PROPOSED FORCE XXI ENGINEER DESIGNS: VIABLE COMBAT MULTIPLIERS?

A MONOGRAPH
BY

Major William D. Brinkley
Corps of Engineers

School of Advanced Military Studies
United States Army Command and General Staff College
Fort Leavenworth, Kansas

First Term AY 97-98

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	18 December 1997	MONOGRAPH

4. TITLE AND SUBTITLE
PROPOSED Force XXI Engineer Designs: Viable Combat Multipliers?

5. FUNDING NUMBERS

6. AUTHOR(S)
Major William D. Brinkley

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
SCHOOL OF ADVANCED MILITARY STUDIES
COMMAND AND GENERAL STAFF COLLEGE
FORT LEAVENWORTH, KANSAS 66027

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
COMMAND AND GENERAL STAFF COLLEGE
FORT LEAVENWORTH, KANSAS 66027

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
DISTRIBUTION UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
SEE ATTACHED

14. SUBJECT TERMS
Engineer Organizations, Force XXI, Division ReDesign

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSFIED	UNCLASSIFIED	UNLIMITED

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18 298-102

USAPPC V1.00

ABSTRACT

PROPOSED FORCE XXI ENGINEER DESIGNS: VIABLE COMBAT MULTIPLIERS? By Major W. David Brinkley, USA 69 pages.

This monograph analyzes the ability of two proposed engineer organizations to adequately support the future Force XXI Division.

Examinations of four historical case studies determine engineer support requirements for division operations. The U.S. Army's participation in Vietnam and Bosnia define engineer support analysis criteria for stability operations. Combat engineer support in World War II and the Persian Gulf define analysis criteria for major theater war. The key criteria are tactical bridging capability, breaching and countermine capability, combat construction capability, and engineer command and control capability.

The monograph deems both proposed engineer designs inadequate to support the Force XXI division. Design One has inadequate amounts of tactical bridging and an insufficient number of engineer company headquarters to adequately conduct countermine/breaching missions. However, Design One's division-level headquarters is flexible and rapidly expandable, and should easily integrate additional engineer forces. Design One can plan and execute major division river crossings. With the addition of one additional corps combat engineer battalion, Design One will provide adequate divisional support. Design two will adequately support brigade operations but lacks division-level flexibility. The lack of a divisional engineer headquarters will preclude adequate integration of additional engineer forces without engineer headquarters augmentation. Design Two cannot adequately plan and execute division-level engineer mission such as major river crossings without significant augmentation.

The monograph recommends a third design that incorporates a three-battalion, divisional engineer brigade organized along the current ERI division engineer organization. However, this third design uses the Force XXI engineer company as its foundation. The recommended design will have 30% fewer soldiers than the ERI Brigade, but should provide better support to the future division.

SCHOOL OF ADVANCED MILITARY STUDIES

MONOGRAPH APPROVAL

Major W. David Brinkley

Title of Monograph: *Proposed Force XXI Engineer Designs: Viable Combat Multipliers?*

Approved by:

_____________________________ Monograph Director
COL Leonardo V. Flor, MECE, MMAS

_____________________________ Director, School of Advanced Military Studies
COL Danny M. Davis, MA, MMAS

_____________________________ Director, Graduate Degree Program
Philip J. Brookes, Ph.D.

Accepted this 18th Day of December 1997

ABSTRACT

PROPOSED FORCE XXI ENGINEER DESIGNS: VIABLE COMBAT MULTIPLIERS? By Major W. David Brinkley, USA 69 pages.

This monograph analyzes the ability of two proposed engineer organizations to adequately support the future Force XXI Division.

Examinations of four historical case studies determine engineer support requirements for division operations. The U.S. Army's participation in Vietnam and Bosnia define engineer support analysis criteria for stability operations. Combat engineer support in World War II and the Persian Gulf define analysis criteria for major theater war. The key criteria are tactical bridging capability, breaching and countermine capability, combat construction capability, and engineer command and control capability.

The monograph deems both proposed engineer designs inadequate to support the Force XXI division. Design One has inadequate amounts of tactical bridging and an insufficient number of engineer company headquarters to adequately conduct countermine/breaching missions. However, Design One's division-level headquarters is flexible and rapidly expandable, and should easily integrate additional engineer forces. Design One can plan and execute major division river crossings. With the addition of one additional corps combat engineer battalion, Design One will provide adequate divisional support. Design two will adequately support brigade operations but lacks division-level flexibility. The lack of a divisional engineer headquarters will preclude adequate integration of additional engineer forces without engineer headquarters augmentation. Design Two cannot adequately plan and execute division-level engineer mission such as major river crossings without significant augmentation.

The monograph recommends a third design that incorporates a three-battalion, divisional engineer brigade organized along the current ERI division engineer organization. However, this third design uses the Force XXI engineer company as its foundation. The recommended design will have 30% fewer soldiers than the ERI Brigade, but should provide better support to the future division.

