AMERICA

From	Through	Effort By Task	Brigade Area 1	Brigade Area 2	Brigade Area 3	DRA
		Increment G-1:				
D+1	D+2	Construct 1-km pioneer roads (DRA)	--	--	--	2
D+3	D+4	Construct 1-km pioneer roads (DRA)	--	--	--	1
D+5	D+8	Repair 10-m MSR (dirt/gravel repair)	--	--	--	1
D+9	D+10	Repair 10-m MSR (dirt/gravel repair)	--	--	--	1
		Construct 1-km pioneer roads (DRA)	--	--	--	4
		Increment G-2:				
D+1	D+2	Construct water points	--	--	--	2
		Maintain 1-km MSRs	--	--	--	1
D+3	D+4	Repair MSR bridges (bypass within 1 km of bridge)	--	--	--	1
		Construct 1-km pioneer road (EAD)	--	--	--	1
		Construct water points	--	--	--	1
		Maintain 1-km MSRs	--	--	--	16
D+5	D+8	Maintain 1-km MSRs	--	--	--	33
D+9	D+10	Repair MSR bridges (bypass within 1 km of bridge)	--	--	--	1
		Construct 1-km pioneer road (EAD)	--	--	--	1
		Construct water points	--	--	--	1
		Maintain 1-km MSRs	--	--	--	78
		Increment G-3:				
D+1	D+2	Construct POL berms (11.5 x 11.5 x 1.8 m)	--	--	--	1
		Maintain 100-m MSR bridges	--	--	--	1
		Maintain 1-km pioneer roads (DRA)	--	--	--	6

Figure F-12 (Continued on Next Page)

GENERAL ENGINEERING WORKLOAD -- LATIN AMERICA (Continued)

From	Through	Effort By Task	Brigade Area 1	Brigade Area 2	Brigade Area 3	DRA
		Increment G-3: (Continued)				
D+3	D+4	Construct POL berms (11.5 x 11.5 x 1.8 m)	--	--	--	2
		Construct general support sites	--	--	--	1
		Maintain 100-m MSR bridges	--	--	--	4
		Maintain 1-km pioneer roads (DRA)	--	--	--	8
		Maintain 1-km pioneer roads (EAD)	--	--	--	1
D+5	D+8	Construct POL berms (11.5 x 11.5 x 1.8 m)	--	--	--	1
		Maintain 100-m MSR bridges	--	--	--	8
		Maintain 1-km pioneer roads (DRA)	--	--	--	8
		Maintain 1-km pioneer roads (EAD)	--	--	--	1
D+9	D+10	Construct POL berms (11.5 x 11.5 x 1.8 m)	--	--	--	1
		Construct general support sites	--	--	--	1
		Maintain 100-m MSR bridges	--	--	--	13
		Maintain 1-km pioneer roads (DRA)	--	--	--	8
		Maintain 1-km pioneer roads (EAD)	--	--	--	3
		Increment G-4:				
D+1	D+2	Construct CP/support center	--	--	--	5
D+3	D+4	Construct CP/support center	--	--	--	3
D+5	D+8	Construct CP/support center	--	--	--	1
D+9	D+10	Construct CP/support center	--	--	--	2
		Construct CSH facility (54,500 m^2)	--	--	--	1

Figure F-12

GENERAL ENGINEERING WORKLOAD -- EUROPE

From	Through	Effort By Task	Brigade Area 1	Brigade Area 2	Brigade Area 3	Brigade Area AR*	DRA
		Increment G-1:					
D-10	D+7	Repair 30.48-m MSR (Clear two lane RBE)	--	--	--	--	67
		Construct 1-km pioneer roads (DRA)	--	--	--	--	5
D+8	D+10	Repair 30.48-m MSR (Clear two lane RBE)	--	--	--	--	67
		Construct 1-km pioneer roads (DRA)	--	--	--	--	5
H-hour	H+23	Repair 30.48-m MSR (Clear two lane RBE)	--	--	--	--	58
		Repair forward area airfield (DSA)	--	--	--	--	1
H+24	H+47	Repair 30.48-m MSR (Clear two lane RBE)	--	--	--	--	67
H+48	H+95	Repair 30.48-m MSR (Clear two lane RBE)	--	--	--	--	72
		Repair forward area airfield (DSA)	--	--	--	--	1
		Construct 1-km pioneer roads (DRA)	--	--	--	--	5
		Increment G-2:					
D-10	D+7	Repair MSR bridges (bypass within 1 km of bridge)	--	--	--	--	1
		Maintain 1-km MSRs	--	--	--	--	51
D+8	D+10	Repair MSR bridges (bypass within 1 km of bridge)	--	--	--	--	1
		Maintain 1-km MSRs	--	--	--	--	51

Figure F-13 (Continued on Next Page)

GENERAL ENGINEERING WORKLOAD -- EUROPE (Continued)

From	Through	Effort By Task	Brigade Area 1	2	3	AR*	DRA
		Increment G-2: (Continued)					
H-hour	H+23	Repair MSR bridges (bypass within 1 km of bridge)	--	--	--	--	1
		Repair POL berms	--	--	--	--	1
		Maintain 1-km MSRs	--	--	--	--	88
		Maintain forward area airfield	--	--	--	--	1
H+24	H+47	Repair MSR bridges (bypass within 1 km of bridge)	--	--	--	--	1
		Repair POL berms	--	--	--	--	1
		Maintain 1-km MSRs	--	--	--	--	203
H+48	H+95	Repair MSR bridges (bypass within 1 km of bridge)	--	--	--	--	1
		Repair POL berms	--	--	--	--	1
		Maintain 1-km MSRs	--	--	--	--	313
		Maintain forward area airfield	--	--	--	--	1
		Increment G-3:					
D-10	D+7	Construct POL berms	--	--	--	--	3
		Maintain MSR bridges	--	--	--	--	3
D+8	D+10	Repair CP/support center	--	--	--	--	1
		Construct POL berms	--	--	--	--	3
		Maintain MSR bridges	--	--	--	--	3
		Maintain 1-km pioneer roads (DRA)	--	--	--	--	30
H-hour	H+23	Repair CP/support center(DRA)	--	--	--	--	1
		Maintain MSR bridges	--	--	--	--	5
		Maintain 1-km pioneer roads (DRA)	--	--	--	--	10

Figure F-13 (Continued on Next Page)

GENERAL ENGINEERING WORKLOAD -- EUROPE (Continued)

From	Through	Effort By Task	Brigade Area 1	Brigade Area 2	Brigade Area 3	Brigade Area AR*	Brigade Area DRA
		Increment G-3: (Continued)					
H+24	H+47	Repair battle area airfields (BSA)	--	--	--	1	--
		Repair CP/support center (DRA)	--	--	--	--	1
		Repair CP/support center (BSA)	--	1	--	1	--
		Maintain MSR bridges	--	--	--	--	12
		Maintain 1-km pioneer roads (DRA)	--	--	--	--	10
H+48	H+95	Repair battle area airfields (BSA)	--	--	--	1	--
		Repair CP/support center (DRA)	--	--	--	--	1
		Repair CP/support center (BSA)	--	1	--	1	--
		Construct POL berms	--	--	--	--	3
		Maintain MSR bridges	--	--	--	--	9
		Maintain 1-km pioneer roads (DRA)	--	--	--	--	20
		Increment G-4:					
D-10	D+7	Construct CP/support center (DRA)	--	--	--	--	1
D+8	D+10	Construct CP/support center (DRA)	--	--	--	--	1
		Construct CP/support center (BSA)	1	1	1	1	--
H-hour	H+23	Construct CP/support center (DRA)	--	--	--	--	1
		Construct CP/support center (BSA)	--	1	--	1	--
H+24	H+47	Maintain battle area airfield	--	--	--	1	--
H+48	H+95	Maintain battle area airfield	--	--	--	1	--
		Construct CP/support center (BSA)	1	1	1	1	--

Figure F-13

EAD GENERAL ENGINEERING REQUIREMENTS -- ALL INCREMENTS

From	Through	Effort (Hours)	Brigade Area 1	2	3	CAB	AR*	DRA
		Latin American Scenario						
D+1	D+2	Man	--	--	--	--	NA	--
		ACE	--	--	--	--	NA	--
		Grader	--	--	--	--	NA	--
		Truck	--	--	--	--	NA	--
		SEE	--	--	--	--	NA	--
D+3	D+4	Man	--	--	--	--	NA	4
		ACE	--	--	--	--	NA	7
		Grader	--	--	--	--	NA	1
		Truck	--	--	--	--	NA	1
		SEE	--	--	--	--	NA	--
D+5	D+8	Man	--	--	--	--	NA	1
		ACE	--	--	--	--	NA	--
		Grader	--	--	--	--	NA	1
		Truck	--	--	--	--	NA	1
		SEE	--	--	--	--	NA	--
D+9	D+10	Man	--	--	--	--	NA	33
		ACE	--	--	--	--	NA	37
		Grader	--	--	--	--	NA	5
		Truck	--	--	--	--	NA	16
		SEE	--	--	--	--	NA	15
		European Scenario						
D-10	D+7	--	--	--	--	--	--	--
D+8	D+10	--	--	--	--	--	--	--
H-hour	H+23	--	--	--	--	--	--	--
H+24	H+47	--	--	--	--	--	--	--
H+48	H+95	--	--	--	--	--	--	--

*Attached to the division during the European scenario.

Figure F-14

5. Airfield Excursion -- Latin America. The general engineering requirements to upgrade an existing host nation sod strip with a 2,500- x 60-foot taxiway and a 600- x 150-foot parking apron were evaluated separately as an independent excursion from the study scenarios. The runway, parking apron, run-up area, and the taxiway were all covered with M-19 matting. Once upgraded, the runway would sustain continuous C-130 aircraft operations.

a. The following assumptions were made for this excursion:

(1) It was estimated that the excursion would require a 20-BCY cut and fill for every 200 feet of 60-foot-wide airfield, based on assumed erosion damage to the sod airfield.

(2) The M-19 matting will cover all load-bearing portions of the airfield. The size of the airfield would require the installation of 416,000 square feet of panels.

(3) It takes one manhour to lay 250 square feet of M-19 matting; therefore, it takes 1,664 manhours (208 squad-hours) to lay 416,000 square feet of matting.[2]

(4) Equipment-hour factors used were acquired from standard sources, such as E-FOSS. SEE equipment-hours for the 85-inch dozer blade attachment were obtained by ESC directly from the Mercedes-Benz UNIMOG representative.

b. Four alternatives were considered for this excursion: Alternatives A and B used the equipment organic to the LID engineer battalion. Alternative A assumes the AO can be reached by road; therefore, the more efficient ACE is employed for all equipment tasks. Alternative B assumes the road

[2]Planning and Design of Roads, Airbases, and Helipads in Theater of Operations, TM 5-330 (DA HQ, September 1968).

network is inadequate, requiring all equipment to be airlifted by helicopter into the AO. Since the ACE cannot be airlifted by helicopter, the SEE was the only item of equipment available under Alternative B. Alternatives C and D used engineer EAD battalion units. Alternative C is the corps battalion (TOE 5-35H) and Alternative D is the airborne corps battalion (TOE 5-195L). These units have similar organic equipment, except the airborne unit has the smaller D-6 dozer, which can be broken down into two loads and airlifted by a CH-47 helicopter. Figure F-15 lists the equipment-hours required by each excursion.

c. An ESC terrain analysis was also conducted on a fictional area in the shallow tropics using a synthetic map developed for a 1970 US Army Waterways Experiment Station study.[3] From that terrain analysis, it was determined the average distance from any AO to a C-130-capable airfield was 52 kilometers. In the worst possible case, the maximum distance was 138 kilometers from AO to airfield.

6. Observations.

a. Several AOs in the Latin American scenario were only accessible by helicopter. In those AOs, only the SEE (which can be airlifted by helicopter) was used for general engineering tasks instead of the ACE (which cannot be airlifted by helicopter). Under the European scenario, the extensive European road net allowed the engineers to choose either the SEE or the ACE, so the more efficient ACE was always selected. Therefore, there are no SEE equipment-hours required for general engineering tasks under the European scenario.

[3] Grabau, W.E. and Shamburger, J.H., Intratheater Transportation Requirement Study, A Procedure for Constructing Synthalogous Environments, Volume I, "Rationale" (US Army Waterways Experiment Station [WES], September 1970).

AIRFIELD REHABILITATION/UPGRADE
(C – 130 AIRCRAFT)

RESOURCES	REQUIREMENT (HOURS)			
	DIVISION		EAD	
	W/ACE (A)	WO/ACE (B)	CORPS (C)	ABN CORPS (D)
SQUAD**	208	208	208	208
DOZER				
D7 / ACE	17	–	9	–
D6	–	–	–	12
GRADER	–	–	6	6
SEE:				
BLADE	–	20	–	–
OTHER	–	46	–	–

** 8 – MAN SQUAD

Figure F-15

b. No general engineering tasks were required for maneuver brigades under the Latin American scenario. Therefore, the entire workload was estimated as part of the DRA. This is partially due to the use of the TFOB concept, where there is neither a precise brigade rear boundary nor any division rear boundary. Many engineer tasks for a brigade, such as an airfield, simply shared the division asset in the same TFOB. The remaining workload that could be associated with a brigade area was not completed, mainly because there was so little air threat.

c. The results of the airfield excursion indicate that in an area with a large number of accessible airfields, such as in the case of Latin America, the need to build or maintain forward or battle area airfields is greatly reduced. The data in Figure F-15 indicate that excursion Alternative D (i.e., a corps follow-on airborne engineer battalion) is more efficient for areas inaccessible by road. Therefore, it should have priority for the task of constructing and maintaining C-130-capable airfields. This seems to be an acceptable risk for the LID, which could still complete this task in extreme situations with the SEE (or with the ACE, when roads are available). The establishment of a D5/D6 dozer for the ACE in the LID for the purposes of acquiring a helicopter-transportable dozer cannot be justified by the results of this analysis, especially considering the number of tasks for the more productive ACE.

LAST PAGE OF ANNEX F

ANNEX G

ENGINEER CLASS IV AND V REQUIREMENTS

ANNEX G

ENGINEER CLASS IV AND V REQUIREMENTS

1. Purpose. This annex identifies and quantifies the engineer Class IV and V requirements for supporting the LID in the Latin American and European scenarios considered by this study.

2. Scope. This analysis calculated the Class IV and V requirements for divisional and nondivisional engineer units under the LID's control during the study scenarios. The analysis includes requirements for all engineer functional areas: mobility, countermobility, survivability, and general engineering, and to a lesser degree the requirements for artillery- and aviation-delivered scatterable mines. In addition to quantifying the engineer Class IV and V requirements, this analysis calculates the transportation requirements associated with the movement of engineer Class IV and V materiel within the LID's area of operations.

3. Assumptions and Their Significance.

a. ASSUMPTION: The engineer Class IV and V requirements of the LID are logistically supportable in both study scenarios. SIGNIFICANCE: The overall study methodology determines the requirements for engineer squad- and equipment-hours. If these requirements were not logistically supportable, the study case comparisons overstate shortfalls or understate surplus capability.

b. ASSUMPTION: Engineer Class IV and V materiel and munitions will be delivered to the BSA by other than engineer transportation assets. SIGNIFICANCE: If engineers must travel further than the BSA to obtain Class IV and V supplies, then transportation requirements will be greater than estimated. If engineer Class IV and V materiels are pushed farther forward than the BSA, then engineer transportation requirements will decrease.

c. ASSUMPTION: The logistical and physical properties of nitromethane and XM-268, when averaged together, are equivalent to a generic liquid explosive. SIGNIFICANCE: The logistical advantages of nitromethane and XM-268 can then be compared (using the ESC-calculated properties of the generic liquid) with conventional explosives without prejudice to either system.

4. Methodology. Figure G-1 shows the overall methodology ESC used to calculate the engineer Class IV and V requirements for the two study scenarios.

a. Case descriptions. ESC examined a base case for and a new explosive excursion to both the Latin American and the European scenarios.

(1) In the Latin American scenario, the base case consisted of conventional munitions only. Transportation requirements were based on the use of the UH-60 helicopter and the 5-ton cargo truck. In the new explosive excursion, scatterable or improved conventional mines (ICOMs) and the generic

liquid explosive were substituted for conventional munitions wherever possible. The means of transporting engineer Class IV and V requirements remained the same as in the base case.

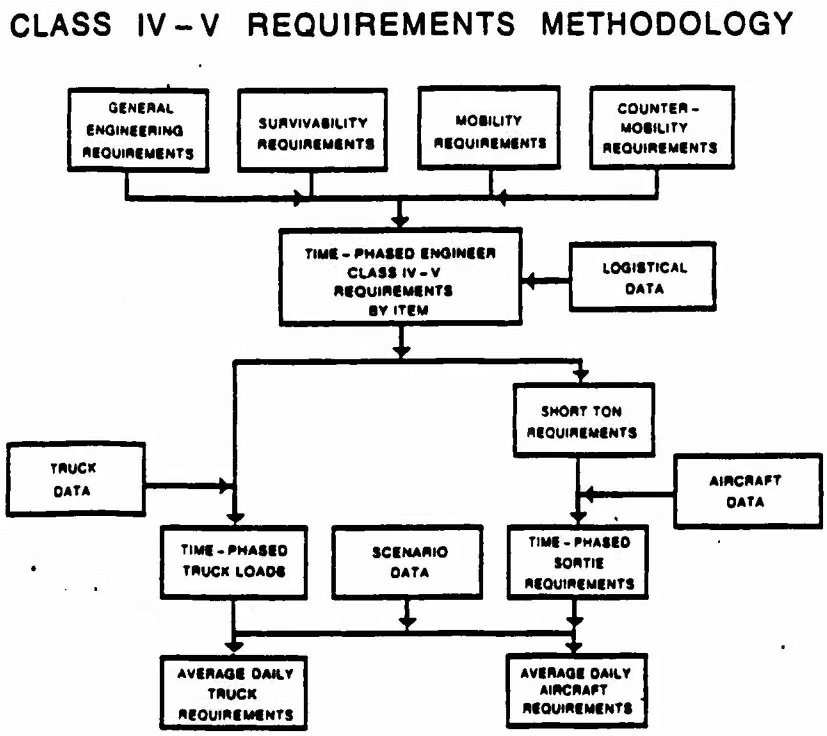

Figure G-1

(2) The base case for the European scenario consisted of conventional munitions and of artillery-delivered scatterable mines. Transportation requirements were based on the 5-ton dump truck, which is the predominant truck in the engineer support structure. The new explosive excursion uses all scatterable mines, ICOMs, and liquid explosives. Transportation requirements were evaluated using 5-ton cargo trucks, which are recommended by ESC for the engineer support structure.

b. Class IV and V requirements. The major data for this analysis are simply the Class IV and V requirements generated in the study's four engineer functional areas: mobility, countermobility, survivability, and general engineering. These requirements were developed independently during the analysis of each engineer functional area, and then combined. The total engineer Class IV and V requirement for the LID is in terms of the total quantity of individual Class IV and V items which engineers must move from the BSAs to engineer work sites.

c. Logistical data. Logistical information included packaging and shipping data about engineer barrier materiel and munitions, and information about the capabilities and configurations of aircraft and trucks used to transport engineer Class IV and V supplies.

d. Transportation requirements. ESC calculated the transportation requirements associated with LID's Class IV and V requirements in two steps: First, using the appropriate volume or weight, logistical data relating to the quantities of Class IV and V items were converted into truckloads or aircraftloads of materiel. Next, this result was combined with scenario-generated data, such as distances and speeds, to yield the LID's average daily transportation requirements for engineer Class IV and V materiel. These results are expressed in terms of the average daily number of trucks or aircraft needed to transport the engineer Class IV and V materiel.

5. Analysis of Engineer Class IV and V Requirements.

a. Engineer functional area requirements. Figure G-2 shows the contribution of each of the engineer functional areas to the total engineer Class IV and V requirement.

(1) General engineering did not generate any significant engineer Class IV and V requirement. General engineering tasks mostly require construction-related materiel (cement, culverts, lumber, aggregate, etc.) and

mostly occur in the DRA. Since this analysis focused on the more combat-oriented tasks generated in the brigade areas, Class IV or V requirements generated by general engineering tasks were not considered by this analysis.

ENGINEER FUNCTIONAL AREA CLASS IV AND V REQUIREMENTS
(Percentage by Weight)

	Functional areas			
	Mobility	Counter-mobility	Survivabilty	General Engineering
		Latin America Scenario		
Base case	2.2	96.8	<1	0
New Explosive excursion	9.4	90.0	<1	0
		European Scenario		
Base case	<1	99.0	0	0
New Explosive excursion	<1	97.6	0	0

Figure G-2

(2) Survivability work generated an almost insignificant demand for Class V materiel in the Latin American scenario. Explosives were used to help emplace protective positions and weapons positions on TFOBs inaccessible to the SEE. There were no such survivability requirements generated by the European scenario.

(3) Mobility work created a small requirement for Class IV and V materiel (bangalore torpedos and HEMMSs) in both scenarios. This requirement is proportionally higher in Latin America than in Europe, because that scenario is more offensively oriented. The increase in the mobility portion of the total Class IV and V requirement from the base case to the new explosive excursion was caused by a marked decrease in countermobility requirements.

The mobility Class IV and V requirement was the same in both the base case and new explosive excursion of each scenario.

(4) Depending on the scenario and case, countermobility Class IV and V requirements account for between 90 and 96 percent of the total engineer Class IV and V requirement. Countermobility Class IV and V requirements are generated by the need for explosives to emplace obstacles, mines for minefields, and HEMMS for marking minefields. Due to the overwhelming preponderance of countermobility Class IV and V requirements, this analysis examined the total engineer Class IV and V requirement primarily in terms of the countermobility requirement.

b. Countermobility Class IV and V requirements. In the Latin American scenario, the countermobility Class IV and V requirement was based on a site-specific obstacle plan. The European scenario requirements were based on a form of regression analysis, and the Countermobility Requirements Algorithm described in Figure D-13 of Annex D.

(1) In the Latin American scenario, specific obstacles the LID will emplace were chosen based on scenario data and a terrain analysis of the divisional AO. The Class IV and V requirements were derived by multiplying the number of obstacles selected by the logistical requirements of each obstacle type. This was done for each brigade and scenario time period for each obstacle type. The total requirement equaled the sum of the brigade requirements.

(2) In the European scenario, the engineer countermobility Class IV and V requirement was calculated by simply expanding the basic countermobility methodology described in Annex D to include Class IV and V items. This was done by modifying the Countermobility Requirements Algorithm, as shown in

Figure G-3. Notice that the final component of the algorithm has been changed to show Class IV and V item requirements.

COUNTERMOBILITY CLASS IV AND V REQUIREMENTS ALGORITHM

Engineer Countermobility Class IV and V Requirements
(Items by type obstacle) =

Area of brigade AO (km)	X	Target density (Obstacles per km)	X	Target mix (Percentage of type obstacle)	X	Class IV and V planning factor (Items per obstacle)

Figure G-3

(3) Figure G-4 shows an example of the Countermobility Class IV and V Requirements Algorithm using data for the 2d Brigade, during period 2 of the European scenario. The equation in Figure G-4 also shows an additional factor of 0.9. This factor adjusts for the fact that 10 percent of the minefields planned in period 2 were left open as gaps and lanes. This calculation was then repeated by brigade and time period for each type obstacle. The total Class IV and V requirement is equal to the sum, by time period, of each brigade's requirements.

SAMPLE COUNTERMOBILITY CLASS IV AND V REQUIREMENTS CALCULATIONS
(2d Brigade, European Scenario, Period 2)

69 km (Figure D-7)	x	1.33 obstacles per km (Figure D-8)	x	0.33 minefields per obstacle (Figure D-12)	x	0.9	x	122 AT mines 122 AP mines 0.4 HEMSS (Figure G-5)	per minefield

= 3,325 AT mines and 3,325 AP mines and 11 HEMMS

Figure G-4

c. Mobility and survivability requirements. ESC used an essentially similar procedure to estimate the much smaller mobility and survivability Class IV and V requirements. In each of these functional areas, ESC multiplied the engineer tasks by the appropriate Class IV and V requirements per task and summed the results by brigade and period.

d. Class IV and V planning factors. Planning factors for Class IV and V requirements are nothing more than the quantity of Class IV and V items consumed per engineer task. In the case of countermobility tasks, this is the number and type of Class IV and V items per obstacle. Figures G-5 and G-6 list the countermobility-related planning factors used in this study for linear and point targets. The appropriate planning factor selected from these two figures was substituted into the Countermobility Class IV and V Requirements Algorithm in Figure G-4. Similar planning factors were used for estimating mobility and survivability Class IV and V requirements.

e. Class IV and V logistical data. In order to complete all the necessary Class IV and V calculations and estimates, ESC assembled a great deal of logistical data about Class IV and V items. This information, collected from a variety of sources, is shown in Figure G-7.

f. Truck calculations. Trucks were used as the primary means of moving Class IV and V supplies for the 2d Brigade in the Latin American scenario and for all brigades in the European scenario. The number of trucks needed to move the required amount of Class IV and V materiel was estimated using a four-step procedure.

(1) Truck capacity. To determined the number of truckloads of Class IV and V materiel required, ESC first computed the capacity of the trucks in terms of individual Class IV and V items. ESC assumed that each

COUNTERMOBILITY CLASS IV AND V PLANNING FACTORS -- LINEAR OBSTACLES
(Items Per Obstacle)

Item	Obstacle type*					
	Conventional minefield	ICOM minefield	Air Volcano	Ground Volcano	Artillery-delivered minefield	Anti-tank ditch
M-15 AT mine (each)	122	--	--	--	--	23.8
M-16 AP mine (each)	122	--	--	--	--	5.6
NATO ICOM (each)	--	50	--	--	--	17
Volcano mine (each)	--	--	804	960	--	--
RAAM AT mine (each)	--	--	--	--	405	--
ADAM AP mine (each)	--	--	--	--	160	--
HEMMS (set)	0.4	0.4	--	0.4	--	--

*See Figures D-3 and D-10 for a fuller description of each obstacle.

Figure G-5

COUNTERMOBILITY CLASS IV AND V PLANNING FACTORS -- POINT OBSTACLES*
(Items Per Obstacle)

Item	Road craters <25 ft B**	Road craters >25 ft E***	Road craters <25 ft B	Road craters >25 ft E	Bridge demolition B	Bridge demolition E	Abatis B	Abatis E	Rubble blast emplacement B	Rubble blast emplacement E
40-lb shaped charge (each)	3	--	5	--	3	--	--	--	--	--
40-lb cratering charge (each)	3	--	5	--	3	--	--	--	--	--
1-lb TNT (block)	30	10	50	10	160	20	--	--	850	50
Liquid explosive (lb)	--	140	--	240	--	260	--	--	--	800
Detonating cord (ft)	150	150	150	300	300	300	--	--	150	150
M-15 AT mine (each)	18	--	36	--	36	--	18	--	18	--
M-21 AT mine (each)	12	--	24	--	24	--	12	--	12	--
M-16 AP mine (each)	3	3	6	6	6	6	3	3	3	3
NATO ICOM (each)	--	17	--	34	--	34	--	17	--	17

*See Figure D-11 for a fuller description.
**Base case.
***New explosive excursion.