CONTENTS

Section | Page

APPENDICES

ILLUSTRATIONS

Figure | Page

Section I. Introduction

Background

The Army of Excellence (AOE) heavy division structure performed admirably in the Gulf War. The last major evolution of this division was the Engineer Restructuring Initiative (ERI). This evolution replaced the World War II era engineer organization of one combat engineer battalion per heavy division with a three battalion, combat engineer brigade. At the tactical level, ERI solved many of the reoccurring problems with earlier engineer force structure. It provided "experienced engineer leaders"[1] with the appropriate level maneuver commanders. Battalion and Task Force commanders were now supported by full engineer companies. Previously, these same commands were supported by thirty-man engineer platoons. Overall, the ERI organization provided "maneuver commanders with significant, forward arrayed engineer assets needed to conduct an independent fight"[2] (See page 53).

Despite success in Operation Desert Storm, and perhaps because of the end of the Cold War, the U.S. Army is in transition. It must deal with the combined challenges of changing threat, changing focus, and force reduction. Given this, the Training and Doctrine Command (TRADOC) proposes a heavy division to fight in the 21st Century. Phase I of this process was completed in March 1996.

This redesign effort proposes a significantly altered engineer force to support the division; it replaces the ERI-type engineer brigade with either an engineer group with only two engineer battalions or three separate engineer battalions. The Force XXI Division Design Analysis approved these organizations for experimentation[3] (See pages 54 and 55). Interestingly, the report states that the "absence of a third headquarters and the reduction in... engineer line companies require the engineers to explicitly tailor their forces."[4] At face value, these organizations appear less capable than the ERI based engineer brigade.

The Force XXI Division Redesign Analysis states that "the AOE (engineer brigade) design was deemed adequate."[5] Ultimately, the divisional engineer force structure was cut without detailed "supporting analysis."[6] This monograph analyzes the adequacy of the proposed engineer designs in supporting the Force XXI division.

The monograph uses four historical case studies to define adequate engineer support for a division. The case study results provide criteria to analyze the Force XXI engineer designs' capabilities. The case studies analyze heavy division and armored cavalry operations in World War II, Vietnam, Operation Desert Storm, and Bosnia. The case studies determine typical engineer support requirements, what that engineer support consists of, and what organizational structure proved most effective.

Assumptions

This monograph assumes that Force XXI engineers provide similar support as that its predecessors provided earlier heavy forces: breaching obstacles, constructing barriers, constructing fortifications and upgrading infrastructure for the division. None of the available literature indicates the relief from these historical engineer support tasks. The monograph also assumes corps engineers continue to augment heavy divisions.

Applicable Doctrine

The United States National Security Strategy provides a spectrum for military employment. This spectrum includes both operations other than war as well as major theater war. The May 1997 National Security Strategy states that:

> The U.S. Military conducts smaller-scale contingency operations to vindicate national interests. These operations encompass the full range of military operations short of major theater warfare, including humanitarian assistance, peacekeeping, disaster relief, no fly zones, reinforcing key allies, limited strikes, and interventions. These operations will likely pose the most frequent challenge for U.S. Forces and cumulatively require significant commitments over time.[7]

For the purposes of this analysis the above defines potential military operations other than war. The National Command Authority sees these type operations as the most likely undertaken by the U.S. Army. The conduct of "small scale contingencies" was once the special purview of light forces. However, given force reductions, these forces increasing are heavy and mechanized. The current deployment of the 1st Infantry Division to Bosnia, as part of a multinational peacekeeping effort, underscores this trend. These forces rely heavily on engineer support to conduct their operations. As such, the examination of 11th ACR operations in Vietnam and 1st Armored Division operations in Bosnia determine the required engineer forces to adequately support these "smaller scale contingencies."

U.S. Army forces must prepare to fight and win the nation's higher intensity, theater level wars as well. The National Security Strategy states that "at the high end of responding to crises is fighting and winning major theater wars. This mission will remain the ultimate test of our Total Force."[8] The U.S. Army's divisions constitute the primary, independent fighting force that responds to this "ultimate test." As this monograph examines the adequacy of a future division's engineer force it is important to define what a division does.

FM 71-100, *Division Operations*, states that "the division is a large Army organization that trains and fights as a tactical team. Largely self-sustaining, it is capable of independent operations."[9] Heavy divisions must operate on any given terrain during anytime of the year. Moreover, heavy divisions gain their tactical punch by rapidly concentrating combat power. Again, FM 71-100 states "their mobility allows them to rapidly concentrate, attack, reinforce, or block enemy forces."[10] The divisional engineers provide the division its ability to "rapidly concentrate" in theater level war. The same force provides the division its "staying power" in stability operations.