Figure G-6

LOGISTICAL CHARACTERISTICS OF SELECTED ENGINEER CLASS IV AND V MATERIEL

Item	Type Package	Shipping Weight (lb)	Quantity per Package	Shipping Volume (ft)	Dimensions (in)			Capacity 5-Ton Truck (Package Per Truckload)	
					Length	Width	Height	Dump	Cargo
15-lb shaped charge	Wooden box	65	3 each	2.04	33.9	9.8	10.6	48	108
40-lb shaped charge	Wooden box	65	1 each	1.86	20.5	11.8	13.4	80	168
40-lb cratering charge	Wooden box	51	1 each	1.38	27.5	8.9	9.8	72	162
1-lb TNT	Wooden box	81	56 blocks	1.52	18.5	9.5	14.5	96	144
M-180 cratering charge	Wire bound wooden crate	165	1 kit	7.15	45.5	13.2	20.5	13	40
Liquid explosive	55-gal drum	690	615 lb	8.8	[diameter=24.1]		34.8	15	18
Detonating cord	Wooden box	105	4500 ft	3.81	30.0	15.0	14.6	40	50
Bangalore torpedo	Wooden box	198	1 set	3.67	64.1	13.9	7.5	27	56
M-15 AT mine	Wooden box	49	1 each	1.17	18.0	15.0	7.5	90	225
M-21 AT mine	Wooden box	91	4 each	1.96	20.2	13.4	12.5	72	144
M-16 AP mine	Wooden box	39	4 each	0.72	15.4	9.8	8.2	180	320
NATO ICOM	Pallet	550	30 each	11.2	30.9	19.9	31.5	15	20
US ICOM	Pallet	735	80 each	31.1	40.0	48.0	28.0	4	6
MOPMS	Pallet	1,070	6 dispensers	49.0	39.0	53.0	47.0	4	6
Volcano	Pallet	2,000	240 each	45.4	59.0	38.0	35.0	4	4
ADAM	Pallet	874	8 rounds	9.6	14.9	29.1	39.4	NA	NA
RAAM	Pallet	875	8 rounds	10.1	14.9	29.1	40.9	NA	NA
HEMMS	Wooden chest	174	1 set	8.34	55.2	17.4	15.0	16	30

Figure G-7

truckload would consist of only one type of Class IV or V item. Volume was based on loading trucks to the top of the side racks (for cargo trucks) or the top of the bed (for dump trucks). Weight capability was based on the 5-ton cross-country rating for these trucks. Capability was checked against both volume and weight criteria. In all cases, cargo volume was the limiting criterion. ESC combined the dimensional data on truck beds with shipping dimensions of Class IV and V items (Figure G-7) to determine the number of Class IV or V items each truck could transport. This capacity is shown in the last two columns of Figure G-7.

(2) Truckloads. Step 2 calculated the total number of truckloads by dividing the total scenario time-phased Class IV and V item requirements by the appropriate truck capacity list in Figure G-7. The truckloads for separate items were then added to arrive at the time-phased Class IV and V scenario requirements expressed as truckloads. Because this calculation assumes optimal loading of each truck, this step tends to produce an optimistic estimate of the total number of truckloads. However, engineers will use trailers when transporting Class IV and V supplies; this methodology does not capture that trailer capability, which should offset the methodology's overestimate of truckload capability.

(3) Turnaround time. Step 3 estimates the turnaround time required for a truck to pick up a load of materiel at the BSA, deliver it to an engineer worksite, and return to the BSA. Figure G-8 defines turnaround time and shows how it was evaluated in both scenarios. Travel distances were based on the MSR net and BSA locations developed for both scenarios. Speeds are based on scenario conditions and recommendations in Army Field Manual

(FM) 55-15.[1] The delay times are primarily load and unload times and are modifications of times in FM 55-15.

TRUCK TURNAROUND TIME
(Hours)

$$\text{Turnaround time (hr)} = \frac{2 \times \text{One-way distance (km)}}{\text{Average speed (kph)}} + \text{delay (hr)}$$

Latin American Scenario
(2d Brigade)

Period	Turnaround time (hr)	Factor: Distance (km)	Factor: Speed (kph)	Factor: Delay (hr)
2	1.9	15	35	1
3	3.6	45	35	1
4	5.6	81	35	1

European Scenario

Period	Turnaround time (hr)	Distance (km)	Speed (kph)	Delay (hr)
All periods				
Infantry brigade	2.7	10	30	2
Armored brigade	3.0	15	30	2

Figure G-8

(4) Daily truck requirements. Steps 1 through 3 provide the data for Step 4 — the daily number of trucks needed to transport Class IV and V materiel. Figure G-9 shows the equation for calculating the average daily truck requirement. In the Latin American scenario, ESC estimated that the LID's trucks would be available one-third of the time to haul Class IV and V supplies. Therefore, the operational day was 4 hours. In the European scenario, the primary mission of the LID's and supporting engineer's trucks was to transport the Class IV and V materiel. The operational day was estimated

[1] Transportation Reference Data, FM 55-15 (Department of the Army, February 1968).

at 12 hours. This algorithm was repetitively applied by item, time period, and brigade. The brigade results were summed to determine the total scenario truck requirement.

TRUCK REQUIREMENTS ALGORITHM

$$\text{Daily number of trucks} = \frac{\begin{array}{c}\text{Class IV and V}\\ \text{requirements}\\ \text{(Items per day)}\end{array}}{\begin{array}{c}\text{Truck capacity}\\ \text{(Items per truck)}\\ \text{(Figure G-7)}\end{array}} \times \frac{\begin{array}{c}\text{Turnaround}\\ \text{time (hr)}\\ \text{(Figure G-8)}\end{array}}{\begin{array}{c}\text{Operational day}\\ \text{(Hr per day)}\end{array}}$$

Figure G-9

g. Helicopter calculations. Helicopters are involved the transportation of Class IV and V materiel in the Latin American scenario because the 1st and 3d Brigades are operating in semiclandestine TFOBs which are inaccessible to ground transportation. The UH-60 helicopter is used to transport Class IV and V supplies from the DRA to the 1st and 3d Brigades. The calculation of helicopter requirements is similar to that used to calculate truck requirements.

(1) UH-60 capacity. ESC first estimated the lift capability of the UH-60 under the conditions of the Latin American scenario, using the data listed in Figure G-10. ESC determined that the UH-60 could lift 100 percent of its rated load (6,870 lb) under worst-case conditions in the Latin American scenario.

(2) UH-60 turnaround time. Figure G-11 shows how turnaround time was computed for the UH-60 in the Latin American scenario. The process is similar to that used for trucks, except that any delay time will be incorporated later as a degradation to the operational day.

LATIN AMERICAN UH-60 HELICOPTER CAPABILITY

FACTORS

Weather	Topographic	Mission
Temperature (97 F)	Station elevation (25 ft)	One-way distance (125 km)
Dewpoint (84 F)	Maximum in-flight elevation (1000 ft)	Ground speed (161 kph)
Barometric pressure (29.73 in.)		Fuel burn rate (890 lb/hr)

RESULT: UH-60 capability under worst-case conditions is 100 percent of the rated capability, or 6,870 lb.*

*Actual calculation of UH-60 capability was performed by using the Battlefield Environmental Effects Simulation model at the US Army Engineer Topographic Laboratories.

Figure G-10

LATIN AMERICAN UH-60 HELICOPTER TURNAROUND TIME

$$\text{Turnaround time (hr)} = \frac{2 \times \text{One-way mission distance (km)}}{\text{Average ground speed (kph)}}$$

Brigade	Turnaround time (hr)	One-way distance (km)	ground speed (kph)
1	1.6	125	161
3	1.2	100	161

Figure G-11

(3) Daily UH-60 requirements. The computation of daily helicopter requirements was somewhat simpler than for trucks. Helicopter capability is based on weight, so it was possible to estimate helicopter requirements directly from the total Class IV and V weight and not have to deal with various types of items. Figure G-12 shows how the daily UH-60 requirements

were estimated. The 8-hour operational day for helicopters is degraded by 30 percent to account for all types of delay.[2]

UH-60 HELICOPTER REQUIREMENTS ALGORITHM

$$\text{Daily number of UH-60 helicopters} = \frac{\text{Class IV and V requirements (lb per day)}}{\text{UH-60 capability}} \times \frac{\text{Turnaround time (hr)}}{\text{Operational day}}$$

Figure G-12

h. C-141B calculations. In the Latin American scenario, Class IV and V requirements take on added significance because they must transport to the divisional AO by inter-theater airlift. C-141B aircraft were used to airlift all of the LID's Class IV and V items to the divisional AO. Figure G-13 shows how ESC calculated this requirement. The total number of C-141B sorties were estimated by applying the equation in Figure G-13 against the LID's time-phased Class IV and V requirements.

C-141B REQUIREMENTS ALGORITHM

$$\text{C-141B sorties} = \frac{\text{Class IV and V Requirements (STON)}}{\text{24 STON per C-141B*}}$$

*Table III, Appendix A, JCS PUB 15, SEP 83.

Figure G-13

i. Format of results. This annex presents the results of the Class IV and V analysis in several different formats. They are presented as Class

[2]This information was provided to ESC by the Concepts and Studies Division, Directorate of Combat Developments, Fort Rucker, Alabama.

IV and V item requirements, in terms of average daily STON of Class IV and V supply, and finally as the number of trucks or aircraft needed to move the Class IV and V requirements about the divisional AO.

6. Countermobility Alternatives Suitable to LID Operations. During the Class IV and V analysis, ESC found it necessary to evaluate several different munitions capable of fulfilling the same or similar functions. The munitions considered are liquid explosive, ICOM, the Modular Pack Mine System (MOPMS), and the M-180 cratering demolition kit.

a. Liquid explosives. Over the past several years, liquid nitromethane and XM-268 (a binary slurry blasting agent) have been extensively evaluated for their potential as military demolition materiels. Both of these materiels have been found suitable for military use in such applications as antitank ditching, cratering, and assault entry charges.[3,4] ESC believes that neither of the two munitions is clearly superior to the other. They have strengths and weaknesses depending on the intended use and the priority assigned to any evaluation criteria.[5] Therefore, this analysis is limited to determining if liquid explosives have any logistical advantages over standard military demolitions. Figure G-14 compares selected characteristics of nitromethane and XM-268 to TNT. In this annex, ESC used the average of the properties of nitromethane and XM-268 to represent a typical liquid explosive. This average is shown in Figure G-14 as liquid explosive. Since the available information does not suggest otherwise ESC substituted liquid explosive on a pound-for-pound basis for conventional military explosives.

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[3] Urban Street Cratering Tests Fort Rucker, Alabama, Joachin, C.E., (US Army Waterways Experiment Station [WES], December 1981).

[4] Liquid Explosives in Antiarmor Ditching, Cratering and Assault Entry Charges (WES, November 1983).

[5] Tactical Explosives Systems (TEXS), Integration Alternatives and Issues, (McLean Research Center, February 1986).

COMPARISON OF EXPLOSIVES

Characteristic	TNT	Explosive Nitromethane	XM-268	Liquid
Physical:				
Specific gravity	1.63	1.13	1.55	1.34
Natural state	solid	liquid	slurry	
Relative effectiveness	1	1.15	1.5-2.0	1
Logistical:				
Classification	Explosive	Flammable	Non-explosive	Either
Packaging	Wooden box	55-gal drum	55-gal drum	55-gal drum
Shipping weight (lb per package)	81	593	711	690
Shipping volume (ft per package)	1.52	8.8	8.8	8.8
Shipping density (lb per ft)	53	67	81	78
5-ton cargo truck capacity (lb)	8,064*	9,324*	9,654**	9,660**

*Based on volume.
**Based on 5-ton cross-country load rating.

Figure G-14

b. ICOMs.

(1) ESC believes that light infantry operations have continuing and substantial need for conventional, hand-emplaced mines and minefields. Light forces are likely to be employed in a manner where support from artillery- and ground-emplaced scatterable mines is unavailable. In other cases, light forces may chose to maintain security and tactical surprise by hand-emplacing minefields. Finally, the target itself may require handemplaced mines for such uses as mining underwater at fords or in soft marshy ground. In the new explosive excursion, hand-emplaced minefields accounted for 20 and 25 percent of all linear minefields in the Latin American and European scenarios, respectively. These percentages would have been even higher if the mining of point obstacles were included. This annex will identify the logistical savings attainable if ICOMs are substituted for conventional antitank mines wherever mines are hand-emplaced.

(2) ICOMs have two logistical advantages. First, ICOMs weigh at least 50 percent less than conventional mines. Second, they are full-width sensing, so fewer mines are required. ESC evaluated two different ICOMs and selected one as the base from which to make the logistical estimates. These ICOMs are the US ICOM (under development) and the NATO ICOM (in production).[6,7] Figure G-15 compares the US and NATO ICOMs to the M-15 AT mine. In this analysis ESC, decided to calculate the minimum and immediately achievable logistical savings. Therefore, all estimates have been based on

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[6]The developmental information on the US ICOM in this annex is from the draft ICOM Systems Requirements, and the draft Organizational and Operational Plan for Improved Conventional Mine Systems (ICOMS), provided by Directorate of Combat Developments, US Army Engineer School (USAES), Fort Belvoir, Virginia.

[7]The NATO ICOM is the FFV 028 antitank mine produced by FFV Ordnance, Eskiltuna, Sweden. It has been adopted as a standard antitank mine by several NATO countries.

characteristics of the NATO ICOM, which is currently in production, rather than the US ICOM, which is still in the early stages of development.

ANTITANK MINE CHARACTERISTICS

Characteristic	M-15	US ICOM	NATO ICOM
Mine weight (lb)	30	8	17.6
Shipping weight (lb)	49	9.2*	18.4
Sensing width	Track**	Vehicle	Vehicle
Fuse	Pressure	Electronic	Electronic
Antihandling devices	Field installed	Integral	Integral
Capacity			
5-ton cargo truck	198	640	600
C-141B	979	5,224	2,617
Available	yes	no	yes

*Estimate by ESC and USAES.
**10 percent are being upgraded with a tilt-rod fuse.

Figure G-15

c. MOPMS.

(1) MOPMS is a munition which will eventually be available to help fullfill the Class V needs of the LID. It is intended for use in applications such as gap and lane closing, and for point minefields. The command emplacement and detonation capability of MOPMS gives it some unique tactical possibilities. MOPMS offers very great manhour savings for emplacement requirements and also greatly reduces the duration of emplacement when used for gap and lane closing and point targets. (These savings are identified in Annex D.)

(2) ESC does not believe it is appropriate to replace hand-emplaced mines with MOPMS in all situations. This is especially true in light

infantry operations. Some point minefields may be smaller than the MOPMS footprint. There may be a requirement to place mines under water or snow, or in very soft ground, situations for which the MOPMS is ill-suited. Some targets may call for the emplacement of mines in specific locations, and the MOPMS is incapable of meeting this requirement, even though it is a very probable requirement for light forces employed in suitable terrain. Finally, the MOPMS pack itself, can be hand-carried only over short distances.

(3) To evaluate the logistical savings of MOPMS, ESC compared the logistical requirements of a point minefield emplaced by several different means (Figure G-16). Both the MOPMS- and ICOM-based point minefields have great advantages over a point minefield of conventional mines. The case between MOPMS and ICOMs is less clear. MOPMS weighs slightly less than the US ICOM and decidedly less than the NATO ICOM. This is important when discussing inter-theater airlift to the LID's AO. Volume becomes more important within the divisional AO. Both types of ICOM point minefields are superior to MOPMS when measured by volume. Thus, neither munition is clearly best. Seeking to evaluate immediately attainable savings, ESC did not evaluate MOPMS as an alternative Class V item.[8] The NATO ICOM was used for closing all gaps and lanes, and point minefields.

[8]According to USAES, the earliest MOPMS fielding date is late 1988.

LOGISTICAL COMPARISON OF POINT MINEFIELD ALTERNATIVES*

Method	Logistics Burden Weight (lb)	Volume (ft)
Conventional mines	1,184	27.5
MOPMS	178	8.2
US ICOM	185	7.2
NATO ICOM	341	6.5

*MOPMS mines a semicircular area with radius = 35 meters, and a mix of AT and AP mines. The conventional and ICOM point minefields have been constructed to be equivalent to a MOPMS minefield. They are 30 x 70 meters and contain eighteen M-15 ATs, fifteen M-21 ATs, and three M-16 AP mines, or seventeen ICOMs and three M-16 AP mines, respectively.

Figure G-16

d. M-180. The M-180 cratering kit is available to meet the LID's Class V needs. The M-180 is intended for the emplacement of road craters and results in great manhour savings and reduced emplacement times. As with MOPMS, ESC does not feel that the M-180 is suitable for all the LID's requirements. For example, in an antiarmor ambush it may be tactically desirable to delay detonation of the road crater until the enemy is very near or even on top of the target to achieve the maximum surprise and shock effect. A second example could be a road crater employed at the rear of an enemy column in restricted terrain to trap the column. These uses are not appropriate to the M-180. Finally, the M-180 achieves its rapid emplacement and reduced manhour requirement at a great logistical expense. A single M-180 kit cannot be carried more than a short distance on foot. It is even more logistically burdensome than standard military demolitions. Figure G-17 is a logistical comparison of several means of emplacing road craters. Because of its great logistical burden and partial tactical unsuitability for light infantry operations, the M-180 was not evaluated as a Class V alternative.

LOGISTICAL COMPARISON OF ROAD CRATERING ALTERNATIVES*

Method	Logistics Burden Weight (lb)	Logistics Burden Volume (ft)
Conventional munitions	668	16.5
M-180	825	35.8
SEE with auger and conventional munitions	343	7.2
SEE with auger and liquid explosives	286	3.6

*All methods are for equivalent-sized craters. The first two are from Appendix D, Countermobility, FM 5-102 (Department of the Army, March 1985). The third is a hasty crater with boreholes augered by the SEE. The last uses three bore holes, each 10 feet deep and 10 feet on center. In this last example, each borehole is loaded with 85 pounds of liquid explosive.

Figure G-17

7. Class IV and V Item Requirements. Figures G-18 through G-21 show the individual item requirements for Class IV and V supplies by scenario base case and integrated excursion. The results are shown as divisional total requirements by time period and item. Appendix G-1 contains similar data, detailed down to the brigade level.

a. In the base case of the Latin American scenario, Figure G-18 shows a total requirement for 18,915 M-15 antitank mines. This is the first

ENGINEER CLASS IV AND V ITEM REQUIREMNTS -- LATIN AMERICAN SCENARIO BASE CASE
(Period Totals)

From	Through	Item: 15-lb Shaped Charge (Each)	40-lb Shaped Charge (Each)	40-lb Cratering Charge (Each)	TNT (lb)	Detonating Cord (x 1000) (ft)	M-15 Mine (Each)	M-21 Mine (Each)	M-16 Mine (Each)	Bangalore Torpedo (Set)	HEMMS (Set)
D+1	D+2	24	0	24	510	4.5	108	144	36	0	0
D+2	D+4	68	0	68	1,530	18.0	8,131	408	1,646	0	33
D+5	D+8	57	35	57	900	18.0	2,840	312	568	47	19
D+9	D+10	73	0	73	940	22.5	7,836	384	1,566	28	12
Scenario		222	35	222	5,690	63.0	18,915	1,248	3,816	78	53

Figure G-18

ENGINEER CLASS IV AND V ITEM REQUIREMENTS -- LATIN AMERICAN SCENARIO NEW EXPLOSIVE EXCURSION
(Period Totals)

From	Through	Item: 15-lb Shaped Charge (Each)	40-lb Shaped Charge (Each)	40-lb Cratering Charge (Each)	TNT (lb)	Detonating Cord (x 1000) (ft)	M-15 Mine (Each)	M-21 Mine (Each)	M-16 Mine (Each)	Bangalore Torpedo (Set)	HEMMS (Set)
D+1	D+2	1,200	60	4.5	153	27	--	--	--	--	--
D+3	D+4	3,400	172	18.0	425	75	4,970	153	17	--	12
D+5	D+8	4,205	134	18.0	757	243	1,206	--	--	47	19
D+9	D+10	3,650	166	18.0	1,509	553	3,779	--	--	28	12
Scenario		12,455	532	58.5	2,844	898	9,955	153	17	75	43

Figure G-19

ENGINEER CLASS IV AND V ITEM REQUIREMENTS -- EUROPEAN SCENARIO BASE CASE
(Period Totals)

From	Through	40-lb Shaped Charge (Each)	40-lb Cratering Charge (Each)	TNT (lb)	Detonating Cord (x 1000) (ft)	M-15 Mine (Each)	M-21 Mine (Each)	M-16 Mine (Each)	RAAM Rounds (Each)	ADAM Rounds (Each)	Bangalore Torpedo (Set)	HEMMS (Set)
						LID						
D+8	D+10	615	615	4,900	63.0	23,856	4,212	18,427	--	--	--	57
H-Hour	H+23	75	75	850	18.0	2,830	522	2,105	--	--	--	7
H+24	H+47	66	66	15,820	9.0	2,740	672	1,882	405	45	2	6
H+48	H+96	1,380	1,380	9,100	135.0	12,754	8,460	2,132	1,755	195	--	--
Scenario		2,136	2,136	30,670	225.0	42,188	13,866	24,545	2,160	240	2	70
						Attached AR Brigade						
D+8	D+10	267	267	2,240	27.0	9,783	1,656	1,776	--	--	--	21
H-Hour	H+23	30	30	250	4.5	1,106	186	201	--	--	--	2
H+24	H+47	84	84	730	9.0	3,119	522	566	405	45	58	38
H+48	H+95	231	231	1,520	22.5	2,433	1,416	427	315	35	--	--
Scenario		612	612	4,740	63.0	16,441	3,780	2,970	720	80	58	61
						Divisional AO						
D+8	D+10	882	882	7,140	90.0	33,639	5,868	20,203	--	--	--	78
H-Hour	H+23	105	105	1,100	22.5	3,936	708	2,306	--	--	--	9
H+24	H+47	150	150	16,550	18.0	5,859	1,194	2,448	810	90	60	44
H+48	H+95	1,611	1,611	10,620	157.5	15,195	9,876	2,559	2,070	230	--	--
Scenario		2,748	2,748	35,410	288.0	58,629	17,646	27,515	2,880	320	60	131

Figure G-20

ENGINEER CLASS IV AND V ITEM REQUIREMENTS -- EUROPEAN SCENARIO NEW EXPLOSIVE EXCURSION
(Period Totals)

		Item									
From	Through	Liquid Explosive (lb)	TNT (lb)	Detonating Cord (x 1000) (ft)	NATO ICOM (Each)	M-16 Mine (Each)	Volcano Mine (Each)	RAAM Mine (Each)	ADAM Mine (Each)	Bangalore Torpedo (Set)	HEMMS (Set)
						LID					
D+10	D+8	33,600	748	31.5	6,289	4,033	6,720	--	--	--	35
H-Hour	H+23	4,350	103	3.5	829	513	2,532	--	--	--	8
H+24	H+47	18,000	260	4.5	1,049	756	1,699	405	45	2	6
H+48	H+95	73,500	1,590	67.5	8,381	1,487	--	1,755	195	--	--
Scenario		129,450	2,701	108.0	16,548	6,789	12,460	2,160	240	2	49
						Attached AR Brigade					
D+10	D+8	14,700	330	13.5	2,911	809	2,880	--	--	--	14
H-Hour	H+23	1,650	37	1.0	305	80	576	--	--	--	2
H+24	H+47	4,650	105	4.5	964	277	2,086	405	45	58	28
H+48	H+95	12,300	266	13.5	1,615	319	--	315	35	--	--
Scenario		33,000	738	31.5	5,795	1,485	5,542	720	80	58	44
						Divisional AO					
D+10	D+8	48,300	1,078	45.0	9,200	4,842	9,600	--	--	--	49
H-Hour	H+23	6,000	140	4.5	1,134	593	4,618	--	--	--	10
H+24	H+47	22,650	365	9.0	2,013	1,033	3,875	810	90	60	34
H+48	H+95	85,500	1,856	81.0	9,996	1,806	--	2,070	230	--	--
Scenario		162,750	3,439	139.5	22,343	8,274	18,002	2,880	320	60	93

Figure G-21

indication as to the importance of antitank mines in determining the total engineer Class IV and V requirement. Figure G-19 shows that in the new explosive excursion, the NATO ICOM (2,844) and the Volcano mine (9,955) will have the greatest impact on the total engineer Class IV and V requirement.

b. When Figures G-18 and G-20, and Figures G-19 and 21 are compared, it is clear that the European scenario has a much greater Class IV and V requirement than the Latin American scenario. Item by item, the European requirements are three to four times greater. Figure G-20 shows that the 58,629 M-15 antitank mines will control the European base case Class IV and V requirements. Figure G-21 indicates that the NATO ICOM (22,343) and the Volcano mine (18,002) will control total requirements in the new explosive excursion.

8. Class IV and V Short Ton (STON) Requirements. Figure G-22 shows the total LID Class IV and V requirements expressed as average daily STON of supply. The results are shown by scenario and time period. In the European scenario, the results for the LID and the attached armored brigade are shown separately from the scenario total. Detailed data down to the LID brigade level is contained in the Appendix.

a. The Latin American scenario base case daily average Class IV and V requirement is 53 STON per day. There are two distinct peaks in the supply requirements, which are about twice the scenario daily average. These peak requirements are for 109 and 106 STON per day and occur in periods 2 and 4, respectively. In the new explosive excursion, the average daily Class IV and V requirement decreases by about a factor of 5 to 10 STON per day. The new explosive excursion shows the same peaks and relative magnitudes as the base case.

ENGINEER CLASS IV AND V DAILY SUPPLY TONNAGE
(Average daily STON)

Unit	From	Through	Base Case	New Explosive Excursion
		LATIN AMERICAN SCENARIO		
	D+1	D+2	3.15	1.13
LID	D+3	D+4	109.51	18.67
	D+5	D+8	28.36	7.27
	D+9	D+10	105.96	19.12
	SCENARIO AVERAGE:		53.02	9.96
		EUROPEAN SCENARIO		
	D+8	D+10	255.70	42.02
LID	H-hour	H+23	91.27	29.94
	H+24	H+47	121.89	54.97
	H+47	H+95	307.05	114.70
	SCENARIO AVERAGE:		227.77	62.91
	D+8	D+10	95.48	17.20
AR	H-hour	H+23	32.38	6.65
brigade	H+24	H+47	124.27	54.11
	H+47	H+95	55.86	20.99
	SCENARIO AVERAGE:		79.26	22.05
	D+8	D+10	351.18	59.22
SCENARIO	H-hour	H+23	123.65	36.59
TOTALS	H+24	H+47	246.16	109.08
	H+47	H+95	362.91	135.69
	SCENARIO AVERAGE:		307.03	84.96

Figure G-22

b. In the European scenario base case, the Class IV and V average daily requirement is 307 STON per day. Class IV and V requirements are more constant than in the Latin American scenario. There are two minor peak requirements of 351 and 362 STON per day which occur in periods 2 and 5, respectively. These two peaks are only about 15 percent greater than the scenario daily average. The new explosive excursion average daily supply rate of 85 STON per day is about 3.5 times less than the base case requirement of 307 STON per day. The new explosive excursion shows supply peaks of 109 and 135 STON per day occurring in periods 4 and 5. These are about 30 and 60 percent above the scenario daily average. In both the base case and new explosive excursion, the LID accounts for about 75 percent of the total Class IV and V requirement and the attached armored brigade accounts for the remainder.

9. Class IV and V Daily Transportation Requirements.

a. Figure G-23 shows the engineer Class IV and V transportation requirements within the LID's divisional AO. The results are shown as the average daily number of helicopters and trucks needed to transport these supplies. This figure does not include requirements for the Air Volcano or artillery-delivered mines, as they are not an engineer responsibility. Helicopters were used only in the Latin American scenario. European scenario results are separately shown for the LID and the attached armored brigade. The detailed brigade level data are contained in the Appendix to his annex.

(1) The movement of engineer Class IV and V supplies requires a scenario daily average of five UH-60 helicopters and three 5-ton cargo trucks in the Latin American base case. This requirement is reduced one helicopter and one 5-ton cargo truck in the new explosive excursion.

ENGINEER CLASS IV AND V TRANSPORTATION REQUIREMENTS
(Average Daily Number of Helicopters and Trucks)

Unit	From	Through	Base Case		New Explosive Excursion	
			LATIN AMERICAN SCENARIO			
			UH-60	5-Ton Cargo Truck	UH-60	5-Ton Cargo Truck
	D+1	D+2	0.5	0	0.5	0
LID	D+3	D+4	1	6	0.5	2
	D+5	D+8	3	1	0.5	1
	D+9	D+10	7	2	1	1
	SCENARIO AVERAGE:		5	3	1	1

EUROPEAN SCENARIO

Unit	From	Through	5-Ton Dump Truck	5-Ton Cargo Truck
	D+8	D+10	25	2
LID	H-hour	H+23	9	1
	H+24	H+47	9	1
	H+47	H+95	24	2
	SCENARIO AVERAGE:		20	2
	D+8	D+10	10	1
AR	H-hour	H+23	3	1
brigade	H+24	H+47	11	2
	H+47	H+95	5	1
	SCENARIO AVERAGE:		8	1
	D+8	D+10	35	3
SCENARIO	H-hour	H+23	12	2
TOTALS	H+24	H+47	20	3
	H+47	H+95	29	3
	SCENARIO AVERAGE:		28	3

Figure G-23

(2) The European scenario base case has an average daily requirement for 28 five-ton dump trucks to transport engineer Class IV and V supplies. The LID generates about 22 percent of this requirement and the attached armored brigade generates the remainder. In the new explosive excursion, there is an average daily requirement for three 5-ton cargo trucks to transport the engineer Class IV and V supplies. Two-thirds of this is for the LID and one-third for the attached armored brigade.

b. Figure G-24 shows the number of C-141B sorties needed to deploy engineer Class IV and V requirements for the Latin American scenario. The base case requires an average of three C-141B sorties per day. This decreases to well under one sortie per day in the new explosive excursion.

C-141B SORTIES FOR ENGINEER CLASS IV AND V REQUIREMENTS --
LATIN AMERICAN SCENARIO
(Daily Averages)

From	Through	Base Case	New Explosive Excursion	Savings
D+1	D+2	—	—	—
D+3	D+4	5	1	4
D+5	D+8	1	--	1
D+9	D+10	5	1	4
SCENARIO AVERAGE:		3	—	3

Figure G-24

10. Observations.

a. Antitank mines. The most striking feature of the Class IV and V analysis is the overwhelming importance of antitank mines in determining the total Class IV and V requirements Figure G-25 shows all categories of antitank mines as a percentage of total requirements. Because they dominate the Class IV and V requirement, antitank mines are an area of high logistical payoff for the LID. The quantities of Air Volcano and RAAM listed in Figure G-25 and cited in the following paragraphs refer only to the quantities of these munitions needed to offset engineer-emplaced obstacles. This analysis does not forecast the total LID Air Volcano and RAAM requirements.

COMPARISON OF ANTITANK MINES TO TOTAL REQUIREMENT
(Percentage by Weight)

	Scenario			
	Latin American		European	
Type AT Mine	Base Case	New Explosive Excursion	Base Case	New Explosive Excursion
Conventional	90.1	--	76.1	--
NATO ICOM	--	26.2	--	34.4
Volcano	--	41.6	--	12.6
RAAM	--	8.4	7.3	26.5
Total	90.1	76.2	83.4	73.5

Figure G-25

(1) Ground Volcano. This system plays an important role in reducing the overall logistical requirements in both scenarios. Figure G-26 shows the savings attributable to Ground Volcano when it is employed in the new explosive excursion of both scenarios. The logistical savings of ground Volcano would have been greater in the Latin American scenario had its use not been restricted to one brigade.

(2) Air Volcano. This system was used as a substitute for hand-emplaced minefields in the new explosive excursion of both scenarios. Its use provides some major logistical savings, especially in the Latin American scenario, as shown in Figure G-27. The Latin American savings are large because of the very low air threat which permitted widespread use of helicopters in forward areas. The European savings are lower for two reasons: the high air

threat restricted the use of helicopters and there was a reduced use of minefields compared to point obstacles.

GROUND VOLCANO LOGISTICAL SAVINGS

Mine System	Scenario: Latin America	Scenario: Europe
Conventional:		
Number of modules	29	149
Weight (STON)	90	512
Replaced by:		
Ground Volcano:		
Number of modules	3.0	14.9
Weight (STON)	12	60
Weight Savings:		
STON	66	452
Percent	12	21

Figure G-26

AIR VOLCANO LOGISTICAL SAVINGS

Mine System	Scenario: Latin American	Scenario: European
Conventional:		
Number of modules	70	37
Weight (STON)	217	124
Replaced by:		
Ground Volcano:		
Number of modules	8.8	4.6
Weight (STON)	29	15
Weight Savings:		
STON	188	109
Percent	35	5

Figure G-27

(3) RAAM. The use of the artillery-delivered RAAM contributes to the overall savings in both scenarios, but especially in Europe where it

was used extensively in the delay phase. The savings due to RAAM are difficult to quantify. In most cases RAAM is used in situations where engineers have no capabilty to respond. In effect, RAAM adds a new capability where the engineers were previously unable to respond. This is especially true in fluid combat situations, such as a delay.

(4) NATO ICOM. The use of the NATO ICOM provides very significant savings in both scenarios as shown in Figure G-28. These savings result from the substitution of the NATO ICOM for conventional antitank mines in the hand-emplaced point and linear minefields of the new explosive excursion.

NATO ICOM LOGISTICAL SAVINGS

	Weight Savings	
Scenario	STON	Percent
Latin American	96	45
European	714	55

Figure G-28

(5) A comparison of Figures G-26 through G-28 provides some overall logistical conclusions about mining. In a logistical sense, the decision about which mining system provides the greatest benefits is scenario dependent. The payoff depends on the terrain, combat intensity, and friendly posture. The Volcano system provides the greatest logistical savings in the Latin American scenario, which is a low- to mid-intensity conflict, has a low air threat, and is offensively oriented. The NATO ICOM gives greater benefits in the high-intensity European conflict, where the terrain is extremely difficult and the friendly posture is defensive. The greatest savings naturally occur when both systems are used as shown in Figure G-29. These two systems

should be viewed as complementary. The area where they overlap is small. Ground Volcano is more efficient than the NATO ICOM where conditions are suitable. The LID still has a large requirement for hand-emplaced mines in both linear and point minefields. The fielding of an ICOM is very important to the logistical supportability of the LID.

SUMMARY OF ANTITANK MINE SAVINGS

	Scenario			
	Latin America		Europe	
AT Mine System	STON	Percent	STON	Percent
NATO ICOM	88	17	812	37
Ground Volcano	66	12	452	21
Air Volcano	188	35	109	5
Total	342	64	1375	63

Figure G-29

b. Liquid explosives.

(1) The substitution of liquid explosive for conventional explosives did not provide any significant Class V savings. There are two reasons for this. First, conventional explosives are only a small part of the total Class IV and V requirement as shown in Figure G-30. Thus, the potential for making meaningful reductions is small. Second, when liquid explosive is substituted on a pound-for-pound basis for conventional explosives, the only weight reductions available are in packaging. This does not leave room for dramatic improvement. Figure G-31 shows the total savings achieved by using liquid explosive. The higher percentage savings achieved in the new explosive excursion is due to the decrease in the total requirements, and not to an increase in the use of liquid explosive.

CONVENTIONAL AND LIQUID EXPLOSIVE REQUIREMENTS
(Percentage by Weight)

	Explosive	
	Conventional	Liquid
Latin American Scenario		
Base case	3.3	--
New Explosive excursion	0.4	6.3
European Scenario		
Base case	8.7	--
New Explosive excursion	0.4	13.7

Figure G-30

LIQUID EXPLOSIVE LOGISTICAL SAVINGS

	Weight Savings	
	STON	Percent
Latin American Scenario		
Base case	5.7	1.1
New Explosive excursion	5.7	5.8
European Scenario		
Base case	41.2	5.8
New Explosive excursion	41.2	6.9

Figure G-31

(2) Liquid explosive should remain an attractive Class V item for light infantry operations because of its versatility. It can be used for shaped charges, cratering charges and is well suited for denial operations because it can be pumped or poured. Liquid explosive has been shown to be an effective cratering means when employed in sewer lines and manholes. It has been suggested as a road cratering means if poured down existing drainage culverts. This makes it attractive to light forces, which are likely to find themselves employed in urban terrain. Before liquid explosive can provide significant Class V savings, additional testing is needed. When used in cratering applications, liquid explosive has up to twice the relative effectiveness of TNT.[9] Testing should be conducted to determine the optimum combination of boreholes, borehole depth, spacing, and explosive loading. It may be possible to reduce the explosive content by up to 50 percent. This would result in greater Class V savings.

c. Class IV. Outside of the HEMMS, this analysis did not identify any Class IV requirements. There were no engineer requirements for items such as barbed wire, concertina, or sand bags. This does not mean maneuver units will not need these type of items, but that these kind of requirements were not within the scope of this analysis.

d. Class IV and V transportation.

(1) The movement of Class IV and V supplies is a major task for the 5-ton series vehicles in the engineer support force, especially in the European scenario. This requirement reaches very high peaks during the battle preparation and the delay phases, as shown in Figure G-23. The demand for

[9] Kirshenbaum, M.S., et al; Demolitions--Current Formulation and Future Options (US Army Armament Research and Development Center, July 1985).

trucks during these periods is high enough to cause concern to LID and supporting engineers. In the new explosive excursion, the availability of trucks is no longer a problem, for two reasons: First, the combined use of the Family of Scatterable Mines (FASCAMs) and ICOMs reduced the quantity of materiel to be moved by about 70 percent. Second, the increased capacity of the 5-ton cargo truck over the 5-ton dump truck reduced the need for trucks by about one-half.

(2) The number of trucks needed to transport Class IV and V supplies is directly related to the distance which these trucks must travel. Thus, ESC's assumption that engineer supplies would be delivered to the BSA is critical. If engineers must travel to the DRA or further to pick up Class IV and V materiel, the daily number of trucks required will increase quickly. In the European scenario, each additional 15 kilometers of one-way travel will increase daily truck requirements by at least one-third.

(3) ESC feels that the 5-ton dump truck is poorly suited for the missions facing the LID's engineer support force. One of the most important missions for these trucks is hauling Class IV and V supplies. In this role volume capacity is the limiting criteria. Figure G-7 clearly shows that the 5-ton cargo truck is greatly superior in this respect. ESC feels that the decision to equip the divisional engineer battalion with the cargo truck was the correct one.

(4) To improve the overall ability to transport Class IV and V materiel, ESC recommends replacing all or part of the dump trucks in the supporting corps engineer battalion with cargo trucks. An alternative to this would be to select a dump truck which is a more efficient cargo hauler. The bed on such a dump truck should be longer and wider than the current dump

truck and it should have substantial side racks. The dump bed should have drop sides to facilitate munitions handling by materiel handling equipment. There are trucks available today which incorporate the features of this concept without sacrificing the dump capability.[10] It may be possible to incorporate these concepts into an engineer version of the palletized load system.

[10] The Bundeswehr of the Federal Republic of Germany currently has 7.5-metric ton, 6-x-6 dump truck which has these characteristics. It has the added capability to dump materiel from both sides as well as to the rear.

LAST PAGE OF ANNEX G

APPENDIX

ENGINEER CLASS IV AND V REQUIREMENTS -- BRIGADE LEVEL RESULTS

APPENDIX

ENGINEER CLASS IV AND V REQUIREMENTS -- BRIGADE LEVEL RESULTS

ENGINEER CLASS IV AND V ITEM REQUIREMENTS --
LATIN AMERICAN SCENARIO BASE CASE
(Period Totals)

Unit	Time Period	40-lb Shape	15-lb Shape	40-lb Crater	1-lb TNT	Det Cord	Mine M-15	Mine M-21	Mine M-16	Bang Torp	HEMMS
	1	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0
1	3	0	0	0	0	0	0	0	0	0	0
	4	45	0	45	860	2	6534	264	1340	0	0
	Total	45	0	45	860	2	6534	264	1340	0	0
	1	0	0	0	0	0	0	0	0	0	0
	2	44	0	44	1020	3	6923	264	1389	0	22
2	3	0	0	0	720	0	0	0	0	47	0
	4	0	0	0	360	0	0	0	0	22	0
	Total	44	0	44	2100	3	6923	264	1389	75	22
	1	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0
3	3	48	35	48	1150	3	2732	240	550	0	0
	4	28	0	28	80	2	1302	120	226	0	0
	Total	76	35	76	1230	5	4034	360	776	0	0
	1	24	0	24	510	1	108	144	36	0	0
	2	24	0	24	510	1	1208	144	257	0	0
CAB	3	9	0	9	480	1	108	72	18	0	0
	4	0	0	0	0	0	0	0	0	0	0
	Total	57	0	57	1500	4	1424	360	311	0	0
T	1	24	0	24	510	1	108	144	36	0	0
o	2	68	0	68	1530	4	8131	408	1646	0	22
t	3	57	35	57	900	4	2840	312	568	47	0
a	4	73	0	73	940	5	7836	384	1566	28	0
l	Total	222	35	222	5690	14	18915	1248	3816	75	22

Figure G-1-1

ENGINEER CLASS IV AND V ITEM REQUIREMENTS -- LATIN AMERICAN SCENARIO NEW EXPLOSIVE EXCURSION (Period Totals)

Unit	Time Period	Liquid Explos	1-lb TNT	Det Cord	ICOM	Volcano	Mine M-16	RAAM	ADAM	Bang Torp	HEMMS
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4	2250.00	110.00	2.40	1189.00	3376.80	456.00	0.00	0.00	0.00	0.00
	Total	2250	110.00	2.40	1189.00	3376.80	456.00	0.00	0.00	0.00	0.00
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	2200.00	112.00	2.70	272.00	4086.00	48.00	153.00	17.00	0.00	12.00
2	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.00	19.00
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.00	12.00
	Total	2200	112.00	2.70	272.00	4086.00	48.00	153.00	17.00	75.00	43.00
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	3755.00	104.00	2.10	706.00	1206.00	234.00	0.00	0.00	0.00	0.00
	4	1400.00	56.00	1.20	320.00	402.00	97.50	0.00	0.00	0.00	0.00
	Total	5155	160.00	3.30	1026.00	1608.00	331.50	0.00	0.00	0.00	0.00
	1	1200.00	60.00	1.35	153.00	0.00	27.00	0.00	0.00	0.00	0.00
	2	1200.00	60.00	1.35	153.00	884.40	27.00	0.00	0.00	0.00	0.00
CAB	3	450.00	30.00	0.90	51.00	0.00	9.00	0.00	0.00	0.00	0.00
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	2850	150.00	3.60	357.00	884.40	63.00	0.00	0.00	0.00	0.00
Total	1	1200.00	60.00	1.35	153.00	0.00	27.00	0.00	0.00	0.00	0.00
	2	3400.00	172.00	4.05	425.00	4970.40	75.00	153.00	17.00	0.00	12.00
	3	4205.00	134.00	3.00	757.00	1206.00	243.00	0.00	0.00	47.00	19.00
	4	3650.00	166.00	3.60	1509.00	3778.80	553.50	0.00	0.00	28.00	12.00
	Total	12455.00	532.00	12.00	2844.00	9955.20	898.50	153.00	17.00	75.00	43.00

Figure G-1-2

ENGINEER CLASS IV AND V ITEM REQUIREMENTS --
EUROPEAN SCENARIO BASE CASE
(Period Totals)

Unit	Time Period	40-lb Shape	15-lb Shape	40-lb Crater	1-lb TNT	Det Cord	Mine M-15	Mine M-21	Mine M-16	RAAM	ADAM	Bang Torp	HEMMS
	1	0	0.00	0	0	0	0	0	0	0	0	0	0
	2	207	0.00	207	1590	5	7346	1434	5499	0	0	0	17
1	3	24	0.00	24	230	1	877	162	656	0	0	0	2
	4	0	0.00	0	0	0	122	0	122	0	0	2	1
	5	459	0.00	459	3030	10	4221	2814	704	585	65	0	0
	Total	690	0.0	690	4850	16	12566	4410	6981	585	65	2	20
	1	0	0.00	0	0	0	0	0	0	0	0	0	0
	2	135	0.00	135	1050	3	4737	930	3538	0	0	0	11
2	3	18	0.00	18	210	1	579	126	403	0	0	0	1
	4	66	0.00	66	15820	2	2618	672	1760	405	45	0	5
	5	462	0.00	462	3040	10	4248	2832	708	585	65	0	0
	Total	681	0.0	681	20120	16	12181	4560	6408	990	110	0	17
	1	0	0.00	0	0	0	0	0	0	0	0	0	0
	2	156	0.00	156	1270	3	5441	1074	4062	0	0	0	12
3	3	18	0.00	18	210	1	579	126	403	0	0	0	1
	4	0	0.00	0	0	0	0	0	0	0	0	0	0
	5	459	0.00	459	3030	10	4292	2814	720	585	65	0	0
	Total	633	0.0	633	4510	14	10312	4014	5185	585	65	0	14
	1	0	0.00	0	0	0	0	0	0	0	0	0	0
	2	117	0.00	117	990	3	6333	774	5329	0	0	0	17
CAB	3	15	0.00	15	200	1	796	108	643	0	0	0	2
	4	0	0.00	0	0	0	0	0	0	0	0	0	0
	5	0	0.00	0	0	0	0	0	0	0	0	0	0
	Total	132	0.0	132	1190	4	7128	882	5971	0	0	0	19
	1	0	0.00	0	0	0	0	0	0	0	0	0	0
	2	267	0.00	267	2240	6	9783	1656	1776	0	0	0	21
AR	3	30	0.00	30	250	1	1106	186	201	0	0	0	2
	4	84	0.00	84	730	2	3119	522	566	405	45	58	38
	5	231	0.00	231	1520	5	2433	1416	427	315	35	0	0
	Total	612	0.0	612	4740	14	16441	3780	2970	720	80	58	61
T	1	0	0	0	0	0	0	0	0	0	0	0	0
o	2	882	0	882	7140	20	33639	5868	20203	0	0	0	78
t	3	105	0	105	1100	5	3936	708	2306	0	0	0	[illegible]
a	4	150	0	150	16550	4	5859	1194	2446	810	90	60	12
l	5	1611	0	1611	10620	35	15195	9876	2559	2070	230	0	0
	Total	2748	0	2748	35410	64	58629	17646	27515	2880	320	60	131

Figure G-1-3

ENGINEER CLASS IV AND V ITEM REQUIREMENTS -- EUROPEAN SCENARIO NEW EXPLOSIVE EXCURSION (Period Totals)

Unit	Time Period	Liquid Explos	1-lb TNT	Det Cord	ICOM	VOLCANO	Mine M-16	RAAM	ADAM	Bang Torp	HEMMS
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	11250.00	249.00	2.30	2047.00	1920.00	1505.80	0.00	0.00	0.00	10.00
1	3	1350.00	31.00	0.27	237.00	1587.60	158.10	0.00	0.00	0.00	3.10
	4	0.00	0.00	0.00	50.00	0.00	122.50	0.00	0.00	2.00	1.40
	5	24450.00	529.00	5.10	2771.00	0.00	489.00	585.00	65.00	0.00	0.00
	Total	37050	809	8	5105	3508	2275	585	65	2	14
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	7350.00	163.00	1.50	1303.00	1440.00	917.20	0.00	0.00	0.00	6.90
2	3	1050.00	25.00	0.20	203.00	0.00	152.10	0.00	0.00	0.00	0.40
	4	18000.00	260.00	1.33	999.00	1699.20	633.60	405.00	45.00	0.00	4.90
	5	24600.00	532.00	5.13	2788.00	0.00	492.00	585.00	65.00	0.00	0.00
	Total	51000	980	8	5293	3139	2195	990	110	0	12
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	8550.00	191.00	1.73	1556.00	1440.00	1189.20	0.00	0.00	0.00	7.70
3	3	1050.00	25.00	0.20	203.00	962.40	152.10	0.00	0.00	0.00	1.90
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5	24450.00	529.00	5.10	2822.00	0.00	505.80	585.00	65.00	0.00	0.00
	Total	34050	745	7	4581	2402	1847	585	65	0	10
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	6450.00	145.00	1.30	1383.00	1920.00	421.70	0.00	0.00	0.00	10.40
CAB	3	900.00	22.00	0.17	186.00	1491.60	51.10	0.00	0.00	0.00	2.80
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	7350	167	1	1569	3412	473	0	0	0	13
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	[illegible]	[illegible]	2.97	2911.00	2880.00	808.50	0.00	0.00	0.00	14.20
AR	3	1650.00	37.00	0.33	305.00	576.00	79.90	0.00	0.00	0.00	2.20
	4	4650.00	105.00	0.93	964.00	2085.60	277.10	405.00	45.00	58.00	28.00
	5	12300.00	266.00	2.57	1615.00	0.00	318.80	315.00	35.00	0.00	0.00
	Total	33300	738	7	5795	5542	1484	720	80	58	44
T	1	0	0	0	0	0	0	0	0	0	0
o	2	48300	1078	10	9200	9600	4842	0	0	0	49
t	3	[illegible]	[illegible]	[illegible]	1134	4618	593	0	0	0	[illegible]
a	4	[illegible]	365	2	2013	3765	1333	810	90	60	34
l	5	[illegible]	1356	18	9996	0	1806	2070	230	0	[illegible]
	Total	162750	3439	31	22343	18002	8274	2880	320	60	93

Figure G-1-4

ENGINEER CLASS IV AND V SUPPLY TONNAGE -- LATIN AMERICAN SCENARIO BASE CASE (Period Total STON)

Unit	Time Period	40-lb Shape	15-lb Shape	40-lb Crater	1-lb TNT	Det Cord	Mine M-15	Mine M-21	Mine M-16	Bang Torp	HEMMS	Total
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4	1.46	0.00	1.15	0.62	0.13	160.09	3.00	6.53	0.00	0.00	172.99
	Total	1.46	0.00	1.15	0.62	0.13	160.09	3.00	6.53	0.00	0.00	172.99
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	1.43	0.00	1.12	0.74	0.16	169.61	3.00	6.77	0.00	1.88	184.71
2	3	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	4.65	0.00	5.17
	4	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	2.18	0.00	2.44
	Total	1.43	0.00	1.12	1.52	0.16	169.61	3.00	6.77	7.42	1.88	192.92
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	1.56	0.38	1.22	0.83	0.14	66.93	2.73	2.68	0.00	0.00	76.48
	4	0.91	0.00	0.71	0.06	0.11	31.89	1.36	1.10	0.00	0.00	36.15
	Total	2.47	0.38	1.94	0.89	0.25	98.82	4.09	3.78	0.00	0.00	112.63
	1	0.78	0.00	0.61	0.37	0.07	2.65	1.64	0.18	0.00	0.00	6.29
	2	0.78	0.00	0.61	0.37	0.07	29.59	1.64	1.25	0.00	0.00	34.31
CAB	3	0.29	0.00	0.23	0.35	0.05	2.65	0.82	0.09	0.00	0.00	4.47
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	1.85	0.00	1.45	1.08	0.19	34.88	4.09	1.51	0.00	0.00	45.07
T	1	0.78	0.00	0.61	0.37	0.07	2.65	1.64	0.18	0.00	0.00	6.29
o	2	2.21	0.00	1.73	1.11	0.23	199.20	4.64	8.02	0.00	1.88	219.02
t	3	1.85	0.38	1.45	0.65	0.19	69.58	3.55	2.77	4.65	0.00	85.08
a	4	2.37	0.00	1.86	0.68	0.24	191.98	4.37	7.63	2.77	0.00	211.91
l	Total	7.21	0.38	5.66	4.12	0.72	463.41	14.20	18.60	7.42	8.44	530.16
	Percent	1.36	0.07	1.07	0.78	0.14	87.41	2.68	3.51	1.40	1.59	100.00

Figure G-1-5

ENGINEER CLASS IV AND V SUPPLY TONNAGE --
LATIN AMERICAN SCENARIO NEW EXPLOSIVE EXCURSION

Unit	Time Period	Liquid Explos	1-lb TNT	Det Cord	ICOM	Volcano	Mine M-16	RAAM	ADAM	Bang Torp	HEMMS	Totals
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4	1.12	0.08	0.13	10.90	14.07	2.22	0.00	0.00	0.00	0.00	28.52
	Total	1.12	0.08	0.13	10.90	14.07	2.22	0.00	0.00	0.00	0.00	28.52
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	1.10	0.08	0.14	2.49	17.03	0.23	8.37	0.93	0.00	1.04	31.41
2	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.65	1.65	6.31
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77	1.04	3.82
	Total	1.10	0.08	0.14	2.49	17.03	0.23	8.37	0.93	7.42	3.74	41.54
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3	1.88	0.08	0.11	6.47	5.02	1.14	0.00	0.00	0.00	0.00	14.70
	4	0.70	0.04	0.06	2.93	1.67	0.48	0.00	0.00	0.00	0.00	5.89
	Total	2.58	0.12	0.17	9.40	6.70	1.62	0.00	0.00	0.00	0.00	20.59
	1	0.60	0.04	0.07	1.40	0.00	0.13	0.00	0.00	0.00	0.00	2.25
	2	0.60	0.04	0.07	1.40	3.68	0.13	0.00	0.00	0.00	0.00	5.93
CAB	3	0.22	0.02	0.05	0.47	0.00	0.04	0.00	0.00	0.00	0.00	0.81
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	1.42	0.11	0.19	3.27	3.68	0.31	0.00	0.00	0.00	0.00	8.39
T	1	0.60	0.04	0.07	1.40	0.00	0.13	0.00	0.00	0.00	0.00	2.25
o	2	1.70	0.12	0.21	3.90	20.71	0.37	8.37	0.93	0.00	1.04	37.35
t	3	2.10	0.10	0.16	6.94	5.02	1.18	0.00	0.00	4.65	1.65	21.81
a	4	1.82	0.12	0.19	13.83	15.74	2.70	0.00	0.00	2.77	1.04	38.23
l	Total	6.23	0.38	0.63	26.07	41.48	4.38	8.37	0.93	7.42	3.74	99.63
	Percent	6.3	0.4	0.6	26.2	41.6	4.4	8.4	0.9	7.5	3.8	100.0

Figure G-1-6

ENGINEER CLASS IV AND V SUPPLY TONNAGE --
EUROPEAN SCENARIO BASE CASE
(Period Total STON)

Unit	Time Period	40-lb Shape	15-lb Shape	40-lb Crater	1-lb TNT	Det Cord	Mine M-15	Mine M-21	Mine M-16	RAAM	ADAM	Bang Torp	HEMMS	Total
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	6.73	0.00	5.28	1.15	0.26	179.99	16.31	26.81	0.00	0.00	0.00	1.46	237.99
1	3	0.78	0.00	0.61	0.17	0.05	21.48	1.84	3.20	0.00	0.00	0.00	0.17	28.31
	4	0.00	0.00	0.00	0.00	0.00	2.99	0.00	0.59	0.00	0.00	0.20	0.09	3.87
	5	14.92	0.00	11.70	2.19	0.52	103.41	32.01	3.43	31.99	3.55	0.00	0.00	203.73
	Total	22	0.00	18	4	1	308	50	34	32	4	0	2	473.90
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	4.39	0.00	3.44	0.76	0.16	116.05	10.58	17.25	0.00	0.00	0.00	0.94	153.56
2	3	0.58	0.00	0.46	0.15	0.05	14.18	1.43	1.97	0.00	0.00	0.00	0.10	18.93
	4	2.14	0.00	1.68	11.44	0.10	64.14	7.64	8.58	22.15	2.46	0.00	0.45	120.79
	5	15.01	0.00	11.78	2.20	0.52	104.08	32.21	3.45	31.99	3.55	0.00	0.00	204.80
	Total	22	0.00	17	15	1	298	52	31	54	6	0	1	498.09
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	5.07	0.00	3.98	0.92	0.16	133.29	12.22	19.80	0.00	0.00	0.00	1.03	176.52
3	3	0.58	0.00	0.46	0.15	0.05	14.18	1.43	1.97	0.00	0.00	0.00	0.10	18.93
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5	14.92	0.00	11.70	2.19	0.52	105.16	32.01	3.51	31.99	3.55	0.00	0.00	205.57
	Total	21	0.00	16	3	1	253	46	25	32	4	0	1	401.01
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	3.80	0.00	2.98	0.72	0.16	155.15	8.80	25.98	0.00	0.00	0.00	1.46	199.05
CAB	3	0.49	0.00	0.38	0.14	0.05	19.50	1.23	3.13	0.00	0.00	0.00	0.17	25.10
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	4	0.00	3	1	0	175	10	29	0	0	0	2	224.15
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	8.68	0.00	6.81	1.62	0.31	239.68	18.84	34.50	0.00	0.00	0.00	1.84	312.25
AR	3	0.97	0.00	0.76	0.18	0.05	27.10	2.12	3.90	0.00	0.00	0.00	0.21	35.30
	4	2.73	0.00	2.14	0.53	0.10	76.41	5.94	11.05	22.15	2.46	5.74	3.31	132.56
	5	7.51	0.00	5.89	1.10	0.26	59.62	16.11	2.08	17.23	1.91	0.00	0.00	111.70
	Total	20	0.00	16	3	1	403	43	52	39	4	6	5	591.34
T	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
o	2	28.66	0.00	22.49	5.16	1.05	824.16	66.75	124.33	0.00	0.00	0.00	6.79	1079.39
t	3	3.41	0.00	2.68	0.80	0.26	96.44	8.05	14.17	0.00	0.00	0.00	0.77	126.57
a	4	4.87	0.00	3.82	11.97	0.21	143.54	13.58	20.22	44.30	4.92	5.94	1.08	254.45
l	5	52.36	0.00	41.06	7.68	1.84	372.27	112.34	12.47	113.20	12.56	0.00	0.00	725.81
	Total	89	0.00	70	26	3	1436	201	171	156	17	6	9	2186.23
	Percent	4.09		3.21	1.17	0.15	65.70	9.18	7.83	7.20	0.80	0.27	0.39	100.00

Figure G-1-7

ENGINEER CLASS IV AND V SUPPLY TONNAGE --
EUROPEAN SCENARIO NEW EXPLOSIVE EXCURSION
(Period Total STON)

Unit	Time Period	Liquid Explos	1-lb TNT	Det Cord	ICOM	VOLCANO	Mine M-16	RAAM	ADAM	Bang Torp	HEMMS	Totals
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	5.62	0.18	0.12	18.76	8.00	7.34	0.00	0.00	0.00	0.87	40.90
1	3	0.67	0.02	0.01	2.17	6.61	0.77	0.00	0.00	0.00	0.27	10.54
	4	0.00	0.00	0.00	0.46	0.00	0.60	0.00	0.00	0.20	0.12	1.38
	5	12.22	0.38	0.27	25.40	0.00	2.38	31.99	3.55	0.00	0.00	76.20
	Total	18.52	0.59	0.40	46.80	14.62	11.09	31.99	3.55	0.20	1.26	129.02
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	3.68	0.12	0.08	11.94	6.00	4.47	0.00	0.00	0.00	0.60	26.89
2	3	0.53	0.02	0.01	1.86	0.00	0.74	0.00	0.00	0.00	0.03	3.19
	4	9.00	0.19	0.07	9.16	7.08	3.09	22.15	2.46	0.00	0.43	53.62
	5	12.30	0.38	0.27	25.56	0.00	2.40	31.99	3.55	0.00	0.00	76.4[illegible]
	Total	25.50	0.71	0.43	48.52	13.08	10.70	54.14	6.01	0.00	1.06	160.15
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	4.27	0.14	0.09	14.26	6.00	5.80	0.00	0.00	0.00	0.67	31.23
3	3	0.53	0.02	0.01	1.86	4.01	0.74	0.00	0.00	0.00	0.17	7.33
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5	12.22	0.38	0.27	25.87	0.00	2.47	31.99	3.55	0.00	0.00	76.75
	Total	17.02	0.54	0.37	41.99	10.01	9.00	31.99	3.55	0.00	0.84	115.32
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	3.22	0.10	0.07	12.68	8.00	2.06	0.00	0.00	0.00	0.90	27.04
CAB	3	0.45	0.02	0.00	1.70	6.21	0.25	0.00	0.00	0.00	0.24	8.89
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	3.68	0.12	0.08	14.38	14.21	2.30	0.00	0.00	0.00	1.15	35.92
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	7.35	0.24	0.16	26.68	12.00	3.94	0.00	0.00	0.00	1.24	51.61
AR	3	[illegible]	0.03	0.02	2.80	2.40	0.39	0.00	0.00	0.00	0.13	6.65
	4	2.32	0.08	0.05	8.84	8.59	1.35	22.15	2.46	5.74	2.44	54.11
	5	6.15	0.19	0.13	14.80	0.00	1.55	17.23	1.91	0.00	0.00	41.97
	Total	16.65	0.53	0.36	53.12	23.09	7.24	39.37	4.37	5.74	3.86	154.34
T	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
o	2	24.15	0.78	0.51	84.33	40.00	23.61	0.00	0.00	0.00	4.28	177.66
t	3	3.00	0.10	0.06	10.39	19.24	2.89	0.00	0.00	0.00	0.90	36.59
a	4	11.32	[illegible]	[illegible]	18.45	15.77	5.0[illegible]	44.31	4.92	5.94	[illegible]	104.[illegible]
l	5	42.[illegible]	1.34	0.94	91.53	0.00	8.[illegible]	113.2[illegible]	12.55	[illegible]	[illegible]	271.[illegible]
	Total	81.37	2.49	1.63	204.81	75.01	40.34	157.50	17.48	5.94	8.14	59[illegible]
	Percent	13.7	0.4	0.3	34.4	12.6	6.8	26.5	2.9	1.0	1.4	100.0

Figure G-1-8

LATIN AMERICAN SCENARIO HELICOPTER REQUIREMENTS
(Average Daily Number of Helicopters)

	Time Period	Unit 1	Unit 2	Unit 3	Division CAB	Division Total
	1	0.00	NA	0.00	0.21	0.21
Base	2	0.00	NA	0.00	1.16	1.16
Case	3	0.00	NA	3.18	0.08	3.25
	4	5.84	NA	1.50	0.00	7.34
Daily Helicopter Requirement						2.99

	Time Period	Unit 1	Unit 2	Unit 3	Division CAB	Division Total
	1	0.00	NA	0.00	0.08	0.08
Int.	2	0.00	NA	0.00	0.20	0.20
Exc.	3	0.00	NA	0.61	0.01	0.62
	4	0.96	NA	0.24	0.00	1.21
Daily Helicopter Requirement						0.53

Figure G-1-9

LATIN AMERICAN SECNARIO TRUCK REQUIREMENTS
(Average Daily Number of Trucks)

Brigade	Period 1	Period 2	Period 3	Period 4	Scenario Average
			Base Case		
1	--	--	--	--	--
2	0	6	1	1	3
3	--	--	--	--	--
CAB	--	--	--	--	--
			New Explosive Excursion		
1	--	--	--	--	--
2	0	6	1	2	3
3	--	--	--	--	--
4	--	--	--	--	--

Figure G-1-10

EUROPEAN SCENARIO TRUCK REQUIREMENTS
(Average Daily Number of Trucks)

	Time Period	Daily Truckloads 1	2	3	CAB	Subtotal	Division Truck Requirement	AR Brigade	AR Brigade Requirement	Total Truck Loads	Total Truck Requirement
	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Base	2	101.18	65.28	75.02	84.85	326.33	24.68	125.85	10.58	452.18	35.26
Case	3	12.04	8.04	8.04	10.69	38.81	8.81	14.23	3.59	53.04	12.39
	4	1.66	38.92	0.00	0.00	40.58	9.21	44.18	11.14	84.76	20.35
	5	70.57	71.02	71.39	0.00	212.98	24.16	39.05	4.92	252.03	29.08
Total Truck Loads		185.45	183.26	154.45	95.54	618.70		223.31		842.01	
Daily Truck Requirement		6.01	5.94	5.01	3.10		20.05		8.04		28.10
	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Int	2	7.40	4.89	5.65	5.04	22.98	1.74	9.49	0.80	32.47	2.54
Exc	3	1.98	0.56	1.36	1.69	5.59	1.27	1.24	0.31	6.83	1.58
	4	0.26	5.56	0.00	0.00	5.82	1.32	5.83	1.47	11.65	2.79
	5	7.14	7.18	7.23	0.00	21.55	2.44	4.02	0.51	25.57	2.95
Total Truck Loads		16.78	18.19	14.24	6.73	55.94		20.58		76.52	
Daily Truck Requirement		0.54	0.59	0.46	0.22		1.81		0.74		2.55

Figure G-1-11

LAST PAGE OF APPENDIX G

ANNEX H

SENSITIVITY ANALYSIS

ANNEX H

SENSITIVITY ANALYSIS

I. INTRODUCTION

1. Purpose. This annex examines the sensitivity of the study's findings to selective additions of key personnel and equipment to the divisional engineer battalion.

2. Scope. The LID's organic engineer battalion was examined to determine whether increases in equipment or strength would affect its ability to meet its wartime mission requirements.

a. Two sensitivity analyses were done for the Latin American scenario: an analysis of the effects of adding more trucks or squad vehicles to the engineer battalion's current TOE, and an analysis of the effect of adding a fourth line company to the LID.

b. One sensitivity analysis was done for the European scenario: an analysis of the effect of adding a fourth line company to the LID.

3. Methodology Overview. All the sensitivity analyses described in this annex were conducted by comparing the performance of the LID's current equipment and personnel under the conditions imposed by the study scenarios to the LID's expected performance with a different allotment of equipment and personnel, as extrapolated from the scenario results.

a. The overall methodology for these sensitivity analyses is based on practical assumptions which limit the kinds of trade-offs which can be recommended to improve the equipment and personnel mix of the LID's organic engineer battalion. The most important of these practical assumptions is that no personnel increases will be recommended without also recommending a corresponding decrease in the same or other engineer units. For equipment, it was assumed that modest increases in the number of equipment items could be recommended. However, the methodology required that item increases be matched in volume and weight by equipment decreases, when all recommended equipment increases and decreases were expressed in terms of C-141B cargo space and weight limitations. For the LID, the need to limit personnel to 10,000 individuals and deployment to 500 C-141B sorties has resulted in a small 290-man engineer battalion with a small pool of key equipment. Therefore, as now organized, the LID's engineer battalion has very little room to absorb any recommended increases in equipment or personnel.

b. The LID is a new concept, and its organic engineer battalion is organized with some startling differences from the past. Since the concept is new and since other areas of the division are continually being evaluated, the sensitivity analyses presented here looked at the advantages of certain additions without evaluating the trade-offs. That evaluation is left for others to make, when appropriate. Consequently, equipment or personnel additions that have promise are part of the study's conclusions, but not the study's recommendations.

c. The divisional engineer battalion is the first engineer battalion organized without an engineer squad vehicle and without dedicating an engineer platoon or company to each maneuver battalion or brigade. The ommision of an engineer squad vehicle was hotly debated during the development of the LID TOE; the shortage of dedicated support was a visible concern to the staff of the 7th ID(L) during ESC's data collection trip in October 1985. For these reasons, ESC proposed two excursions to this study at IPR 2; the SAG approved the effort on 9 December 1985. Additional background notes for each excursion are given in the individual analysis descriptions that follow.

II. ENGINEER BATTALION VEHICLE ANALYSIS

4. Objective. This analysis examines the requirements and capability of the LID's existing vehicles to determine whether enough vehicles are now allocated to allow the engineers to perform their wartime mission.

5. Background.

a. Traditionally, engineers have had enough vehicles to be essentially self-sufficient in performing their combat mission on the battlefield. During a battle, engineers must keep up with forward units to provide unhindered movement for the attacking friendly forces, provide protective positions for all forces, and delay the advance of the opposing forces. Engineers also must transport their mission supplies from division and corps supply points to the project work sites on the battlefield. These combat and logistical requirements mean engineers must move easily and rapidly on the battlefield.

b. Based on the role engineers play in battle, limiting their transportation assets could affect their level of performance and the overall effectiveness of the combat force. Because the LID is a unique division and designed to be self-sufficient, ESC examined how its organic engineers' performance in the Latin American scenario was affected by vehicle capability.

6. Scope. Three main questions were asked by the vehicle analysis:

a. Can the battalion's assigned vehicles accomplish the project work required at battlefield job sites?

b. Do engineers have the logistic capability to transport the required Class IV/V materiel generated by the countermobility and survivability tasks? What is the transport capability from the BSA to the project sites within the forward line companies?

c. Would a squad vehicle enhance the engineer's capability and reduce the time devoted to moving between project sites?

7. Constraints.

a. Based on guidance received from the SAG at IPR 3, only the Latin American scenario was analyzed to determine if additional vehicles were required.

b. The analysis was conducted in AO Red -- the joint operational area of the 2d Brigade and the DRA. The analysis concentrated on the defensive phase (period 2) and offensive phases (periods 3 and 4) of the scenario. The offensive periods for the 2d Brigade constituted the LID main advance up Axis Sally, part of AO Red extended. Since engineers and equipment are airlifted into the other AOs of the scenario, a capability and requirements analysis for these areas was inappropriate.

c. Additional vehicle candidates considered in the analysis included the 5-ton truck and the High Mobility Multipurpose Wheeled Vehicle (HMMWV).

(1) The 5-ton cargo truck and the 5-ton dump truck are considered at platoon, company, and battalion levels. These two vehicles were selected based on their capability to support engineer functions -- the cargo truck has a primary capability of hauling logistic supplies and the dump truck primarily hauls earth and fill material for combat operations.

(2) The HMMWV is the only candidate for a squad vehicle, since other vehicles do not have the mobility range required of light engineer squads.

8. Methodology. This analysis first examined the TOE of the LID engineer battalion to determine what kind and how many vehicles were assigned to it and where they were distributed.

a. Of the eight 5-ton cargo trucks in the current engineer TOE, five are distributed to the headquarters company (one in company headquarters, one in maintenance, and three in S-4) and one each to the three line companies. One HMMWV is provided for each platoon in the line companies. No squad vehicles are designated.

b. Once the number and type of vehicles in the engineer TOE were determined, ESC used the EFFORT computer model to calculate the number of hours of work time (in truck-hours) represented by each vehicle which supports engineer combat operations; Figure H-1 describes how EFFORT computes in daily truck-hours per battalion truck (see Annex B for an explanation of the EFFORT capability methodology).

PRODUCTIVE WORKHOURS PER DAY

	Latin American Scenario LID	
	Personnel	Equipment
Hours in day	24.0	24.0
Nonwork time	- 6.0	- 8.0
Workday	18.0	16.0
Nonproductive time	- 4.5	- 4.0
Movement*	- 4.5	- 4.0
PRODUCTIVE WORK TIME	9.0	8.0

*Movement accounts for 25% of the work-day in the Latin American scenario and represents time available for the transport of logistical supplies from the BSA to project work sites.

Figure H-1

(1) The 8 hours of daily productive work time listed in Figure H-1 for equipment represents one truck's daily capability to accomplish project work tasks at and between job sites. Three trucks -- one in each line company -- are available for this type of work. Many project work tasks can generate truck requirements. Among the more common are carrying material at the project site (e.g., mines at minefield points), dumping or providing fill material for obstacle breaching, and maintaining and upgrading MSRs and LAPES.

(2) The movement time of 4 hours listed in Figure H-1 is for the logistical work of resupplying or transporting engineer material and supplies (e.g., Class IV/V material) from the BSA to the project sites within the forward line companies. The three trucks in the line companies and the three trucks in the Headquarters' S-4 section are used for this purpose. It is assumed that while the trucks in the S-4 section are dedicated to providing supplies from the division rear to the BSA, they could also be used the same percentage of the time (4 hours) as the trucks in the line companies to transport supplies forward of the BSA.

c. The truck requirements generated by both project work and logistical transport work were independently analyzed by scenario time period and priority ranking. These requirements were then compared with the truck capability available for each category of work. Finally, total truck requirements were compared with total truck capability.

d. After the basic comparison of requirements with capability was completed, ESC examined the possibility of adding squad vehicles to the engineer TOE. Truck requirements at the project work sites were analyzed to determine if squad vehicles would reduce the time trucks spend moving personnel, equipment, and material between job sites, therefore increasing the time trucks have available for project work. The resulting increase in truck time on project site work was evaluated and compared with the results of the basic requirements/capability comparison to determine whether adding a squad vehicle would enhance the total capability of the LID engineers.

9. Project Work Truck Analysis.

a. Capability. Engineer truck-hours of capability for work at the project sites were computed using the EFFORT model. The model used a base of three trucks (one in each line company) working 16-hour days. As shown in Figure H-1, the 16-hour work day for trucks was then degraded for nonwork time (mess for drivers, change of mission, etc.) and for time the trucks were transporting supplies. Battle casualties were also assessed once combat commenced. Figure H-2 shows the total available truck capability for project work, in hours and by time period.

TRUCK CAPABILITY BY TIME PERIOD FOR PROJECT WORK

Period	From		Through	Capability (Hours)
1	D+1	-	D+2	24
2	D+3	-	D+4	45
3	D+5	-	D+8	89
4	D+9	-	D+10	39
	TOTAL			197

Figure H-2

b. Requirements. Figure H-3 displays the number of truck-hours required by the four mission areas, and the time periods in which those requirements occur. The same truck-hour requirements are arrayed by priority task group and time period in Figure H-4.

TRUCK REQUIREMENTS BY MISSION AREA AND TIME PERIOD
(Number of Hours)

Mission Area	Time Period 1	2	3	4	Total Requirement
Mobility	24	41	203*	121	389
Countermobility	0	128	0	0	128
Survivability	0	0	0	0	0
General Engineering	3	6	11	36	56
TOTAL	27	175	214	157	573

*The majority of this work is in constructing and maintaining MSRs, breaching obstacles, and constructing river fords.

Figure H-3

TRUCK REQUIREMENTS BY PRIORITY AND TIME PERIOD
(Number of Hours)

Priority	Time Period 1	2	3	4	Total Requirement
Vital	1	35	0	0	36
Critical	26	3	132	51	212
Essential	0	126	82	91	299
Necessary	0	11	0	15	26
TOTAL	27	175	214	157	573

Figure H-4

c. Comparison. Figure H-5 compares truck capability with truck requirements. The requirement numbers are limited to only the top three priorities - vital, critical, and essential tasks. Truck requirements associated with the fourth priority - necessary tasks - are excluded, since the overall study methodology outlined in the main report assumes this work is not to be started until after the scenario ends (i.e., after D+10).

COMPARISON OF TRUCK CAPABILITY AND REQUIREMENTS

Time Period	Available Capability (Hours)	AO-Red Requirement* (Hours)	Shortage (Hours)
1	24	27	3
2	45	164	119
3	89	214	125
4	39	142	103
TOTAL	197	547	350

*Requirements include vital, critical, and essential tasks.

Figure H-5

(1) During Period 1, units are deployed into the theater and relocated to their area of operations to establish their operating positions. Truck requirements and capability during this period are minimal and relatively balanced. These requirements were eliminated from further analysis in order to be consistent with the methodology assumption in the EAD structure analysis (Annex J), which concentrates solely on the "key situations" of the scenario. The last three periods, identified as the key situations in the EAD methodology, are the defensive and offensive phases of the scenario. As shown in Figure H-5, the requirements generated by these periods greatly exceed the available truck capability. Figure H-6 further examines this peak shortfall and converts the truck-hour shortage into the number of trucks required to complete all work at the project sites.

SUMMARY OF TRUCK CAPABILITY FOR WORK AT PROJECT SITES
(Periods 2, 3, and 4)

	Latin American Scenario	
	Base Case (Truck-Hours)	New Explosive Excursion (Truck-Hours)
Requirement for project work*	520	353
Capability at project site** (Three 5-ton cargo trucks)	- 173	- 173
SHORTFALL	347	180
Additional capability:		
Add six 5-ton trucks	346	—
Add three 5-ton trucks	—	173
SHORTFALL	- 1	- 7
TOTAL 5-ton trucks required	9	6

*Does not include period 1 requirement (27 hours) or the 26 hours of requirements for necessary tasks in periods 2, 3, and 4.

**One truck equals 8 hours productive time after 25% degradation for movement and 25% standard degradation for maintenance, mess, etc. The 8 truck-hours are then degraded for casualties.

Figure H-6

(2) Figure H-6 shows that six additional 5-ton trucks are required to accomplish all tasks in the vital, critical, and essential priority groups that occur in periods 2, 3, and 4 of the scenario. No distinction was made as to the difference in capability between the 5-ton cargo truck and the 5-ton dump truck in the development of the scenario requirements. But, based on the type of work causing the truck shortage, the addition of six 5-ton dump trucks would be more beneficial to the engineers than the addition of cargo trucks.

(3) In Annex D, the use of scatterable mines in lieu of standard hand-emplaced mines was examined to illustrate the savings in emplacement time and tonnage that could be derived by using scatterable mines. Figure H-6 shows this new explosive excursion as it relates to savings in project site workload for trucks. In this case, there is a reduction of 167 truck-hours in project work. Thus, only three additional 5-ton trucks are required.

10. Logistic Truck Analysis. The engineer mission requirements for transporting Class IV and V materiel from the BSA to the project sites was analyzed separately from the requirements for project work performed at the job sites. The quantity of Class IV and V material required by the engineers was calculated for the mission areas of mobility, countermobility, and survivability, converted to the required number of truckloads and number of trucks, and then compared with the available transport capability.

a. Capability. Figure H-1 shows that movement or transport capability was computed based on 25 percent of the 16-hour workday (i.e., 4 hours per day per truck). The three 5-ton trucks in the line companies that were used for work at the project sites, along with the three 5-ton cargo trucks in the S-4 section of the headquarters company, were counted as available for hauling and transport. Thus, for a single day, there were six trucks, each available for 4 hours -- a total daily capability of 24 truck-hours.

b. Requirements. The transport requirements were developed primarily for Class V demolition material, since no traditional Class IV material (e.g., barbed wire) was used by engineers in the Latin American scenario. The various types and quantities of mines and demolition material used in the scenario were broken down by time period and AO requirement. As stated in paragraph 8, only AO Red requirements and capability were analyzed.

(1) Once the quantity of each type of mine or demolition was determined for AO Red, the number of truckloads required to move those quantities was calculated. The size and weight of the shipping packages, along with the dimensions and capacity of the 5-ton, M-813 cargo truck, were used to convert the quantities to the number of truckloads required. Figure H-7 is an example of the calculations used to determine the required number of truckloads. The figure shows that for period 2, 23 truckloads are required to transport Class IV/V material. While the figure only portrays period 2, the requirements for other periods in the scenario were calculated in the same manner.

(2) The number of truckloads was used to determine the number of trucks required. Since trucks can make many round trips during a given time period, the number of trucks required depends on the distance and time involved in completing a round trip. Figure H-8 continues the example in Figure H-7, and shows the methodology and calculations used to determine that 5.3 trucks are required in period 2 to transport Class IV/V material in AO Red. The average distance from the BSA to the project sites was computed using maps and the gamed rate of advance. As the forward companies advance up Axis Sally and away from the BSA, the average one-way distance increases for each time period. Correspondingly, the time required to complete one round trip also increases.

c. Comparison. Figure H-9 summarizes and individually compares transport requirements and truck capability in hours and number of trucks for each time period. Also shown is an average daily truck requirement. This number is derived using the same calculations shown in Figure H-8, but with an average scenario distance. As can be seen by the comparison, the greatest

SAMPLE TRUCK COMPUTATIONS FOR CLASS IV/V LOGISTIC TRANSPORT
(Period 2 -- AO Red)

Item	Shipping Package	Weight (lb)	Cubic Feet	Package Size: Length (in.)	Package Size: Width (in.)	Package Size: Height (in.)	No. in Package	Quantity Req'd	Number of Boxes Req'd	5-Ton Cargo Truck Capacity (boxes/load)	Number of 5-Ton Cargo Truckloads
1-lb TNT	wooden box	81	1.52	18.5	9.5	14.9	56	540	10	239	0.0
40-lb crater charge	wooden box	51	1.39	27.5	8.9	9.8	1	35	35	264	0.1
40-lb shaped charge	wooden box	65	1.88	20.5	11.8	13.4	1	35	35	220	0.2
15-lb shaped charge	wooden box	65	2.04	33.9	9.8	10.6	3	0	0	188	0.0
Detonation cord	wooden box	105	3.80	30.0	15.0	14.6	4,500 ft.	2	2	135	0.0
M-180	wooden box	165	7.13	45.5	13.2	20.5	1	0	0	34	0.0
Bangalore torpedo	wooden box	198	3.87	64.1	13.9	7.5	1	0	0	84	0.0
Mines											
M15 AT	wooden box	49	1.17	18.0	15.0	7.5	1	6,761	6,761	315	21.5
M21 AT	wooden box	91	1.96	20.2	13.4	12.5	4	156	39	188	0.2
M16 AP	wooden box	39	0.72	15.4	9.8	8.2	4	1,362	340	512	0.7
M26 AP	wooden box	60	1.15	21.2	9.7	9.7	18	0	0	166	0.0
Other											
HEMMS	wooden box	174	8.34	55.2	17.4	15.0	1	22	22	81	0.3
TOTAL TRUCKLOAD REQUIREMENT*											23.0

*Numbers may not add exactly, since the computer retains numbers less than 0.1 truckload in memory, then adds all values back in when calculating a total.

Figure H-7

demand for logistics is in period 2; however, it does not cause a shortage in truck capability. The figure also shows that there is a significant excess of truck capability in periods 3 and 4 for this work category.

TRUCK TRANSPORT COMPUTATIONS -- HOURS AND TRUCKS REQUIRED
Period 2 -- AO Red, Class IV/V

Average distance traveled -- one way (BSA to forward company)	15.0 km
Rate of travel	35.0 kph
Delay (1/2-hour load & 1/2-hour unload)	1.0 hour
Time required for one truckload roundtrip ([15.0 km x 2]/35 kph + 1 hour)	1.9 hours
Truckloads required in period 2 (See Figure H-7)	23.0
Total transport time required (1.9 hours x 23 truckloads)	42.7 hours
Average daily transport requirement (42.7 hours/2 days)	21.4 hours
AVERAGE DAILY TRUCK REQUIREMENT (21.4 hours/4 hours capability per truck per day)	5.3 trucks

Figure H-8

11. Squad Vehicle Analysis. The squad vehicle analysis postulated whether adding squad vehicles to the engineer TOE would reduce the amount of truck-hour requirements by assisting in some of the project work at the job sites. The analysis also examined whether project work time would be increased as a result of having squad vehicles relocate material and squads between work sites, instead of walking or relying on the one HMMWV at platoon level or the one company truck for transportation between the various job sites.

SUMMARY OF CLASS IV/V TRUCK TRANSPORT
(AO Red)

	Time Period 2	Time Period 3	Time Period 4	AO Red Average (Hours/Daily)
	Total Hours			
Available truck capability*	48.0	96.0	48.0	24.0
Transport requirement	-42.7	- 7.1	- 5.6	- 9.6
	+ 5.3	+88.9	+42.4	+14.4
	Number of Trucks			
Available -- Daily	6	6	6	6
Required -- Daily**	6	1	2	3
Surplus	0	5	4	3

*Capability equals 25% of the 16-hour workday (4 hours), times the number of trucks (six), times the number of days in the period. Number of trucks includes the three trucks in the line companies and the three trucks in the S-4 section.

**All numbers are rounded up. A truck is required whether partially loaded or fully loaded.

Figure H-9

a. Most tasks that generated truck-hour requirements at the project sites involved hauling fill material for the construction, repair, and maintenance of roads and river fords, etc. These tasks are not conducive or productive for the use of the HMMWV, which has limited capability for hauling this type of material. While adding squad vehicles could reduce the truck-hour requirement for some of the other types of project work (e.g., moving mines to various minefield points), the amount of effort saved by using the HMMWV to haul fill material would not be significant.

b. The engineers are assisting and following the infantry advance up Axis Sally and most of the engineers' task work is in this corridor. In examining the scenario, it was determined that the engineers could walk to most of their missions or be transported by helicopter into those AOs that were not accessible by road. Walking distance between job sites was, on average, within 1 or 2 kilometers. Relocation of equipment and supplies, when required, can be accomplished with vehicles at the platoon or company level.

c. Based on the LID's "light" concept and the limited increase in project capability, the addition of a vehicle for each squad is not warranted. Further, the addition of squad vehicles for mobility or to assist in moving supplies and equipment is not justified in this scenario.

12. Findings.

a. While the engineers have a shortage of truck capability for accomplishing the truck's project tasks at the work sites, there is excess truck capability for transporting Class IV/V material. With careful management of the truck resources used for logistic and project assignments, the project work shortage could be significantly reduced or offset by the excess logistic transport capability. Based on this scenario, no additional trucks are warranted.

b. The analysis did not indicate any significant savings in time, capability, or mobility to warrant adding squad vehicles to the TOE. These findings were briefed and concurred with by the members of the SAG at the third IPR.

III. FOURTH LINE COMPANY

13. Objective. This section analyzes results of the study's two scenarios in order to determine what advantages would accrue if a fourth line company was added to the divisional engineer battalion.

14. Background.

a. The divisional engineer battalion of the former infantry division was organized with four line companies. Each line company, in turn, had three platoons with three 10-man squads -- a total of 36 squads, divided among nine platoons. With this configuration, the engineers could support each maneuver battalion with a platoon, or each maneuver brigade (plus the DRA) with a company, or some allocation in between.

b. The LID has an engineer battalion with only three line companies. Each line company has two platoons with three 8-man squads. This equals 18 squads divided into six platoons, but with only 40 percent of the former battalion's manpower. At the same time, the LID maintained nine maneuver battalions and increased its maneuver brigades to four with the activation of the combat aviation brigade (CAB). Engineer equipment is now centralized in the HHC, leaving the line companies with only a few wheeled vehicles. The engineer battalion is now allocated to where the work is most important, since continuous, habitual association is not possible at either brigade or battalion levels.

c. During ESC's data collection trip in October 1985 at Fort Ord, California, the maneuver brigade commanders voiced concern about not having a habitually associated engineer company. One commander was even willing to trade-in another branch to get his own organic engineer platoon. As a result of these concerns, ESC agreed to conduct an analysis of a fourth line company and the SAG approved this effort at IPR 2.

15. Methodology. This analysis was accomplished sequentially by scenario. Each base case scenario was first completed and the results examined to determine the impact and advantages of using a fourth line company. The methodology attempted to find requirements for the simultaneous use of four line companies. However, other, more pressing needs for a fourth line company were identified. The trade-off to obtain this fourth line company (as mentioned in the introduction) is not part of this methodology and is omitted. However, a summary of advantages common to both scenarios is included.

16. Latin American Scenario.

a. SITUATION: This scenario has a significant squad-hour shortfall, but only a small equipment-hour shortfall. As a result, the primary need for engineer EAD units are those with squad power. The squad shortfall was offset in the base case by deploying two line companies (TOE 5-197L2) of the engineer combat battalion (corps light). However, if a divisional battalion with four line companies was available, it would reduce the EAD requirement shortfall by 25 percent. The added company can accomplish all defensive tasks which eliminates the squad-hour shortfall for the first 4 of the scenario's 10 days. Consequently, only 1-1/2 companies of the EAD battalion would be needed to eliminate the shortfall during the last 6 days of the offensive portion of the scenario. IMPACT: The addition of a fourth line company results in a divisional engineer battalion that is considerably more self-sufficient. When this larger battalion is deployed to a Latin American contingency, it would enhance the division's ability to fight without EAD support.

b. SITUATION: In this scenario, the squad-to-equipment ratio of requirements favors squads by about a 20 percent differential. Figure H-10 shows that this is the reverse of the capability found in the divisional engineer battalion, where equipment is favored by 20 percent. IMPACT: A fourth line company results in an even ratio of squads-to-equipment, which reduces by one-half the differential that exists in the base case scenario between capability and requirements.

SQUAD-TO-EQUIPMENT RATIO --
LATIN AMERICAN SCENARIO

	Percentage	
	Squad	Equipment
1988 TOE capability	40	60
TOE with fourth company	50	50
Scenario requirements	61	39

Figure H-10

c. SITUATION: In this scenario, the engineers lose the equivalent of 4.5 squads to casualties. The remaining 13.5 squads are 64 percent as effective as three full companies. IMPACT: The battalion with a fourth line company will still suffer a 4.5-squad casualty rate. However, now the remaining 19.5 squads are 108 percent effective -- the equivalent of three full companies.

d. SITUATION: The workload in this scenario is fragmented among four AOs. This forces commanders to carefully allocate engineer assets. Two of these AOs are accessible only by air, which places a further premium on good planning. Fortunately, the workload is generally spread out, allowing use of divisional engineers on a centralized basis. Figure H-11 shows the scenario's major work zones for engineers. A major work zone is defined when there is close combat (or heavy LOC work) requiring a brigade engineer or equivalent to manage the effort, and to provide only one point of contact with the zone commander. The last 2 days of the scenario require work in four zones, one of which is supported only by helicopter. During these 2 days, the scenario requirements exceed the ability of the divisional engineers to decentralize their centralized organization. IMPACT: A fourth line company in the division could provide four brigades with a dedicated company of engineers during period 4, when there is a requirement to have a company in four separate areas.

MAJOR WORK ZONES

	Zones With Close Contact or High LOC Needs					
Period	1st Bde	2d Bde	3d Bde	CAB	DRA	Totals
1	X					1
2		X		X*		2
3		XX	X*			3
4	X*	XX			X	4

*Accessible by air only.

Figure H-11

17. European Scenario.

a. SITUATION: The European base case scenario has a large squad-hour shortfall and no equipment-hour shortfall. The addition of a fourth line company to the divisional engineer battalion would decrease the base case shortfall by almost 25 percent. This 25-percent shortfall reduction also results in a combat-essential force that has more full units. This reduces the need for employing corps battalion companies (TOE 5-37H) without equipment -- an undesirable allocation. IMPACT: The addition of a fourth line company helps the divisional engineer battalion meet a higher percentage of scenario vital tasks, especially tasks needed to complete the initial obstacle plan.

b. In the European scenario, the squad-to-equipment ratio of requirements favors squads by about a 25 percent differential over capability. Figure H-12 shows this differential is almost the same as that found in the Latin American scenario, as shown in Figure H-10. IMPACT: A fourth line company results in a smaller squad-to-equipment differential. This significantly reduces the differences between capability and requirement ratios.

SQUAD-TO-EQUIPMENT RATIO —
EUROPEAN SCENARIO

	Percentage	
	Squad	Equipment
1988 TOE capability	40	60
TOE with fourth company	50	50
Scenario requirements	65	35

Figure H-12

18. Findings.

a. From this analysis, it can be concluded that it would be desirable to have more squad personnel in the LID engineer battalion. The additional squads would alleviate both a squad-hour requirement shortfall and adjust the squad-to-equipment ratio within the TOE to better match capability with requirements. These conclusions apply to both scenarios. The concept of centralized support, using three companies, is also viable from the analysis of each scenario. The analysis showed that major work zones rarely exceeded three, resulting in a need for six to nine more squads. These squads could be added to either a new platoon within the existing three companies, or to a new fourth company, as shown in Figure H-13. The addition of a third platoon per company results in a solution that gives the battalion three more squads and less overhead and vehicles than the fourth line company solution. However, a fourth line company would be desirable if CAB doctrine changes and requires more support than was reflected by the study's two scenarios. The final answer also must consider affordability, as the fourth line company solution requires 17 fewer personnel.

ADDITIONAL SQUAD PERSONNEL

Organizational Element	Existing TOE	Additional Fourth Company	Additional Third Platoon
Company headquarters			
Number	3	4	3
Strength total (10/company)	30	40	30
Platoon headquarters			
Number	6	8	9
Strength total (3/platoon)	18	24	27
Squads			
Number	18	24	27
Strength total (8/squad)	144	192	216
Recapitulations per battalion*			
Strength increases:			
Overhead	—	16	9
Squad personnel	—	48	72
Total	—	64	81
Vehicle Increases:			
HMMWV	—	3	3
5-ton cargo truck	—	1	0
Total	—	4	3
Company totals:			
Strength	192	256	273
Vehicles	12	16	15

* HHC not included.

Figure H-13

b. This analysis also shows the desirability of having engineer EAD units organized with equipment in separate battalion companies. This would allow allocation of full companies to locations where only squad-hours are needed, without tailoring these companies by leaving selected equipment behind.

LAST PAGE OF ANNEX H

ANNEX I

DIVISIONAL ENGINEER BATTALION ORGANIZATIONAL STRUCTURE

ANNEX I

DIVISIONAL ENGINEER BATTALION ORGANIZATIONAL STRUCTURE

1. Purpose. This annex evaluates the design of the LID organic engineer battalion to determine if it can meet the division's engineer support requirements during the key situations of the Latin American and European scenarios.

2. Scope.

a. This analysis evaluated the engineer support capability of the current organizational structure of the LID engineer battalion by:

(1) Comparing its support capability to the scenarios' support requirements during key preparatory and battle situations of the Latin American and European scenarios.

(2) Determining whether the battalion's engineer squad- and equipment-support capabilities were sufficient to satisfy the scenarios' requirements.

(3) Evaluating the quantity and type mix of SEE attachments are best suited to the tasks expected of the SEEs alloted to the battalion.

(4) Recommending changes in organizational structure and equipment mix to improve the battalion's performance.

b. All of the improvements or adjustments made to the LID's engineer battalion structure were made based on the assumptions that the personnel strength indicated in its current TOE will remain the same and that its C-141B deployment sorties will not be increased.

3. Methodology.

a. Capability comparisons. The design of the LID engineer battalion was evaluated by comparing two key aspects of the unit's structure: its squad-to-equipment ratio and its individual equipment mix capability. This evaluation was based on the key situations occurring during each base case scenario. These situations are the most important and difficult for the divisional engineer battalion to support. They were analyzed to find where the engineer workload was concentrated on the battlefield and to determine what work areas had the highest priority for engineers. This same approach was used to determine how different SEE attachment mixes affected engineer capability during key scenario situations.

b. Scenario key situation. The main report establishes key situations for each scenario. The lodgement period was not included in these key situations, because the study assumptions limited the workload generated during this phase of the scenarios. In addition, the lowest one or two task priority groups which enhance the sustainability of the division (i.e., tasks in the necessary and, in some cases essential priority groups) were not considered when calculating the scope of the engineer support requirement during the scenarios' battle preparation and combat periods, because of the short duration of the battle phases.

(1) Figure I-1 shows how the scenario-based engineer requirements were distributed in the divisional AO. The engineer requirements generated by EAD units located in the divisional AO are less than 5 percent. Since this workload was not significant enough to justify analysis in a separate excursion, EAD requirements were included among the overall engineer requirements generated by the division during the scenarios' key situations.

DISTRIBUTION OF REQUIREMENTS*
(Percentage)

	Division Workload		EAD Workload	
	Squad	Equipment	Squad	Equipment
Latin American scenario				
Brigade areas	99	78	--	--
DRA	1	17	--	5
TOTAL	100	95	--	5
European scenario				
Brigade areas --				
LID	61	47	--	1
AR	26	27	--	3
DRA	13	22	--	--
TOTAL	100	96	--	4

*Percentages based on key situation of each scenario.

Figure I-1

(2) In the European scenario, about 28 percent of the workload in the divisional AO is generated by the attachment of a separate armored brigade. The workload generated by the separate armored brigade is important to the analysis of the EAD force structure required to support the LID in a high-intensity conflict (Annex J), but not to this annex's division structure analysis. It is not important because companies of the LID engineer battalion are not assigned to support the attached brigade, nor should they be. The limited engineer capability of the divisional LID battalion is far less than that needed to satisfy LID requirements; the LID's engineer battalion has neither the equipment nor mobility to provide effective support to armored or mechanized elements. For these reasons, the engineer workload requirements associated with the separate armored brigade were not added to the European scenario's key situation requirements.

c. Study excursion comparisions. This study considered two major scenarios and 12 minor study excursions to those scenarios. The analysis described in this annex incorporates the results of three of these excursions: excursion 2, which places divisional engineers forward; excursion 3, which places EAD engineer units in the DRA; and excursion 7, which looks at the effect the mix of SEE attachments has on engineer capability. Excursions 2 and 3 were limited to the European scenario. (Although excursion 1, which evaluates the impact of attaching a corps engineer battalion to the division, is not directly considered here, it does influence divisional engineer capability by showing what tasks divisional design is based upon. The results of ESC's analysis of excursion 1 are presented in more detail in Annex J to this report.)

d. New explosive excursion. Both the capability and excursion comparisons initially use the base case scenarios. The analyses described in

Annexes D and G outline how scatterable mines and liquid explosives could significantly shift the requirements for SEE equipment-hours upwards and for squad-hours downwards. Since the Army is committed to eventually fielding scatterable mine systems, all comparisons in this annex also consider the probable influence of fielding those systems. To avoid confusion with numbered excursions 2, 3, and 7, this comparison of the future effects of scatterable mine systems is called the new explosive excursion; it was applied to each scenario's key situation.

4. Squad-to-Equipment Ratio Analysis.

a. Figure I-2 shows the squad to equipment capability ratios for the LID engineer battalion using the 1988 TOE, and gives the ratios required to satisfy the engineer requirements generated by the base case, key situation, and the new explosive excursions to the base case and key situation of each scenario. The scenario-requirement ratios are segregated in several ways to illustrate the sensitivity of engineer capability to requirements generated in different priority task groups, during different battle phases, and in various battlefield sectors within the divisional AO. Of the battle-related factors listed in Figure I-2, two have the most significant impact on the divisional battalion mission and organization: task priority group and battle phase.

(1) Priority group. Because of the short duration of the scenarios, tasks included in the vital and critical priority groups are the more appropriate work tasks for divisional engineers. Tasks in the essential priority group are also important in the Latin American scenario, since the duration of the battle phases requires the sustaining capability represented by the essential engineer work. Tasks in the necessary priority group either will not be done or will be allocated to EAD engineers.

SQUAD-TO-EQUIPMENT RATIO

	Percentage	
	Squad	Equipment
1988 TOE Capability	40	60
Latin American Requirements		
Priority groups		
Vital, critical, & essential	58	42
Necessary	78	22
Time		
Lodgement	28	72
8-day battle	63	37
Battle zone		
Brigade areas	67	33
DRA	9	91
Key situation*	61	39
European Requirements		
Priority groups		
Vital & critical	59	41
Essential & necessary	29	71
Time		
Lodgement	31	69
Battlefield preparation & 4-day battle	43	57
Battle zone		
Brigade areas	46	54
DRA	30	70
Key situation**	65	35
Weighted Scenarios* **		
Base case key situations	62	38
New explosvie excursion key situations	51	49

*Base case 8-day battle; vital, critical, and essential priorities.

**Base case battlefield preparation and 4-day battle; vital and critical priorities; minus requirements generated in armored brigade AO.

***Two-thirds Latin America, plus one-third Europe.

Figure I-2

(2) Battle phase. Divisional engineers should be structured to support the division where it is engaged in combat operations, and not to support work generated during the initial lodgement phase. The scenario assumptions prevent a significant workload during each lodgement phase. As a result, the key situation eliminates the lodgement phase and focuses on the engineer requirements generated by the division during the combat phases of the scenario. In the European scenario, the study assumptions may understate the engineer capability provided by EAD units, since most are deployed at the end of an 18-day deployment period.

b. Figure I-2 shows that the squad-to-equipment ratio of the divisional engineer battalion does not come close to matching the ratio of the engineer requirements in the brigade areas during the key situations of either the Latin American or European scenario. The TOE squad-to-equipment ratio is 40:60, versus an average key situation requirement ratio of 62:38. The TOE ratio is based on counting only three company 5-ton cargo trucks as available for meeting requirements generated at the work site. If more trucks were counted (i.e., supply and maintenance vehicles at battalion level), the difference between ratios would be even more than the 20 percent indicated. The solution is to either reduce squad effort or increase squad power, or both.

(1) Reduce squad effort. In Europe, the requirement ratio will change as scatterable mines are fully fielded. Scatterable mines are the major ingredient of the new explosive excursion shown in Figure I-2. Scatterable mines greatly reduce the requirement for engineer support manhours, while slightly increasing the need for equipment-hours. The new explosive excursion (Annex G) shows an anticipated squad-to-equipment ratio of 34:66 for the European scenario's key situation. The change for Latin America is negligible, since the requirements generated by that scenario's mining mission are

considerably lower. Thus, the new explosive excursion results in a future weighted scenario ratio of 51:49.

(2) Increase squad power. This analysis shows the LID needs more squad power. The study limitation which caps the divisional engineer battalion strength at design TOE levels does not permit adding squads, although the sensitivity analyses (Annex H) indicate that more squad power is required. The only solution would be to modify the EAD force structure creating a corps battalion which is organized with squad-only companies, separate from equipment-only companies. The squad-only companies could then be deployed sooner to support the LID. At present, no corps battalion is organized in this fashion to augment the LID.

5. Equipment Mix Analysis.

a. Distribution. Figure I-3 shows the distribution of the battalion's dominant equipment items and the distribution reflected by the requirements of the base case, key situation, and new explosive excursions to the base case and key situation of each scenario. Figure I-3 shows five dominant classes of equipment:

(1) D7 bulldozer or ACE.

(2) 2-1/2 cubic yard loader.

(3) Grader.

(4) SEE or JD410 tractor (both with front-end loader and backhoe attachments).

(5) Nondedicated 5-ton truck. (In the divisional engineer battalion, five of the eight 5-ton trucks are considered dedicated. The dedicated trucks are all in the HHC and have POL, maintenance, and supply missions. The remaining three trucks are not dedicated; they represent the 11-percent capability shown in Figure I-3.)

EQUIPMENT DISTRIBUTION

	Dominant Equipment (Percentage)					
	ACE/ D7	Loader	Grader	5-Ton Trucks	SEE/ JD 410	Total
1988 TOE Capability	22	--	--	11	67	100
Latin American Scenario Requirements						
Priority groups						
Vital, critical, & essential	41	9	2	33	15	100
Necessary	49	12	3	17	19	100
Time						
Pre D-day	61	18	1	14	6	100
8-day battle	39	8	2	34	17	100
Battle zone						
Brigade areas	34	10	--	37	19	100
DRA	65	7	10	14	4	100
Key situation*	38	8	2	35	17	100
European Scenario Requirements						
Priority groups						
Vital & critical	33	9	7	40	11	100
Essential & necessary	26	19	6	49	0	100
Time						
Lodgement	17	24	1	58	--	100
Battlefield preparation & 4-day battle	35	14	6	42	3	100
Battle zone						
Brigade areas	39	13	6	39	3	100
DRA	18	23	5	54	--	100
Key situation**	25	9	--	39	27	100
New explosive excursion to key situation**	27	8	6	23	36	100
Weighted Scenarios* **						
Base case key situation	36	8	4	37	15	100
New explosive excursion to key situations	36	9	3	28	24	100

*Base case 8-day battle; vital, critical, and essential priorities.

**Base case battlefield preparation and 4-day battle; vital and critical priorities; minus requirements generated in armored brigade AO.

***Two-thirds Latin America, plus one-third Europe.

Figure I-3

b. Requirements. Equipment mixes affect capability different in each scenario. In Figure I-3, the Latin American and Europe requirements show:

(1) The SEE and ACE workloads are not in proportion to the TOE capability; this imbalance varies by scenario and with the future availability of systems.

(a) The ACE requirements are approximately 2 or 3 times the SEE requirements for the Latin American and weighted scenario. In the base case situation, the weighted scenarios indicate that 2.4 ACE-hours are required for every 1.0 SEE-hour. However, in the new explosive excursion, the ratio drops to 1.5 ACE-hour for every 1.0 SEE-hour. This is because in Europe more SEE-hours are required for countermobility tasks which require the SEE's auger attachment. In Latin America, the ACE still predominates with the ratio of ACE-hours to SEE-hours changing only slightly in the new explosive excursion. The equipment mix suggested by the requirement for ACEs and SEEs indicated by this analysis is almost opposite the actual TOE mix, which provides three SEEs for every one ACE.

(b) Figure I-4 shows the number of SEEs which can be exchanged for ACEs without changing the total number of C-141B sorties for the LID engineer battalion. Based on equipment mix only, 12 ACEs and eight SEEs provide the 1.5:1.0 ratio required by the excursion. This mix requires 20 operators; the TOE now provides 24 operators.

(2) Only 11 percent of all equipment-hour capability at a project site represented 5-ton truck capability, which seemed inadequate when compared to requirement mixes of 23 to 37 percent.

EQUIPMENT CONVERSION TABLE
(1.67 SEEs = 1.00 ACE)*

SEEs	%	+	ACEs	%
18**	75		6**	25
16	70		7	30
15	65		8	35
13	59		9	41
11	52		10	48
10	48		11	52
8	40		12	60
6	32		13	68

*Equivalent C-141B transport.
**1988 TOE quantities.

Figure I-4

6. Truck Capability and Requirements Analysis.

a. The study methodology used to calculate the LID's truck-hour capability and requirements divided the truck-hour day between project and logistical missions. The analysis described so far in this annex has only been concerned with project site requirements. A different methodology was used to determine the ability of the LID's organic engineer trucks to fulfill the Class IV/V haul requirements of the LID's logistical mission. That methodology and the Class IV/V analysis results, are discussed in detail in Annex G. However, to provide a complete and comprehensive picture of the LID's truck-hour capability on the battlefield, this annex compares the results of the Annex G logistical analysis to the results of the project site analysis.

b. ESC's logistical haul analysis indicated the LID has an excess of truck-hour capability. To determine the true truck situation, this excess was subtracted from the shortfall predicted by the equipment mix capability of project work (Figure I-3). Figure I-5 shows the total truck mission requirement -- project plus logistical -- versus capability. Note that in this figure, distribution mixes have been converted to actual capabilities and requirements. This conversion was made so the analysis results of the two different methodologies could be expressed in terms of similar units of measure, i.e., average trucks per day for scenario key situations.

TRUCK REQUIREMENTS VERSUS CAPABILITY
(Average Per Day for Key Situations)

	Base Case			New Explosive Excursion		
	Project +	Logistics =	Total	Project +	Logistics =	Total
Latin American Scenario						
Engineer						
Requirement	3	1	4	2	1	3
Capability	3	3	6	--[a]	3	3[a]
Surplus	None	2	2	-2	2	None
Aviation UH-60 Helicopters (diverted truck haul)						
Requirement	--	5	5	--	1	1
Capability[b]	15	15	30	15	15	30
Available	15	10	25	15	14	29
European Scenario						
	(with corps battalion)[c]			(with airborne battalion)[d]		
Requirement	16	29	45	11	3	14
Capability	--[e]	--[e]	51	--[e]	--[e]	30
Surplus	--[e]	--[e]	6	--[e]	--[e]	16

[a]Three trucks equipped with ground Volcano were not counted.

[b]The 7th ID(L) standard operating procedure is to provide 50% of its helicopters to combat support, and 50% to logistical support.

[c]Assumes 50% (18) squad dump trucks are available from the corps battalion.

[d]The airborne corps battalion replaces the corps battalion; no squad dump trucks are available.

[e]Trucks are not pre-divided between missions in unit TOEs.

Figure I-5

c. Results.

(1) In Latin America, truck capability is adequate. The analysis for this scenario also shows that when the three Ground Volcano systems are added to the engineer battalion, three existing trucks can be diverted as the prime movers with no adverse affect on capability.

(2) Also in Latin America, engineer truck requirements were converted to aviation requirements in two of four AOs; these AOs were inaccessible by road during the last 6 days of battle. As Figure I-5 shows, five helicopters in the base case (but only one helicopter in the new explosive excursion) are required to support Class V engineer haul requirements. Because of the high priority given to engineer support by the LID, this appears to be an acceptable tasking for the LID's CAB.

(3) In Europe, there are more requirements for trucks than there are in Latin America, but there is also more truck capability available from EAD units. In the base case, all project site and logistical support truck requirements can be completed if 12 of 36 squad trucks from the EAD corps battalion are used (Figure I-5 shows 50 percent or 18 squad trucks available). Both ESC's analyses and its interviews with LID engineers indicate that these trucks would actually be available during battle, since they are not required for road maintenance when the EAD corps battalion is assigned to forward combat engineer support.

(4) In the European new explosive excursion, there were fewer truck requirements than in the base case. This permitted consideration of a smaller EAD force. As a result, the EAD corps battalion was changed from the heavy (TOE 5-35H5) to the lighter (TOE 5-195L2) corps battalion (see Annex J). In this excursion, none of the squad trucks are assumed available;

however, there are 18 squad trucks authorized to the lighter airborne battalion. Despite the omission of squad trucks, there is still a 16-truck surplus. This indicates that this unit, TOE 5-195L2, could use a smaller squad vehicle, such as the HMMWV, since the larger vehicle is not needed for hauling.

7. Excursion Analyses. Excursion 2 (which places divisional engineers forward) and excursion 3 (which places EAD units in the DRA) address the distribution of engineer capability within the divisional AO. Excursion 7 specifically looks at how the attachment mix for the SEE can affect engineer capability.

a. Distribution of engineer capability. Study excursions 2 and 3 divided the engineer capability between the brigade areas and the DRA. In excursion 2, the organic divisional battalion was assigned the brigade requirements; in excursion 3, the corps engineer battalion of the EAD force was assigned to the DRA. These excursions assumed that more than two engineer battalions would be needed to accomplish the engineer support requirements generated during the key situation; they were designed to evaluate whether the LID engineer battalion should be configured to accomplish rear area missions.

(1) Latin American scenario. Excursions 2 and 3 were difficult to apply to the Latin American scenario, since the total engineer requirement under that scenario is met by fewer than two engineer battalions. Figure I-6 shows that the LID engineer battalion capability for squads runs out in the brigade areas during the essential task priority group, but that there is enough equipment capability to accomplish all brigade requirements -- there is even enough capability left over to complete tasks in the essential priority group in the DRA. The DRA requirements, according to the excursion procedure,

were to be reserved for the EAD battalion. Therefore, the EAD battalion can do all squad work in the DRA and finish the squad-type work for the brigade areas, but is only required to furnish equipment capability for DRA tasks in the last two priority groups. This may not be practical, because it could mean that two units would work on the same project -- one unit doing the squad work the other the equipment work.

LATIN AMERICAN SCENARIO REQUIREMENTS
(Percentage of Tasks Completed by Priority Group)

	Priority Group*							
	Vital		Critical		Essential		Necessary	
	SH	EH	SH	EH	SH	EH	SH	EH
LID engineer battalion:**								
Brigade areas	100	100	100	100	42	100	--	100
DRA	--	100	--	100	--	87	--	--
EAD corps airborne battalion:***								
DRA	100	NA	100	NA	100	13	100	100
Brigade areas	NA	NA	NA	NA	58	NA	99	NA
Both engineer battalions:								
Brigade areas	100	100	100	100	100	100	99	100
DRA	100	100	100	100	100	100	100	100

*SH = squad hours; EH = equipment hours.
**Priority to brigade areas, then DRA.
***Priority to DRA, then brigade areas; TOE 5-195 (airborne battalion less equipment of two line companies).

Figure I-6

(a) This evaluation does show that under the Latin American scenario, the LID engineer battalion should concentrate its efforts on the top priority groups in the entire divisional AO; the EAD battalion should concentrate on tasks in the lower priority groups and should also be able to split its resources between tasks in the forward and rear. The LID engineer battalion structure must have the capability to support the highest priority tasks in the brigade areas, with some capability to do DRA work in the event EAD engineer units are not deployed.

(b) The EAD battalion is first needed to augment squad-hour shortfalls generated by tasks in the essential priority group. However, the EAD battalion's primary purpose is to provide the engineer squad-hours necessary to complete tasks forward and rear, and to provide all DRA equipment-hours capability. The mission for this battalion will increase for the timeframe beyond D+10 (the Latin American scenarios wargame was halted at D+10), when engineer tasks to enhance the sustainability of the division become priority requirements.

(2) European scenario. When ESC applied excursions 2 and 3 to the European scenario, it examined both the base case scenario situation and the base case situation as affected by the new explosive excursion, which assumed the use of the future countermobility systems.

(a) Option 1 — base case. Figure I-7 shows the requirement distribution in the European base case scenario for excursions 2 and 3. In the base case, the EAD unit is the corps engineer battalion (TOE 5-35H5). In Figure I-7, option 1 represents excursions 2 and 3 where the engineer force is divided between the brigade and division rear areas. The LID engineer battalion has only enough capability to initiate work on vital tasks in the brigade areas. The battalion experiences a significant shortfall in squad-hours to accomplish even this highest priority group of tasks. The EAD corps battalion has enough capability to accomplish all DRA tasks for all four priority groups, and then help in almost completing the vital tasks in the brigade areas. Thus, total effect of option 1 is to accomplish all vital tasks -- forward and rear -- and to fulfill all requirements for engineer equipment-hour through the essential priority group. The only quirk in the allocation represented by option 1 is that all of the equipment-hour tasks in the necessary priority are accomplished in the DRA at the expense of some of the work in the brigade areas, where only 19 percent of necessary equipment-hour tasks are completed.

EUROPEAN SCENARIO — BASE CASE REQUIREMENTS
(Percentage of Tasks Completed by Priority Group)

	Priority Group							
	Vital		Critical		Essential		Necessary	
	SH	EH	SH	EH	SH	EH	SH	EH
	Option 1							
LID engineer battalion:*								
Brigade areas	28	99	--	--	--	--	--	--
DRA	--	--	--	--	--	--	--	--
EAD corps battalion:**								
DRA	100	100	100	100	100	100	100	100
Brigade areas	68	1	--	100	--	100	--	19
Both engineer battalions:								
Brigade areas	96	100	--	100	--	100	--	19
DRA	100	100	100	100	100	100	100	100
	Option 2* **							
Both engineer battalions:								
Brigade area	98	100	--	100	--	100	--	51
DRA	--	100	--	100	--	100	--	--

*Priority to brigade areas, then DRA.
**Priority to DRA then brigade areas; TOE 5-35 (corps engineer battalion).
***Priority of both units to priority groups.

Figure I-7

(b) Option 2 — base case. Under option 2, both battalions are applied to the highest priority group of work, regardless of division area. Note that the significant result of the allocation represented by option 2 is to accomplish more equipment work in the brigade areas (51 percent versus 19 percent) for the necessary priority group. Also note that one EAD engineer battalion cannot offset the significant squad-hour shortfalls experienced throughout the divisional AO, front to rear.

(c) Options 1 and 2 — New explosive excursion. Figure I-8 shows how the requirement distribution changed after ESC applied excursions 2 and 3 to a base case situation modified by the new explosive excursions, which incorporated all countermobility future improvements. This new explosive excursion uses the same airborne engineer battalion as used in the Latin American Scenario by the EAD force. Fewer engineer requirements are generated by this excursion, and most can be met by the total capability of the two battalions available. When one light equipment company (TOE 5-54), is added, requirements are satisfied.

1. Under option 1, the LID engineer battalion completed more vital work than it could in the base case. The EAD battalion can still do the DRA work, but is more useful in executing leftover squad hours in the brigade areas -- so useful, in fact, that the two battalions can complete all work in the top three priority groups.

2. Under option 2, the situation is the same as in the base case. As in the base case, option 2 provides more capability to the brigade areas in the necessary priority group than option 1, where the DRA is given priority over the brigades. Due to the fewer squad-hour requirements generated by this excursion, the battalion can accomplishe 71 percent of the necessary squad-hour task under option 2, which is about 50 percent more than accomplished under option 1; 51 percent more necessary equipment-hour tasks were also completed under option 2, versus 17 percent of the necessary equipment-hour.

EUROPEAN SCENARIO NEW EXPLOSIVE EXCURSION REQUIREMENTS
(Percentage of Tasks Completed by Priority Group)

	Priority Group							
	Vital		Critical		Essential		Necessary	
	SH	EH	SH	EH	SH	EH	SH	EH
Option 1								
LID engineer battalion:*								
Brigade areas	98	74	--	--	--	--	--	--
DRA	--	--	--	--	--	--	--	--
EAD corps battalion:**								
DRA	100	100	100	100	100	100	100	100
Brigade areas	2	26	100	100	100	100	20	17
Both engineer battalions:								
Brigade areas	100	100	100	100	100	100	20	17
DRA	100	100	100	100	100	100	100	100
Option 2* **								
Both engineer battalions:								
Brigade areas	100	100	100	100	100	100	71	50
DRA	100	100	100	100	100	100	--	--

*Priority to brigade areas, then DRA.
**Priority to DRA, then brigade areas; TOE 5-195 (airborne engineer battalion).
***Priority of both units to priority groups.

Figure I-8

(3) Conclusions. Based on the analysis of excursions 2 and 3 in the Latin American and European scenarios, ESC concluded that:

(a) The divisional engineer battalion should be configured to support high-priority brigade requirements. This conclusion is based on the capability analysis which indicates the battalion can only accomplish brigade engineer tasks in the vital and critical priority groups under the Latin American scenario, and only a portion of the vital brigade tasks under the European scenario.

(b) With the future fielding of the family of scatterable mine (FASCAM) systems, the airborne engineer battalion (TOE 5-195L200, land

and unload version) can meet most engineer requirements not met by the LID engineers. No modified TOEs (MTOEs) have been activated for this TOE yet, so design considerations based on this study are very timely. The excursion 2 and 3 analyses show the desirability of separating squad-hour and equipment-hour capability by company. For Europe, additional equipment-hour capability would help eliminate the need for a light equipment company. This additional capability can be provided by changing the type and mix of engineer equipment now alloted to the battalion.

b. Distribution of equipment-hour capability. ESC's SEE attachment excursion determined the optimal number of SEEs and the proper mix of SEE attachments required by the battalion to fulfill the requirements generated by the engineer tasks expected under the study scenarios.

(1) Figure I-9 translates the percentage mix of ACEs and SEEs shown in Figure I-3 to pieces of equipment. (Only the ACE and SEE are considered in this excursion -- truck requirements and capability are discussed in paragraph 6). The new explosive excursions do not affect ACE requirements, which do not vary from those of the base case. However, SEE requirements increase. This increase is because of the new requirement for the SEE auger attachment, which drills the bore hole for cratering charges for conventional or liquid explosives. In the base case, shaped charges were used to construct craters. ESC's recommended mix of 11 ACEs and 10 SEEs meets all engineer requirements generated by the Latin American scenario; comes closer to meeting European requirements than the mix recommended by the TOE; and meets the deployability criteria of Figure I-4.

(a) The mix recommend by ESC in Figure I-9 differs from the mix listed in Figure I-3. That mix was based on equipment only, and incorporated the capability represented by loaders and graders, which belong only to

EAD units. When the loader/grader capability is subtracted, number of ACEs required drop from 12 to 11. (Note: if C-141B constraints were removed, ESC would recommend 12 each of the ACE and SEE.)

EQUIPMENT MIXES

	Base Case		New Explosive Excursion	
	ACE	SEE	ACE	SEE
Key Situation Requirements:				
Latin America	10	5	10	6
Europe	14	5	14	14
Weighted Scenarios*	11	5	11	9
1988 TOE quantity	6	18	6	18
ESC Recommended quantity	11	10	11	10

*Two-thirds Latin America; one-third Europe.

Figure I-9

(b) A subjective look was also taken to see how 10 SEEs could work in Europe now, when the analysis indicated 14 are required in the future. The Europe requirement of 14 is needed to establish two phase lines of survivability positions and an obstacle zone that extends to a third phase line. Some of these tasks were accomplished concurrently because of the priority and sequencing of work. If one phase line is first constructed for both survivability and countermobility missions in each of the nine maneuver battalions (using nine SEEs), followed by construction of the second, third, and so forth phase lines -- then all phase line positions will be completed before enemy contact. This could occur even though there will be some delay in executing tasks in period 2, so some tasks will actually be completed during period 3. The tenth SEE can assist the CAB or back up the maneuver battalions.

(2) Figure I-10 summarizes ESC's analysis of the proper SEE attachment mix for the LID engineer battalion. The TOE column in this figure is the design configuration, but actual buys do not conform to the quantities shown. The inclusion of a SEE trencher in the TOE cannot be justified by this analysis (see Annex D), nor can it be readily explained elsewhere -- it could just be a nomenclature error. The mix suggested under the next column was submitted by the Commander, 7th ID(L), to the Commander, US Forces Command, in a message dated 16 November 1984, Subject: "7ID(L) Small Emplacement Excavator (SEE) Requirements." The 13th Engineer Battalion, 7th ID(L), asked ESC to consider these attachments in its analysis.

(a) Columns 3 through 6 are ESC's estimates of the SEE attachment mix required by the LID engineer battalion. They capture the scenario analysis using the key situation of each scenario and weight the results of the Latin American scenario two-thirds and the results of the European scenario one-third. Note that two attachments can be affixed to the boom; the boom may have a single dedicated attachment or share two attachments, of which only one can be used at one time. ESC also calculated that there is a modest requirement for an 85-inch dozer blade and a 4,000-pound forklift. The Army has not elected to buy the multipurpose or 4-in-1 bucket (bulldozer-grader-loader-clam), but ESC believes it has more versatility and should be tested as a replacement for the loader and blade functions shown in Figure I-10. The requirements call for six SEEs in Latin America, 14 SEEs for the new explosive excursion to the European scenario base case -- a total weighted average of nine SEEs for both scenarios.

SEE ATTACHMENTS[a]

Attachment	1988 TOE	7th ID(L)	ESC Latin America	ESC Europe	ESC Weighted Scenarios	ESC Recommended[b]
3/4-CY loader[c]	18	9	3	5	4	10
Boom with:		(18)	(6)	(14)	(9)	(10)
7-CF backhoe	--	15	3	5	4	10
12-in. auger[d]	--	3	3	14[e]	7	10
85-in. blade[c]	--	6	2	--	1	--
7-in. trencher	18	--	--	--	--	--
4,000-lb forklift	--	3	--	3	1	--
Auger handtool	No	NA	Yes	No	Yes	Yes
Total attachments	36	36	11	27	17	30
Total SEEs	18	18	6	14	9	10

[a]Key situation.
[b]Assumes sequential construction of fighting positions, followed by countermobility targets.
[c]Multipurpose or 4-in-1 bucket preferred (will replace both attachments).
[d]For crater construction using liquid explosives.
[e]New explosive excursion.

Figure I-10

(b) The number of ESC-recommended attachments assume the battalion will have 10 SEEs (see paragraph 5). The auger attachment has a great potential in future countermobility operations. It may be transported by C-141B on the same pallet as the other attachments; on the ground, it can be carried inside the loader scoop. Since the auger provides the biggest payoff in Europe, LIDs that do not have a European contingency mission could get by with fewer augers -- the auger could also be authorized by MTOE only. The other two SEE attachments -- backhoe and loader -- are the backbone of the

LID's capability to meet the engineer survivability requirement. These two attachments are needed more in Europe than in Latin America. In Europe, 10 SEEs can dig in the division's initial phase lines when the scenario calls for a preparation period of 3 or more days. (The European base case scenario has a 3-day preparation period.) The scenario that was utilized for the July 1986 Combined Arms Mission Area Analysis at Fort Leavenworth, assumed a 5-day day preparation period for a LID.

(c) ESC also recommends that the SEE handtool allotment be expanded from the chainsaw and paving breaker to include the hand auger. The hand auger can assist in the explosive emplacement of individual and crew-served weapon positions. The latter is especially useful in the dominant Latin American scenario, when the SEE may be the only piece of equipment on a firebase and can be used to speed the construction of perimeter fighting positions.

8. Findings.

a. The divisional engineer battalion design of 1988 has:

(1) An improper squad-to-equipment ratio that improves in the future, but still does not provide adequate squad power.

(2) A need to change the authorization of ACEs and SEEs in the LID TOE; a mix of 11 ACEs and 10 SEEs is recommended (12 each is much better, but adds to the C-141B sortie rate).

(3) Sufficient truck capability to support scenarios now and in the future -- the ground Volcano may be absorbed with current allocations.

(4) An organization that is fairly self-sufficient in Latin America, but must have sufficient engineer EAD support in Europe.

(5) An improper SEE attachment and tool mix. ESC recommends all SEEs have backhoe, auger, and loader attachments and the auger hand tool. (The forklift attachment can be considered if 11 or 12 SEEs are authorized.)

b. One airborne engineer battalion (TOE 5-195L2) should be assigned per LID in the force structure. This unit needs:

(1) Squads separated from equipment by company.

(2) A smaller and more mobile squad vehicle such as the HMMWV.

(3) To be activated in order to provide adequate, but easily deployable, LID support.

c. Figure I-11 presents ESC's recommended divisional engineer battalion design. This design removes eight SEEs and adds five ACEs. The design criteria are:

REDESIGN OF ENGINEER BATTALION EQUIPMENT

Requirement and Capability	Dominant Unit Equipment		
	ACE	5-Ton Cargo Truck	SEE
Key situation (%)*			
Latin America	56	16	28
Europe	27	63	10
Weighted scenarios**	46	32	22
New explosive excursion weighted scenarios**	44	20	36
Capability			
1988 design TOE (%)	22	11	67
(actual quantities)	(6)	(3)***	(18)
ESC-recommended (%)	46	12	42
(actual quantities)	(11)	(3)***	(10)

*Adjusted for all factors mentioned in annex.

**Latin America = double weight and Europe = single weight.

***Does not count three trucks equipped with ground Volcano systems.

Figure I-11

(1) Key situation tasks. The design is based on the key situation of both scenarios. These situations have the highest priority tasks and the most demanding and appropriate battle phases.

(2) Division area requirements. The design must support the brigade areas plus the DRA, since these zones have equally important tasks despite the workload being heavily located forward.

LAST PAGE OF ANNEX I

ANNEX J

ENGINEER EAD FORCE STRUCTURE

ANNEX J

ENGINEER EAD FORCE STRUCTURE

1. Purpose. This annex describes the methodology used to determine the number and type of EAD engineer units required to support the LID in a wartime contingency in Latin America and Europe.

2. Scope. This annex:

a. Identifies which EAD units and unit missions are best suited to support the LID.

b. Determines the number and type of EAD units needed for each theater.

c. Calculates corps bridging requirements and examines the bridging assets needed for each scenario.

3. Methodology. Figure J-1 shows the general methodology ESC used to determine the EAD engineer force structure. The methodology calculates the engineer requirements over and above the division's own capability, looks at the existing and proposed corps engineer units, and selects those engineer units that could best satisfy the excess engineer requirements (excluding bridging requirements).

a. The first step in the methodology identified and selected the engineer units that could logically be assumed to be candidates to augment the LID in each scenario.

ENGINEER EAD METHODOLOGY

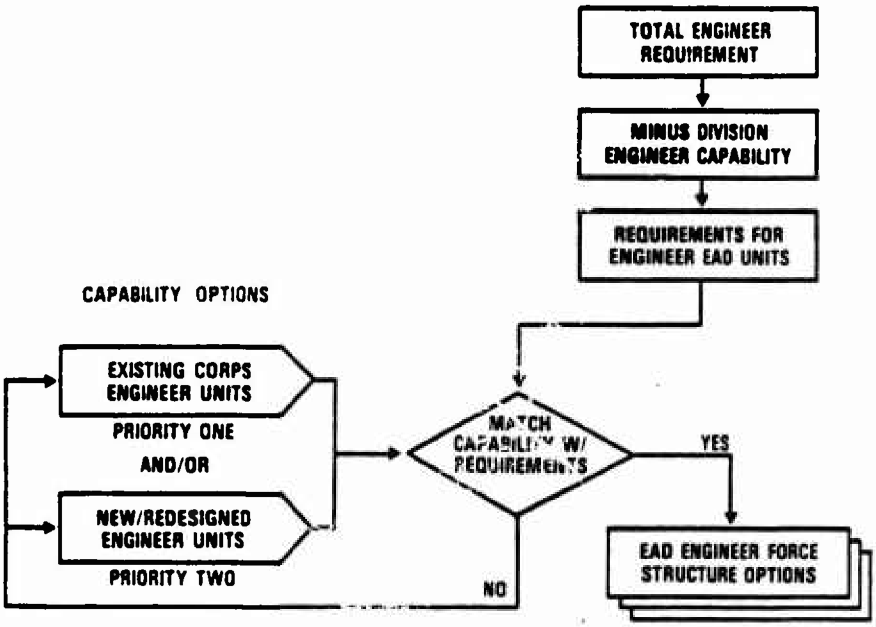

Figure J-1

(1) Specialized engineer units (i.e., port construction companies and mechanized battalions) were eliminated from consideration in structuring an EAD force, since they were not appropriate to the scenarios. Figure J-2 lists the units considered in the EAD force analysis.

CANDIDATE ENGINEER EAD FORCE UNITS

TOE	Unit	Existing	Proposed
5-035H5	Combat battalion, corps	X	
5-058H4	Combat support equipment company	X	
5-054L2	Light equipment company (airborne)		X
5-195L2	Combat battalion (airborne)		X

Figure J-2

(2) The TOEs of both existing and future engineer units were examined to determine the number and type of equipment in each engineer unit and the number of productive personnel available. Two of the units listed in Figure J-2 are existing units, while two are proposed future units. The combat support equipment (CSE) company and the combat battalion (corps), while existing units, use future TOEs that correlate to the scenario timeframes. The L200 versions of the light equipment company (airborne) and the corps battalion (airborne) are the proposed land and unload versions rather than airdrop versions.

b. The second step compared the LID engineer capability with division requirements and computed the shortfall, if any. The shortfall was then matched with the capability of different combinations of engineer units. A match is possible when 100 percent of the unexecuted requirements are satisfied and little excess capability remains in any area.

c. Step 3 determined the influence of time on divisional engineer requirements. Thus, the criticality of requirements, and when those requirements occurred, were evaluated to construct the optimum EAD force for the most timely utilization.

(1) Time sensitivity is present when requirements vary greatly by time period within a scenario. To determine how time-sensitive requirements affect capability, the analysis determined which periods in each scenario were "key" to the engineers. The key situation was selected as being typical and representative of the engineer's role in combat. It also considered engineer capability and where engineer augmentation was required. Thus, in Latin America, the key situation included periods 2, 3, and 4; in Europe, periods 2, 3, 4, and 5 were considered the key situation.

(2) Requirements were also evaluated in priority order (vital only, vital and critical only, etc.) within the key situation. When constructing the EAD force, engineer requirements were divided into two categories: combat-essential requirements and sustainability requirements.

(a) Combat-essential requirements. In the Latin American scenario, the combat-essential category included all vital, critical, and essential requirements; in Europe, only the vital and critical requirements are in this category. Characteristically, the combat-essential requirements are non-deferrable engineer tasks that support the maneuver elements of the LID when it is engaged in combat operations.

(b) Sustainability requirements. The sustainability category for Latin America included only the necessary requirements; in Europe, it included both essential and necessary requirements. Sustainability requirements are engineer tasks that support the combat support units and combat service support units. These tasks can be deferred, but must eventually be done -- sometimes 2 to 4 weeks later than the initiation of combat.

(3) The methodology assumed that engineer requirements were satisfied in order of importance. Deferring requirements to a future time period was not considered practical, since the battle phases of the scenarios are relatively short.

d. Step four of the methodology examined the influence of ESC's new explosive excursion which assumed that new, scatterable mines and liquid explosives will be added to the engineer inventory (see Annex G). The analysis examined how the new systems affect the division engineer requirements and, in turn, the EAD force structure.

e. The last step in the analysis was to recommend an EAD force structure. ESC evaluated alternative EAD force structures and recommended them in priority sequence (i.e., to fulfill all combat-essential requirements and then to fulfill sustainability requirements). The combat-essential EAD force is needed at or close to deployment of the LID, while the EAD force needed to complete the sustainability requirements is not required until 2 to 4 weeks later. The recommendation considers not only the fulfillment of all squad- and equipment-hour requirements, but also takes into account the types of equipment that are needed.

4. <u>Capability of Candidate EAD Engineer Units</u>. Figure J-3 displays the squad- and equipment-hour capability of the units under consideration for both the Latin American and European scenarios. Capability is displayed for each unit from the onset of the key situation through the duration of the scenario.

a. The scenario totals for squad-hours and equipment-hours are the combined total of all key periods. Thus, the capability calculations for the Latin American scenario are based on 8 days, while the European scenario is based on 7 days. The daily capability of the units changed as a result of each scenario's movement rate and casualties. (See Annex B for a detailed discussion of how the capability numbers were derived.)

b. The figure also shows the dominant items of equipment and the amount of hours each type of equipment contributes to the scenario equipment-hour total. All items of equipment that were larger than that contained in standard engineer TOEs were translated into equivalent sizes. The CSE company, which is especially high in truck capability, has many 20- and 15-ton dump trucks. For this unit, truck capability was computed based on 5-ton truck equivalents.

c. Figure J-3 was used to build each scenario's force structure. That process emphasized using units capable of fulfilling the overall

EAD ENGINEER FORCE CAPABILITY

TOE	Scenario/Unit	Daily Squad-Hours	Daily Equip-Hours	Scenario* Squad-Hours	Scenario* Equip-Hours	Individual Equipment Hours: ACE/Dozer	Loader	Grader	5-Ton Truck	SEE/JD410
Latin American Scenario										
5-035H5	Corps battalion:	423	475	3,387	3,797	984	704	281	984	844
	HHC	22	88	179	701	140	140	281	140	0
	4 line companies (each)	100	97	802	776	212	140	0	212	212
5-054L2	Light equipment company (airborne):	0	370	0	2,957	633	423	633	1,268	0
5-058H4	CSE company:	0	880	0	7,039	564	704	633	4,857	281
	Dump truck platoon	0	423	0	3,380	0	0	0	3,380	0
	3 equipment platoons (each)	0	290	0	2,324	423	423	633	633	210
	Equipment support platoon	0	167	0	1,337	141	281	0	844	71
5-195L2	Airborne battalion:	200	626	1,601	5,000	1,268	844	633	987	1,268
	HHC	22	71	179	564	0	0	0	564	0
	3 line companies (each)	60	185	475	1,479	423	281	212	140	423
European Scenario										
5-035H5	Corps battalion:	434	487	3,038	3,411	885	631	252	885	758
	HHC	23	90	161	630	126	126	252	126	0
	4 line companies (each)	103	99	720	695	190	126	0	190	190
5-054L2	Light equipment company (airborne):	0	403	0	2,822	604	404	604	1,210	0
5-058H4	CSE company:	0	902	0	6,315	505	631	568	4,359	252
	Dump truck platoon	0	433	0	3,031	0	0	0	3,031	0
	3 equipment platoons (each)	0	99	0	695	126	126	189	189	63
	Equipment Support platoon	0	171	0	1,199	126	252	0	759	63
5-195L2	Airborne battalion:	217	680	1,517	4,770	1,210	806	604	940	1,210
	HHC	24	77	168	538	0	0	0	538	0
	3 line companies (each)	64	201	449	1,410	403	269	201	135	403

*Key situation.

Figure J-3

equipment shortfall, but also using units that contained specific items of equipment necessary to complete the scenario requirements. Thus, an overage in capability of one type of equipment may not automatically eliminate an equipment shortfall. As an example, a surplus in truck capability should not cancel out a shortage in dozer capability, since the two pieces of equipment are not compatible and cannot be substituted for production work. However, an overage in SEE capability could be used to reduce the ACE shortfall or the loader and grader shortfall.

5. Latin American Scenario EAD Force Structure -- Base Case. The Latin American scenario is a low-intensity conflict. The LID is, therefore, deployed as a stand-alone force and is engaged in 8 days of combat before the scenario is ended. Figure J-4 compares LID engineer capability with the total prioritized requirements of the scenario's defensive phase (period 2) and offensive phase (periods 3 and 4). The figure shows that the majority of all squad and equipment requirements occur in the essential priority group. The capability, in hours, that each of the dominant equipment items contributes toward the total equipment column is also shown.

a. Figure J-4 shows that an EAD force is required to complete all of the vital, critical, and essential tasks of the combat-essential requirements.

(1) The LID engineers can complete all vital and critical squad and equipment tasks of the combat-essential requirements. After calculating the essential tasks, there is a shortage of 1,100 squad-hours and a surplus of 62 equipment-hours. The equipment overage, however, is a result of the SEE surplus, which cancels out the shortages of all the other items of equipment. Theoretically, the SEE surplus could be used to offset the ACE, the loader, or the grader shortfalls. If the excess SEE capability was applied to the loader

LATIN AMERICAN SCENARIO EAD FORCE STRUCTURE

	Total Squad-Hours	Total Equip-Hours	Individual Equipment-Hours: ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD410
Capability							
LID engr bn	1,182	1,531	351	0	0	173	1,007
Combat Essential Requirements							
Vital	259	51	8	4	0	35	4
BALANCE*	923	1,480	343	4	0	138	1,003
Critical	180	472	128	46	26	188	84
BALANCE*	743	1,008	215	-50	-26	-50	919
Essential	1,843	946	421	67	6	297	155
BALANCE*	-1,100	62	-206	-117	-32	-347	764
ADD EAD Force:							
ABN bn HHC & 2 co w/o equipment	1,129	0	0	0	0	0	0
BALANCE*	29	62	-206	-117	-32	-347	764
Sustainability Requirements							
Necessary	499	150	72	19	4	26	29
BALANCE*	-470	-88	-278	-136	-36	-373	735
ADD EAD Force							
ABN bn -- 1 co w/equipment	475	1,479	423	281	212	140	423
BALANCE*	5	1,391	145	145	176	-233	1,158

*Negative balance indicates a shortfall in capability.

Figure J-4

or grader shortfall (at a ratio of three or four SEEs to one loader or grader), it is possible for all of the combat-essential loader and grader requirements to be met.

(2) Figure J-3 provides a "shopping list" of candidate EAD units and their capability. The airborne battalion is the best choice to fill the squad shortage. By adding personnel from the HHC and two companies of the airborne battalion, the squad-power shortage is eliminated. While there is a shortfall in dozer and truck capability, ESC did not recommend adding equipment to the EAD force to alleviate the imbalance in equipment capability, since there was an overall surplus in the total equipment-hour capability.

b. When the sustainability requirements (i.e., necessary priority tasks) are added to the previous balance, the third company of the airborne battalion is needed to fill the new squad-power shortfall. Overall, the equipment-hour shortfall is relatively small; however, this is again the result of the SEE cancelling the shortages in capability of the other equipment items. Figure J-4 shows that the additional third company will bring its equipment. This results in a large overall equipment surplus, since all equipment-hour balances now have a surplus -- except for the truck category which still has a negative balance, indicating a shortfall.

6. European Scenario EAD Force Structure -- Base Case. The European scenario is a high-intensity conflict and the LID engineers are augmented with various units, including an armored brigade and a forward-deployed corps engineer battalion. In this analysis, the base case is defined as total capability for the key situation (i.e., 3 days of preparation and 4 days of combat) compared with total requirements for the same time. Figure J-5 shows the scenario base case. This case includes the capability of not only the LID

EUROPEAN SCENARIO EAD FORCE STRUCTURE -- BASE CASE

	Total Squad-Hours	Total Equip-Hours	Individual Equipment-Hours				
			ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD410
Capability							
LID engr bn	1,194	1,563	344	0	0	173	1,046
AR bde engr co	612	902	180	120	0	602	0
Corps engr bn	2,941	3,547	871	626	268	1,044	738
Total	4,747	6,012	1,395	746	268	1,819	1,784
Combat Essential Requirements							
Vital	5,908	3,259	1,736	244	78	908	293
Critical	303	910	382	72	120	326	10
BALANCE	-1,464	1,843	-723	430	70	585	1,481
ADD EAD Force							
Corps bn -- HHC & 2 co w/o equipment	1,600	0	0	0	0	0	0
BALANCE	136	1,843	-723	430	70	585	1,481
Sustainability Requirements							
Essential	169	863	538	226	29	55	15
Necessary	3,134	7,414	1,730	1,260	538	3,879	7
BALANCE	-3,167	-6,434	2,991	-1,056	-497	-3,349	1,459
ADD EAD Force							
Corps bn equip & 2 co	1,438	3,341	885	631	252	885	758
Corps bn	3,038	3,411	885	631	252	885	758
BALANCE	1,309	388	1,221	206	7	-1,579	2,975

Figure J-5

engineers, but the armored brigade engineer company and the forward-deployed corps battalion. This combined capability is compared against the key situation's total prioritized requirements, regardless of where they are generated. Figure J-5 also shows that most engineer requirements occur in either the vital or necessary priority task group. For a detailed breakout of requirements by LID and armored brigade sectors, see the Appendix.

a. As portrayed in Figure J-5, there is a shortfall in completing all combat-essential requirements. ESC configured an EAD force based on these shortages.

(1) When the combat-essential requirements are compared with the total engineer capability, it is apparent that the vital requirements exhaust the squad-hour capability, and a shortage results. Adding the critical requirements increases the squad-hour deficit to 1,464 squad-hours. Using Figure J-3 to compare the capability of candidate EAD units with the requirement deficit shows that the best configuration of the add-on EAD force is to use personnel from the HHC and two companies of a corps battalion. With the add-on force, all combat-essential squad requirements are completed, with only a modest surplus remaining.

(2) The total equipment column shows there is a surplus in equipment capability; therefore, the equipment of the add-on corps battalion is deferred at this time. The status of the individual items of equipment that comprise the total equipment column shows that the dozer cannot complete over a third of its vital and critical requirements. This rather large shortfall in dozer-hour capability can only be partially offset by the SEE surplus.

b. With the addition of the essential and necessary tasks, there is a large deficit in capability. The last two companies of the corps battalion (with all battalion equipment) plus a second corps battalion are added to the EAD force. All sustainability requirements can be completed with this configuration with a surplus in both squad- and equipment-hours. All individual items of equipment also have a surplus, except for the dozer and truck categories, which still have substantial shortages. Notice that with the addition of the EAD force, the SEE surplus has more than doubled from 1,459 hours to 2,975 hours.

c. Twenty-six trucks -- three from the LID engineer battalion, nine from the armored brigade engineer company, and 14 from the corps battalion -- are currently counted in the scenario as productive items of equipment. Because the number of trucks is limited, an alternative is proposed that would increase truck capability. The corps battalion has thirty-six 5-ton squad dump trucks that are not counted as available and productive items of equipment. If these squad trucks were counted, the scenario's initial 26 trucks would increase to 62 trucks.

(1) Figures J-6 and J-7 show the same scenario base case portrayed in Figure J-5, but with 50 percent and 100 percent of the corps battalion's squad trucks included in the equipment-hour capability. Comparing the figures shows that squad capability decreases while truck capability increases. If squad trucks are counted as an equipment item, the driver must be counted as an integral part of the truck. He is, therefore, no longer classified as productive personnel; thus, squad-hour capability is reduced. Counting squad trucks, even at 50 percent capability, greatly reduces the truck deficit with only a minimal decrease in squad capability. Figure J-7 shows that the truck deficit for sustainability requirements is eliminated only when all of the base case squad trucks are counted as available capability.

EUROPEAN SCENARIO EAD FORCE STRUCTURE -- BASE CASE
WITH 50-PERCENT SQUAD TRUCK CAPABILITY

	Total Squad-Hours	Total Equip-Hours	Individual Equipment-Hours				
			ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD410
Capability							
LID engr bn	1,194	1,563	344	0	0	173	1,046
AR bde engr co	612	902	180	120	0	602	0
Corps engr bn	2,786	4,651	871	626	268	2,148	738
Total	4,592	7,116	1,395	746	268	2,923	1,784
Combat Essential Requirements							
Vital	5,908	3,259	1,736	244	78	908	293
Critical	303	910	382	72	120	326	10
BALANCE	1,619	2,947	723	430	70	1,689	1,481
ADD EAD Force							
Corps bn -- HHC & 2 co w/o equipment	1,600	0	0	0	0	0	0
BALANCE	-19	2,947	-723	430	70	1,689	1,481
Sustainability Requirements							
Essential	169	863	538	226	29	55	15
Necessary	3,134	7,414	1,730	1,260	538	3,879	7
BALANCE	-3,322	-5,330	-2,991	-1,056	-497	-2,245	1,459
ADD EAD Force							
Corps bn equip & 2 co	1,440	3,411	885	631	252	885	758
Corps bn	3,038	3,411	885	631	252	885	758
BALANCE	1,154	1,492	-1,221	206	7	-475	2,975

Figure J-6

EUROPEAN SCENARIO EAD FORCE STRUCTURE -- BASE CASE
WITH 100-PERCENT SQUAD TRUCK CAPABILITY

	Total Squad-Hours	Total Equip-Hours	Individual Equipment-Hours: ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD410
Capability							
LID engr bn	1,194	1,563	344	0	0	173	1,046
AR bde engr co	612	905	180	120	0	602	0
Corps engr bn	2,630	5,759	871	626	268	3,256	738
Total	4,436	8,224	1,395	746	268	4,031	1,784
Combat Essential Requirements							
Vital	5,908	3,259	1,736	244	78	908	293
Critical	303	910	382	72	120	326	10
BALANCE	-1,775	4,055	-723	430	70	2,797	1,481
ADD EAD Force							
Corps bn -- HHC & 2 co w/o equipment	1,600	0	0	0	0	0	0
BALANCE	-175	4,055	-723	430	70	2,797	1,481
Sustainability Requirements							
Essential	169	863	538	226	29	55	15
Necessary	3,134	7,414	1,730	1,260	538	3,879	7
BALANCE	-3,478	-4,222	-2,991	-1,056	-497	-1,137	1,459
ADD EAD Force							
Corps bn equip & 2 co	1,438	3,411	885	631	252	885	758
Corps bn	3,038	3,411	885	631	252	885	758
BALANCE	998	2,600	-1,221	206	7	633	2,975

Figure J-7

(2) Checking the add-on EAD force structure in both examples reveals that two corps battalions are still required because of the squad-hour deficit. The decrease in the initial base case squad-hour capability has not had a significant effect on the final squad balance. The add-on EAD corps battalion squad trucks were not counted as truck capability, since they were assumed to be used in the more fundamental transport role. However, if the squad trucks had been counted as 50-percent productive, the 885 truck-hours of capability per corps battalion would increase to 2,022 truck-hours, while the 3,038 hours of squad capability would decrease to 2,851 squad-hours. All squad requirements would still be completed, but instead of a negative final balance in truck-hours there would be a very large surplus.

7. <u>LID and Armored Brigade EAD Force Structure</u>.

a. In the European scenario, the LID engineers are augmented with a corps battalion. Figure J-8 combines the LID engineer capability with the capability of the forward-deployed corps battalion and compares it to the requirements that occur in the brigade areas occupied by the LID and in the DRA (i.e., armored brigade sector requirements and capability are excluded). Figure J-8 constructs an EAD force needed to assist the augmented LID engineers to complete the combat-essential and sustainability requirements in its AO.

(1) The combined capability of the LID and corps battalion can complete most of the vital squad requirements and all of the vital equipment requirements. There is still, however, a shortage of squad power and none of the critical squad tasks can be completed. One company, without equipment, of an add-on EAD corps battalion is required to satisfy the squad-hour shortfall. The total and individual equipment balances show that after completing the

LID BRIGADE EAD FORCE STRUCTURE

	Total Squad-Hours	Total Equip-Hours	Individual Equipment-Hours ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD410
Capability							
LID engr bn	1,194	1,563	344	0	0	173	1,046
Corps engr bn	2,941	3,547	871	626	268	1,044	738
Total	4,135	5,110	1,215	626	268	1,217	1,784
Combat Essential Requirements							
Vital	4,241	1,687	557	163	55	673	239
Critical	295	730	244	57	120	299	10
BALANCE	-401	2,693	414	406	93	245	1,535
ADD EAD Force							
Corps bn -- 1 co w/o equipment	720	0	0	0	0	0	0
BALANCE	319	2,693	414	406	93	245	1,535
Sustainability Requirements							
Essential	97	600	354	164	27	49	6
Necessary	2,315	5,505	1,205	984	368	2,942	6
BALANCE	-2,093	-3,412	-1,145	-742	-302	-2,746	1,523
ADD EAD Force							
Corps bn -- HHC & 3 co w/all equipment	2,318	3,411	885	631	252	885	758
BALANCE	225	1	-260	-111	-50	-1,861	2,281

Figure J-8

combat-essential requirements, all equipment items have a surplus of capability.

(2) The balance of the add-on EAD corps battalion is needed to complete the squad and equipment sustainability requirements. Only when individual items of equipment are examined, does it become apparent that there is a significant shortfall in all items of equipment -- except the SEE. The high surplus in SEE-hours has theoretically cancelled the shortages of the other equipment items. The substantial truck-hour shortfall can be alleviated if the augmented corps battalion squad trucks are counted as 100-percent available for project work.

b. Figure J-9 compares the armored brigade requirements with the capability of the brigade's engineer company.

(1) The brigade's engineer company has the capability to complete a third of the combat-essential squad-hour requirements, and half of the equipment-hours. The dozer-hour requirement is almost seven times more than what the engineer company can provide. The engineer company must be augmented with the HHC and two companies from a corps battalion in order to complete all of the squad and equipment combat-essential requirements. With the addition of the EAD force, there is a large surplus in total equipment capability; however, less than half of the dozer requirements have been completed and there remains a deficit of 631 dozer-hours.

(2) To complete the sustainability requirements, the last two companies of the corps battalion are needed. The final balance shows there is a large surplus in squad-hours. Overall, the equipment column shows a modest surplus, with all items of equipment also having excess capability -- except the dozer, where the deficit has increased to 960 hours.

ARMORED BRIGADE EAD FORCE STRUCTURE

	Total Squad-Hours	Total Equip-Hours	Individual Equipment-Hours				
			ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD410
Capability							
AR bde engr co	612	902	180	120	0	602	0
Combat Essential Requirements							
Vital	1,667	1,572	1,179	81	23	235	54
Critical	8	180	138	15	0	27	0
BALANCE	-1,063	-850	-1,137	24	-23	340	-54
ADD EAD Force							
Corps bn HHC & 2 co	1,600	2,020	506	378	252	506	380
BALANCE	537	1,170	-631	402	229	846	326
Sustainability Requirements							
Essential	72	263	184	62	2	6	9
Necessary	819	1,909	525	276	170	937	1
BALANCE	-352	-1,002	-1,340	64	57	-97	316
ADD EAD Force							
Corps bn -- 2 co	1,438	1,390	380	252	0	380	380
BALANCE	1,084	388	-960	316	57	283	696

Figure J-9

8. <u>European Scenario EAD Force Structure -- New Explosive Excursion.</u> Annex G evaluated and presented the findings on how scatterable mine systems would affect the capability of the LID engineers. Also examined was the use of the SEE auger to replace shaped charges for emplacing road craters. The savings that could be incurred if these two operational methods were adopted by the LID engineers would change the requirements for squad power and equipment -- especially the SEE and truck requirements. This change in requirements could, in turn, change the composition of the future LID engineer EAD force structure or could postpone when the EAD force would be needed. Figure J-10 presents the scenario base case capability with the revised requirements which were generated by the new explosive excursion of scatterable mines and SEE auger operations.

a. When Figure J-5, the scenario base case, is compared with Figure J-10, three major changes in the combat-essential requirements are evident.

(1) The squad-hour requirement decreases by 3,820 squad-hours -- a 60-percent savings. Most of this saving occurs in the vital priority group, thus reducing both the magnitude and intensity of the crucial engineer workload.

(2) The truck-hour requirement for vital tasks is cut almost in half -- a decrease of 441 hours.

(3) The SEE-hour requirement is four times as great as the base case requirement -- an increase of 991 hours.

b. The add-on EAD force for the integrated excursion shown in Figure J-10 is different than that configured for the base case.

EUROPEAN SCENARIO EAD FORCE STRUCTURE -- NEW EXPLOSIVE EXCURSION

	Total Squad-Hours	Total Equip-Hours	Individual Equipment-Hours ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD410
Capability							
LID engr bn	1,194	1,563	344	0	0	173	1,046
AR bde engr co	612	902	180	120	0	603	0
Corps engr bn	2,941	3,547	871	626	268	1,044	738
TOTAL	4,747	6,012	1,395	746	268	1,819	1,784
Combat Essential Requirements							
Vital	2,121	3,840	1,737	244	78	497	1,284
Critical	270	910	382	72	120	326	10
BALANCE	2,356	1,262	-724	430	70	996	490
Sustainability Requirements							
Essential	169	863	538	226	29	55	15
Necessary	2,838	7,411	1,730	1,260	538	3,822	61
BALANCE	-651	-7,012	-2,992	-1,056	-497	-2,881	414
ADD EAD Force							
Corps bn --							
HHC & 1 co	800	1,326	316	252	252	316	190
CSE co	0	6,315	505	631	568	4,359	252
BALANCE	149	629	-2,171	-173	323	1,794	356

Figure J-10

(1) Because there is such a significant savings in squad-hours, there is no need for an add-on EAD force to assist in completing the combat-essential requirements.

(2) To complete all scenario requirements, an add-on EAD force consisting of one CSE company and the HHC and one company of a corps battalion is required in the new explosive excursion; an add-on EAD force of two corps battalions is required in the base case.

(3) In in the new explosive excursion, equipment capability is more important than squad capability in constructing the add-on EAD force.

c. As shown in Figure J-10, there is a considerable surplus in capability (both squad-hours and equipment-hours) after the combat-essential requirements are accomplished. Because the savings and surplus are so large, ESC examined whether the LID would require a corps battalion as an augmentation unit. Figure J-11 changes the augmentation unit in the base case from a corps battalion to an airborne battalion. The requirements of this new explosive excursion are then compared with the new LID augmentation force.

(1) When Figure J-10 is compared with Figure J-11, it is apparent that the initial squad-hour capability is reduced by almost one-third with the airborne battalion. However, there is still a modest surplus after the vital and critical requirements are completed. Overall, equipment-hour capability is increased with the airborne battalion, and includes more dozer capability.

(2) The add-on EAD force structure needed to address the sustainability requirements is also different than that proposed in Figure J-10. To complete all scenario requirements in Figure J-11, a corps battalion and a light equipment company (airborne) are needed. While the total shortage in

NEW EXPLOSIVE EXCURSION WITH AIRBORNE BATTALION

	Total Squad-Hours	Total Equip-Hours	Individual Equipment-Hours				
			ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD410
Capability							
LID engr bn	1,194	1,563	344	0	0	173	1,046
AR bde engr co	612	902	180	120	0	602	0
ABN engr bn	1,406	4,016	1,098	732	549	903	734
TOTAL	3,212	6,481	1,622	852	549	1,678	1,780
Combat Essential Requirements							
Vital	2,121	3,840	1,737	244	78	497	1,284
Critical	270	910	382	72	120	326	10
BALANCE	821	1,731	-497	536	351	855	486
Sustainability Requirements							
Essential	169	863	538	226	29	55	15
Necessary	2,838	7,411	1,730	1,260	538	3,822	61
BALANCE	-2,186	-6,543	-2,765	-950	-216	-3,022	410
ADD EAD Force							
Corps bn	3,038	3,411	885	631	252	885	758
Lt equip co, ABN	0	2,822	604	404	604	1,210	0
BALANCE	852	-310	-1,276	85	640	-927	1,168

Figure J-11

equipment-hours is relatively small, the dozer- and truck-hour shortages are significant.

9. LID Engineer Battalion Analysis -- Excursion 1. This excursion tests the effect of committing only the divisional engineers to the division requirements and establishes the validity of augmenting the LID engineers with a minimum of one corps battalion, when the LID is assigned to a high-intensity conflict.

a. To present a clear portrayal of the LID engineer capability, the divisional engineer capability was extracted and compared with the requirements that occur in the LID AOs (i.e., armored brigade sector requirements are excluded). Figure J-12 shows the percentage of work that can be completed by the division's engineer battalion.

(1) If all capability is dedicated to only the vital tasks, the LID engineers can complete only 28 percent of the squad-hour tasks and 93 percent of the equipment-hour tasks of the combat-essential requirements. None of the critical or sustainability squad or equipment requirements can be done during the scenario.

(2) An examination of the individual items of equipment shows the dozer can accomplish 62 percent of its vital requirements, while the SEE can complete all requirements during the scenario. Truck capability is low, since the LID engineers have only one 5-ton cargo truck per company. Since the LID engineers do not have any loaders or graders, it is expected that these requirements cannot be accomplished. However, if the excess SEE capability were used (at a ratio of three or four SEEs to one loader or grader), it is possible for all of the loader and grader vital requirements to be completed.

LID ENGINEER BATTALION CAPABILITY VERSUS LID REQUIREMENTS
(Percentage of Tasks Completed by Priority Group)

	Total Squad-Hours	Total Equip-Hours	Individual Equipment-Hours ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD410
Combat Essential Requirements							
Vital	28%	93%	62%	0%	0%	26%	100%
Critical	0%	0%	0%	0%	0%	0%	100%
Sustainability Requirements							
Essential	0%	0%	0%	0%	0%	0%	100%
Necessary	0%	0%	0%	0%	0%	0%	100%

Figure J-12

b. Figure J-13 shows the percentage of tasks that can be achieved when the LID engineer battalion is augmented with the forward-deployed corps battalion. The same requirements used in Figure J-12 (i.e., only those requirements generated in the LID AOs) were used to calculate completion percentages.

LID WITH CORPS BATTALION CAPABILITY VERSUS LID REQUIREMENTS
(Percentage of Tasks Completed by Priority Group)

	Total Squad-Hours	Total Equip-Hours	Individual Equipment-Hours ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD410
Combat Essential Requirements							
Vital	98%	100%	100%	100%	100%	100%	100%
Critical	0%	100%	100%	100%	100%	100%	100%
Sustainability Requirements							
Essential	0%	100%	100%	100%	100%	100%	100%
Necessary	0%	40%	5%	25%	18%	7%	100%

Figure J-13

(1) A comparison of the combat-essential requirements shows that the combined capability of the units can meet 98 percent of the vital squad-hour requirements, but still cannot meet any of the critical squad-hour requirements. The equipment capability fares better, and all vital and critical equipment-hour requirements can be completed.

(2) All essential tasks and part of the necessary tasks can be completed before equipment capability is exhausted. Overall, 40 percent of the necessary equipment tasks can be accomplished. It should be noted that the SEE can complete all its requirements and still have a surplus.

c. The LID engineer performance was next examined to see if there would be any percentage improvement in completing the requirements generated under the new explosive excursion. Again, requirements are only those that occur in the LID brigade sectors; however, the squad and truck requirements are significantly reduced, while the SEE requirements are increased. Figure J-14 shows the percentage of requirements completed for each priority group of the new explosive excursion.

(1) As can be see in Figure J-14, the amount of vital squad work completed (97 percent) has dramatically improved from the 28-percent completion shown in Figure J-12.

(2) The ount of vital equipment-hours completed has dropped from 93 percent to 72 percent as a result of a significant decrease in the SEE surplus. Closer examination of the SEE column shows that all of the critical and essential tasks can be completed. The percentage is slightly misleading since the SEE surplus after completing all vital requirements is only 16 hours. The critical and essential requirements, however, are minimal and thus can be completed. Looking at the other items of equipment shows the dozer,

loader, and grader capability remain the same; however, the percentage of truck-hours completed has doubled.

LID ENGINEER BATTALION CAPABILITY VERSUS LID REQUIREMENTS -- NEW EXPLOSIVE EXCURSION
(Percentage of Tasks Completed by Priority Group)

	Total Squad-Hours	Total Equip-Hours	Individual Equipment-Hours ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD410
Combat Essential Requirements							
Vital	97%	72%	62%	0%	0%	46%	100%
Critical	0%	0%	0%	0%	0%	0%	100%
Sustainability Requirements							
Essential	0%	0%	0%	0%	0%	0%	100%
Necessary	0%	0%	0%	0%	0%	0%	0%

Figure J-14

d. Figure J-15 shows the percentage of tasks that can be achieved when an airborne battalion is combined with the LID engineer battalion. The requirements are the same as those used in Figure J-14 for the new explosive excursion.

(1) All vital, critical, and essential squad and equipment tasks can be completed. In addition, almost half of the necessary squad tasks can be accomplished. Approximately one-third of the necessary equipment requirements can be done.

(2) A comparison of Figure J-13 (i.e., the base case with corps augmentation) with Figure J-15 shows that more squad requirements can be accomplished in the new explosive excursion, even though the airborne

battalion has less squad capability. The reason for the increase in the completion percentage is a 60-percent decrease in squad requirements for the new explosive excursion.

LID WITH AIRBORNE BATTALION CAPABILITY VERSUS LID REQUIREMENTS -- NEW EXPLOSIVE EXCURSION
(Percentage of Tasks Completed by Priority Group)

	Total Squad-Hours	Total Equip-Hours	Individual Equipment-Hours				
			ACE/ Dozer	Loader	Grader	5-Ton Truck	SEE/ JD410
Combat Essential Requirements							
Vital	100%	100%	100%	100%	100%	100%	100%
Critical	100%	100%	100%	100%	100%	100%	100%
Sustainability Requirements							
Essential	100%	100%	100%	100%	100%	100%	100%
Necessary	47%	38%	24%	35%	94%	12%	100%

Figure J-15

10. Bridging Requirements and Capability Analysis.

a. The Latin American scenario had one unfordable river which was encountered on D+6. The river's width of about 40 meters would require a bridge, since the crossing space is too narrow for rafting. The scenario writers discounted this obstacle, but in actuality, it needs to be bridged so that logistic resupply can continue behind the division's main attack. Without this road being kept open, the air resupply of ammunition (especially artillery rounds) is assumed to be impractical -- if not impossible. Since LID engineers do not have bridging capability, the bridge mission is an EAD task.

(1) The M4T6 float bridge set with air compressor is ideal for the bridge mission. This set allows for either a float bridge across the span

or fixed spans on top of piers to bridge damaged spans. The EAD M4T6 units have all but disappeared in the engineer force structure, but not the equipment.

(2) The Ribbon Bridge is a possible wet gap solution, but requires more C-141 sorties, deploys bridge trucks that are not needed once the bridge is erected, and requires trained EAD bridge unit personnel to erect.

b. In the European scenario, all river gaps can be forded and no EAD bridge support is needed. The LID does not have the capability to support a deliberate river crossing. This is consistent with the LID mission when fighting against a high-intensity threat force in closed terrain (i.e., most closed terrain areas lack sizable rivers). Additionally, Europe has an extensive road net that allows many options for engineers to keep roads open for logistical resupply without resorting to tactical bridging.

11. __Findings__. The LID with a mission of fighting in a low-intensity conflict (i.e., Latin America) can support itself during the initial days of combat, but requires EAD engineer support when the conflict extends over a period of time. In a high-intensity conflict (e.g., Europe), the LID must have a sizable augmentation force. The following paragraphs summarize and evaluate the LID engineers' performance in each scenario with regard to squad capability, equipment capability, and the composition of an EAD force to complete the scenario requirements.

a. LID engineer squad power.

(1) In the Latin American scenario, the LID engineers can complete only 52 percent of the squad requirements in the combat-essential requirement category, leaving a deficit of 48 percent. All vital and critical

combat-essential requirements can be achieved, but only 40 percent of the essential tasks can be completed by the LID engineers.

(2) In the European scenario, the LID engineers can complete only 29 percent of the vital tasks and none of the critical tasks of the combat-essential requirements -- a deficit of 71 percent. The LID must be augmented with a corps battalion in order to survive the initial days of combat and an additional corps battalion is required for sustained operations.

b. LID engineer equipment.

(1) Based on the equipment requirements in the Latin American scenario, this analysis determined that the LID engineers can complete all combat-essential requirements. However, upon closer examination of individual items of equipment, the ACE has a 37-percent deficit and the SEE has a surplus of 314 percent. In Annex I, ESC suggests increasing the number of ACEs in the LID engineer battalion from 6 to 11 and reducing the SEEs from 18 to 10. With this suggestion, the ACE deficit is eliminated and the SEE surplus is reduced to 130 percent.

(2) In the European scenario, the LID engineer battalion can complete 93 percent of the vital and none of the critical equipment tasks of the combat-essential requirements. The LID equipment imbalances range from a 57-percent ACE deficit to a 324-percent SEE surplus. Under the same recommendation of 11 ACEs and 10 SEEs, the combat-essential ACE deficit is eliminated and the SEE surplus is reduced to 139 percent.

c. EAD force.

(1) In the Latin American scenario, an airborne battalion is configured to assist the LID engineers in completing all scenario requirements. The augmentation requirement is primarily for additional squad capability. As a result, only one company of the airborne battalion brings

equipment. The equipment was added to eliminate the individual equipment shortages of all items except the SEE.

(2) The European scenario consists of the LID division with an attached armored brigade and a corps engineer battalion. Two EAD forces were structured for this scenario. First, an add-on EAD force is structured for the base case, which looks at the scenario as a whole and includes all requirements and capabilities. The LID and armored brigade portions of the scenario are then extracted and an EAD force is designed for each brigade to complete all requirements that occur within their AOs.

(a) In the base case, an add-on EAD force consisting of the HHC and two companies of a corps battalion (without equipment) is needed to complete all combat-essential requirements in the scenario. The balance of the corps battalion (with all corps equipment) plus another corps battalion is required for the sustainability requirements to be accomplished. If the squad vehicles in the base case corps battalion are counted at 50-percent available capability, the EAD force would not change; however, the truck deficit would be reduced. It is only when the trucks are counted at 100-percent capability that the EAD force would be restructured.

(b) The LID engineer battalion must be augmented with a corps battalion in order to complete the combat-essential requirements that occur in its brigade sectors. An add-on EAD corps battalion is required if all of the division's sustainability requirements are to be completed.

(c) The armored brigade requires an add-on EAD force comprised of two companies from a corps engineer battalion to complete the combat-essential requirements. The remaining two companies of the EAD corps battalion are required to accomplish the sustainability requirements.

12. <u>Observations.</u>

a. If 50 percent of the squad vehicles in the base case corps battalion are counted as equipment capability, truck capability increases by 60 percent but squad capability is only reduced by 3 percent. Using the squad trucks as a viable trade-off to increase the number of truck-hours of capability.

b. The LID engineer battalion in the European scenario must be augmented with a corps battalion in order to meet the division's combat-essential requirements. An additional EAD corps battalion is required if sustainability requirements in the LID sectors are to be accomplished. While all equipment-hour requirements in the two categories can be met, there is a shortage of dozer capability.

c. Combat units have a greater requirement for dozer capability than any other type of equipment item. There is no existing engineer unit available that can provide the needed concentration of dozers without bringing along a lot of equipment that is not needed.

d. The LID concept seldom will require EAD bridging. However, when it is required, EAD units must provide that support. The support usually will require less than a full EAD bridge company, and possibly only equipment. The bridge task, no matter how reduced, will usually be a vital or critical task and must be anticipated.

e. Adding the new mine and explosive systems, along with using the auger attachment on the SEE to emplace shaped charges for road craters, significantly changes the base case requirements for squad- and equipment-hours. Because requirements are significantly reduced, the LID has a better chance of surviving the initial days in a high-intensity combat scenario.

f. The substitution of an airborne battalion for the foward-deployed corps battalion is worth considering when developing future force structures for the LIDs. At this time, the airborne battalion is a future unit with a mission to augment and reinforce the light and motorized divisions. Restructuring the battalion to accommodate squad-only and equipment-only companies could enhance the utility and versatility of this battalion when supporting the LID. Since the battalion has not been fielded on the ground, the units' equipment composition could be redesigned to accommodate more dozer capability -- the one constant shortfall in all engineer scenario requirements.

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APPENDIX

EUROPEAN SCENARIO REQUIREMENTS BY BATTLE PHASE

EUROPEAN SCENARIO CAPABILITY AND REQUIREMENTS COMPARISON -- BASE CASE

	Scenario		LID Brigade Sectors*							AR Brigade Sector**						
			Total LID	Total LID	Individual Equipment Hours					Total AR Bde	Total AR Bde	Individual Equipment Hours				
	Squad-Hours	Equip-Hours	Squad-Hours	Equip-Hours	ACE/Dozer	Loader	Grader	5-Ton Truck	SEE/JD410	Squad-Hours	Equip-Hours	ACE/Dozer	Loader	Grader	5-Ton Truck	SEE/JD410
CAPABILITY																
Period 2	2,214	2,906	1,594	2,090	477	232	115	530	736	620	816	174	114	0	441	87
Period 3	684	829	396	517	123	55	38	97	204	288	312	78	51	0	131	52
Period 4	645	789	380	498	117	53	38	94	196	265	291	72	49	0	122	48
Period 5	1,204	1,488	887	1,122	268	133	77	227	417	317	366	86	59	0	177	44
TOTAL	4,747	6,012	3,257	4,227	985	473	268	945	1,554	1,490	1,785	410	273	0	871	231
COMBAT ESSENTIAL REQUIREMENTS																
Vital & Critical																
Period 2	2,604	1,511	1,926	807	217	34	10	441	105	678	704	493	26	0	159	26
Period 3	307	618	231	343	138	42	22	84	57	76	275	218	28	0	17	12
Period 4	791	838	229	575	132	75	96	262	10	562	263	163	15	23	62	0
Period 5	2,509	1,202	2,150	692	314	69	47	185	77	359	510	443	27	0	24	16
TOTAL	6,211	4,169	4,536	2,417	801	220	175	972	249	1,675	1,752	1,317	96	23	262	54
BALANCE	-1,464	1,843	-1,279	1,809	186	252	93	-27	1,305	-185	34	-905	175	-23	610	177
SUSTAINABILITY REQUIREMENTS																
Essential & Necessary																
Period 2	1,183	3,276	976	2,583	594	484	174	1,330	1	207	693	209	98	70	315	1
Period 3	436	1,156	242	673	200	117	57	299	0	195	483	109	98	26	249	1
Period 4	503	630	229	333	212	51	5	54	11	274	297	186	39	5	60	7
Period 5	1,181	3,215	966	2,516	553	496	159	1,308	0	215	699	205	103	71	319	1
TOTAL	3,303	8,277	2,412	6,105	1,559	1,148	395	2,991	12	891	2,172	709	338	172	943	10
BALANCE	-4,767	-6,434	-3,691	-4,296	-1,373	-896	-302	-3,018	-1,293	-1,076	-2,138	-1,614	-163	-195	-333	167

NOTE: Capability was allocated based on initial interpretation of scenario events. No prior knowledge of requirement results was known when engineer units were assigned to brigade sectors.

*LID brigade capability includes the divisional engineers and the HHC and two companies of the corps battalion.
**Armored brigade capability combines the brigade engineer company with two companies of the corps battalion.

Figure J-1-1

EUROPEAN SCENARIO CAPABILITY AND REQUIREMENTS COMPARISON -- NEW EXPLOSIVE EXCURSION WITH AIRBORNE BATTALION

	Scenario		LID Brigade Sectors*							AR Brigade Sector**						
			Total LID	Total LID	Individual Equipment Hours					Total AR Bde	Total AR Bde	Individual Equipment Hours				
	Squad-Hours	Equip-Hours	Squad-Hours	Equip-Hours	ACE/Dozer	Loader	Grader	5-Ton Truck	SEE/JD410	Squad-Hours	Equip-Hours	ACE/Dozer	Loader	Grader	5-Ton Truck	SEE/JD410
CAPABILITY																
Period 2	1,497	3,045	817	1,855	446	192	145	405	667	680	1,190	317	211	116	393	153
Period 3	463	922	256	471	103	35	27	120	186	207	451	130	86	52	113	70
Period 4	436	871	245	454	98	34	25	118	179	191	417	120	80	47	104	66
Period 5	816	1,643	567	1,156	275	126	93	262	400	249	487	133	88	44	163	59
TOTAL	3,212	6,481	1,885	3,936	922	387	290	905	1,432	1,327	2,545	700	465	259	773	348
COMBAT ESSENTIAL REQUIREMENTS																
Vital & Critical																
Period 2	736	1,474	529	772	218	34	10	173	337	207	702	493	26	0	57	126
Period 3	102	608	79	333	138	42	22	53	78	23	275	218	28	0	7	22
Period 4	759	838	197	575	132	75	96	262	10	562	263	163	15	23	62	0
Period 5	795	1,830	687	1,230	314	69	47	185	615	108	600	443	27	0	24	106
TOTAL	2,392	4,750	1,492	2,910	802	220	175	673	1,040	900	1,840	1,317	96	23	150	254
BALANCE	820	1,731	393	1,026	120	167	115	232	392	427	705	-617	369	236	623	94
SUSTAINABILITY REQUIREMENTS																
Essential & Necessary																
Period 2	1,183	3,276	976	2,583	594	484	174	1,330	1	207	693	209	98	70	315	1
Period 3	436	1,156	241	673	200	117	57	299	0	195	483	109	98	26	249	1
Period 4	206	627	82	332	212	51	5	30	34	125	295	186	39	5	27	38
Period 5	1,181	3,215	965	2,516	553	496	159	1,308	0	216	699	205	103	71	319	1
TOTAL	3,007	8,274	2,264	6,104	1,559	1,148	395	2,967	35	743	2,170	709	338	172	910	41
BALANCE	-2,187	-6,543	-1,871	-5,078	-1,439	-981	-280	-2,735	357	-316	-1,465	-1,326	31	64	-287	53

NOTE: Capability was allocated based on initial interpretation of scenario events. No prior knowledge of requirement results was known when engineer units were assigned to brigade sectors.

*LID brigade capability includes the divisional engineers and the HHC and two companies of the airborne battalion.
**Armored brigade capability includes the brigade engineer company and one company of the airborne battalion.

Figure J-1-2

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ANNEX K

BIBLIOGRAPHY

ANNEX K

BIBLIOGRAPHY

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ANNEX L

STUDY REVIEW COMMENTS

ANNEX L

STUDY REVIEW COMMENTS

1. Purpose. At the completion of this study, ESC published a draft report that was distributed for review and comment to the study sponsor, the Study Advisory Group, and a select list of agencies interested in the study topic. This annex documents the results of that review process.

2. Scope. This annex presents only the significant and substantive comments ESC received on the draft report. No editorial comments are included, since they were automatically incorporated in the final report, either in response to the review comments or as part of ESC's routine editorial process. All comments were received by the study sponsor, then reviewed, consolidated, and sent to ESC on 29 September 1986.

3. Disposition of Comments. This paragraph lists each substantive comment ESC received on the draft report, and describes the action ESC took as a result of the comment. The originator of each comment is listed in parenthesis following the comment.

COMMENT: "The study is based on the LID Wargame by CAORA, Fort Leavenworth, Kansas. The JIFFY Model used to game these scenarios does not adequately portray engineer mission requirements and workloads. Recommendations concerning changing the force structure and equipment allocations cannot be made solely on the analysis of a single specialized division using two scenarios. Specific organizational re-designs must be generic enough to respond to worldwide requirements." (USAES)

RESPONSE: In regards to the first concern, ESC believes the European and Latin American scenarios are representative of the concept envisioned by GEN John A. Wickham, Chief of Staff of the US Army. In an interview published in Army magazine in September 1986, GEN Wickham responded to a question on the LID mission by stating "Light divisions are designed to function in the low- to mid-intensity environment, to get to crisis areas rapidly, either to deter hostilities or to influence them to our advantage. They are designed to work hand-in-glove with heavier forces."

In regard to ESC's recommendations concerning the EAD force, recommendations for only a single proposed unit (whose mission is to support only light and motorized divisions) are presented. ESC has published three additional studies that include in the troop list LIDs plus the 9th ID (Motorized) for other theaters, including Southwest Asia and Northeast Asia. ESC plans to publish a report that will include an examination of how this proposed EAD unit can be best employed in all four contingency theaters.

COMMENT. "The study also addresses the 7th ID(L) as the primary source of information and interpretation of the role for engineers in a LID. Although the 6th ID(L), 10th ID(L), 25th ID(L), and 29th ID(L) were listed as joining the SAG during IPR 2, little interaction between ESC and these divisions occurred. This limits the validity of the engineer task assessment used to determine engineer task requirements, occurrence rate, completion time, and task location. Since the study bases all conclusions and recommendations on the above methodology for both the Latin American and European scenarios, changes or recommendations from any or all of the LIDs listed could change the final outcome of the study." (USAES)

RESPONSE: It is true that ESC had little interaction with other than the 7th ID(L). However, the experienced 7th ID(L) represented a melting pot of ideas from all of the other less experienced LIDs which visited the 7th ID(L) frequently.

COMMENT: "The study does a good job in portraying the criticality of the ACE to the LID. However, we (USAES) are concerned with the portrayal of the SEE. The full potential of the SEE to the LID is not understood. The SEE is equipped with a wide range of attachments and hydraulic hand tools, giving it a diverse capability profile. It is the only asset the engineer squad has and the SEE will have the following capabilities: (1) a scoop loader bucket for digging positions and berms; (2) a backhoe for digging positions and cutting asphalt; (3) a blade for light bulldozing and rough grading; (4) a trencher for explosive tank ditching using the TEXS; (5) an earth auger for log obstacles, field fortifications, and explosive road craters using TEXS; and (6) a hydraulic hand tool set consisting of a saw, impact drill, and a pavement breaker for use in a variety of mobility and countermobility tasks. The study conclusion to reduce the present allocation of SEEs to the LID was not based on the full potenial of this vehicle. Reevaluation of this issue is required." (USAES)

RESPONSE: ESC considered the full potential of all SEE attachments and hydraulic hand tools and adopted most applications listed above (capabilities 1 through 6), while omitting a few based on the operational concept for a LID. The predominant consideration which prompted the recommendations to reduce the SEE was the study constraint that aircraft sorties required to deploy the engineer battalion could not be increased. ESC evaluated the prioritized requirements for both SEE and ACE tasks and concluded that the number of ACEs should be increased at the expense of the SEE (FORSCOM and the 7th ID(L) Concur).

COMMENT: "The study also discounts the bridging requirements for less than 18 meters, the requirement for wire obstacles, and the requirement to clear lanes through threat minefields. It is unrealistic that in neither the Latin American and European scenario that the Divisional Engineer Battalion is not required to emplace any small-gap bridges to support vehicle traffic within their area of operations. Equally unrealistic is the lack of wire used in both scenarios. LTC Bohn, Commander, 13th Engineer Battalion, indicated the heavy use of wire during the 7th ID(L) certification test. Finally, there is lack of requirements to breach minefields. The study does a good job in addressing mine warfare, but fails to evaluate the impact of threat scatterable minefields on the LID forces. The support base, artillery units, and engineer unit within the division will require at some time a minefield to be breached so they can continue to perform their mission. MICLIC is an ideal system and should not be discouted by the study." (USAES and I Corps)

RESPONSE: Small-gap bridging (less than 18 meters) was not evaluated in this study and an assumption to this effect has been added to the main report. However, if there is a requirement, it must be evaluated in regards to both technique (ford, bridge, bypass, etc.) and applicability for EAD forces.

Regarding wire, IPR 4 also indicated that the wire emplaced during the certification test was a "make work" project, since mines and explosives could not be realistically practiced. In this study, wire obstacles were considered as protective in nature and a responsibility of the user.

Scatterable minefields were not considered a significant threat possibility for 1988 in this study. Although, it is acknowledged that threat scatterable minefields demand new engineer solutions, ESC did not consider explosive line charges an appropriate rear area technique when threat observation on these minefields is minimal. ESC did not discount MICLIC as an interim solution, but relegated it to engineer EAD units.

COMMENT: "The study's requirements methodology for Class IV and V materials for engineers only address Class V items. The general engineering requirement for both classes are listed at less than 1 percent. Mobility requirements are listed at 2 percent and countermobility requirements consume the rest. Even though the study uses the title of both classes, only Class V items are listed. As a result, the transportation requirement for Class IV items required in general engineering, survivability, mobility and countermobility missions is not addressed. If addressed, there could be a significant shortfall in transportation assets now listed as satisfactory by the study." (USAES, 7th ID(L), and I Corps)

RESPONSE: Sand and gravel are addressed for project site requirements under mobility and general engineering missions in this study. These Class IV materials are required in the division area and are considered readily available from the host nation and will be available at or near the project sites. Countermobility Class IV wire items were previously discussed above. Survivability Class IV items were not needed under the scenario conditions; these conditions limited extensive construction in Latin America, since the LID was expected to return to CONUS immediately after the operation. ESC assumed any requirement would not occur until after the end of the scenario at D+10. In Europe, the extensive use of existing host nation facilities reduced Class IV requirements.

COMMENT: "Finally, the scenario used in Latin America places the LID against a conventional force fighting a low- to mid-intensity conflict as opposed to a true low-intensity conflict. As a result, the insurgent campaign associated with low-intensity conflict is not addressed and it eliminates the redundant requirements of mine clearing of MSRs, wire entanglements for artillery fire bases, and revetments for helicopters." (USAES)

RESPONSE: ESC agrees that the Latin American scenario is not a true low-intensity insurgent campaign. However, TRADOC (as reinforced by GEN Wickham's observations) does not believe this is a representative mission for the LID at this time. ESC calculations include a one-time sweep -- based on the threat -- of all MSRs, and 39 helicopter revetment positions, but defers the other tasks mentioned above as either long-term (after the scenario end of D+10) or as mostly a user responsibility.

COMMENT: "At the final IPR, the SAG chairman directed ESC to examine the impact of using the design requirements of the Latin American scenario (in lieu of weighted scenarios) in the European scenario. It was agreed to present this ADEA excursion in this annex."

RESPONSE: The ADEA excursion only concerns the ACE-to-SEE ratio, as this was the only use of weighted scenario data applied in the study (details appear in Annex I).

Figure L-1 shows the ACE-to-SEE capability and requirement ratios as determined by the study, with the addition of a capability for the ADEA excursion based on the Latin American scenario. The added ADEA excursion capability has 13 ACEs and six SEEs. These quantities provide the maximum number of equipment items in the desired 2:1 ACE-to-SEE ratio without increasing the deployment sorties. In the Latin American scenario, both the base case and the new explosive excursion requirements yield a 2:1 ACE-to-SEE ratio.

EQUIPMENT MIXES AND RATIOS

	Equipment Number		ACE-to-SEE
	ACE	SEE	Ratio
TOE capabilities:			
1988 design TOE	6	18	1:3
Main report recommendation	11	10	1:1
ADEA excursion quantity*	13	6	2:1
Key situation scenario requirements:			
European -- new explosive excursion	14	14	1:1
Weighted scenarios -- new explosive excursion (Main report recommendation)	11	9	1:1
Latin American -- base case	10	5	2:1
Latin American -- new explosive excursion	10	6	2:1
Weighted scenarios -- base case	11	5	2:1
European -- base case	14	5	3:1

*See Figure I-4

Figure L-1

Figure L-2 shows what percentage of priority group requirements are completed for the ACE and SEE in the European scenarios. These percentages are shown for the 1988 TOE (six ACEs and 18 SEEs), the recommendations of the main report (11 ACEs and 10 SEEs), and the ADEA excursion of this annex (13 ACEs and six SEEs). A careful examination of the results in Figure L-2 reveals that the ADEA excursion provides the best solution for the base case, but the situation is inconclusive for the new explosive excursion. However, if the Latin American results are also considered, then the main report recommendation is best for the new explosive excursion. In summary, the ADEA excursion is best in the short run, but the study recommendation is best for the long run when the new explosives become available.

EQUIPMENT-HOUR PERCENTAGE COMPLETION BY PRIORITY GROUP
(LID AO Only With No Lodgement Requirements)

	Equipment and Priority Group							
	Vital		Critical		Essential		Necessary	
European Scenario	ACE	SEE	ACE	SEE	ACE	SEE	ACE	SEE
1988 TOE equipment:								
Base case	62	100	0	100	0	100	0	100
New explosive excursion	62	100	0	100	0	100	0	0
Main report recommendations:								
Base case	100	100	31	100	0	100	0	100
New explosive excursion	100	56	30	0	0	0	0	0
ADEA excursion quantity:								
Base case	100	100	82	100	0	100	0	100
New explosive excursion	100	33	81	0	0	0	0	0

Figure L-2

The ADEA excursion and the main study recommendations both require ACEs and SEEs from the initial engineer EAD unit assigned to the LID in Europe. The total equipment needed to be provided by the EAD unit also varies in the short and long run. The ADEA excursion requires one piece of equipment in the base case and nine in the new explosive excursion, while the study-recommended solution requires three in the base case and seven in the new explosive excursion. However, all these equipment levels can easily be met by the assignment of a corps engineer battalion of any type to the LID.

COMMENT: "The squad power shortfall identified in the study has not been experienced by the 13th Engineer Battalion and may be an overstatement. Divisional policy has many engineer-related tasks executed using infantry manpower with engineer technical advice given as appropriate." (7th ID(L))

RESPONSE: ESC also calculated infantry manpower, but only for individual weapon positions and protective wire emplacements. Despite this assistance, an engineer squad-power shortfall persisted. ESC recommended that an engineer EAD unit be available to provide this assistance with squad-only companies.

LAST PAGE OF ANNEX L