FM 5-71-100, *Division Engineer Combat Operations*, states that, "division engineers serve two critical roles for the division. First they provide engineer expertise at every level of command from the division to the company.... Second, they provide the structure necessary to command engineer units at these echelons."[11] The engineer command and control architecture for the division is vital to the engineers' ability to adequately support division operations.

World War II armored division operations and Operation Desert Shield establish adequate engineer support requirements in major theater war. Vietnam and Operation Joint Endeavor establish adequate engineer support requirements in stability operations. From both a doctrinal, historical, and political viewpoint, U.S. Army divisions, and their engineers, must prepare to face a variety of future challenges.

Section II. Stability Operations Case Studies

The U.S. Army must prepare for any and all threats. However, since the conclusion of Operation Desert Storm, the Army has increasingly answered the nation's "call to arms" in operations other than war. Field Manual 100-5, *Operations,* states that operations other than war "are often of long duration and undergo a number of shifts in direction during their course."[12] The U.S. Army's operations in the Republic of Vietnam, and those in Bosnia, exemplify operations other than war.[13]

Operations other than war (or stability operations) frequently occur in primitive areas of the world. Therefore, these type of operations require Army units to "operate in a variety of geographical conditions."[14] Both Vietnam and Bosnia lacked sophisticated infrastructure and presented extremely difficult mounted terrain. Colonel Donn Starry, Commander of the 11th ACR in Vietnam, commented that "to most military men the jungle was... to be avoided by armored forces."[15] However, he notes that a study done in 1967 found that over 46 percent of Vietnam was traversable year round.[16]

For the mounted force, operations in Bosnia posed comparable challenges with those in Vietnam. Mountains, cross compartmentalization, frequent rivers, small towns and villages, and limited infrastructure characterized Bosnia's terrain. As in Vietnam, U.S. forces deployed into a country already heavily damaged by the effects of a long war. The Combined Arms Assessment Team judged operational mobility extremely difficult in Bosnia.[17]

In both cases engineer forces were in high demand. Typical engineer missions included countermine operations, base and facilities construction, and infrastructure upgrade, repair, and construction. Engineers in both "conflicts" were frequently required to build and repair bridges as well as provide a flexible and adaptable force. This section examines the adequacy of engineer support to armored forces during stability operations. Specifically, it focuses on engineer support to armored force operations in Vietnam and in Bosnia.

Stability Operations Case Study - Vietnam

The U.S. Army introduced armored forces into the Republic of Vietnam (RVN) in 1965 with the deployment of 1 Squadron, 4th Cavalry, 1st Infantry Division.[18] Increasingly, as armored and mechanized infantry forces deployed to Vietnam, mobility, flexibility, firepower, and shock action played an important role in combat against the Viet Cong.[19] Armored and mechanized forces cleared lines of communication, protected support bases, conducted search and destroy missions, and protected convoys and logistical traffic.

The terrain and the enemy provided many challenges to the armored forces in Vietnam. In 1967, Headquarters, U.S. Army Vietnam (MACOV) undertook and published a comprehensive study of mechanized and armored operations in Vietnam. This study states that tanks can negotiate 44 percent of the total terrain, with 89 percent of the coastal lowlands trafficable during the dry season.[20] It goes on to state that the extensive hydrology of the area of operations require "...class 60 rafts, bridges or armored vehicle launched bridges"[21] for crossing tanks.

During the wet season the trafficablity in Vietnam is severely restricted. Field Manual 34-130, *Intelligence Preparation Of The Battlefield*, defines severely restricted terrain as that which greatly "hinders or slows movement in combat formations unless some effort is made to enhance mobility."[22] The MACOV study determined that during the wet season "...tank movement along the roads will normally require bridging assistance."[23] During one mounted operation in Vietnam, poor road conditions and blown bridges delayed unit resupply forcing one mechanized commander to limit vehicle movement because of POL shortages."[24]

The lack of responsive bridging support is frequently mentioned in armored force lessons learned and combat after action reviews. In Vietnam, each tank battalion and armored cavalry squadron had two armored vehicle launch bridges (AVLBs).[25] The AVLB was in high demand during this conflict. Many of the reports from the period point to an inadequate number of AVLBs in the force. Engineer battalions deployed to Vietnam were equipped to build both hasty and conventional bridging, but only armored division engineer battalions were authorized the AVLB. No armored divisions deployed to Vietnam; only the 11th Armored Cavalry Regiment, divisional cavalry squadrons, mechanized infantry, and tank battalions. Force structure designs of the time limited the number of AVLBs available to the armored force.

Colonel Starry recommended the squadron AVLB sections be increased to a total of four.[26] He reasoned that each cavalry troop, as well as the Headquarters and Headquarters Troop, required responsive, protected, and quick to install bridging.

Similarly, the MACOV study concluded that "...the requirement to rapidly span antitank ditches, road craters, and natural terrain obstacles necessitates the addition of an armored vehicle launched (AVLB) section [to the divisional cavalry HHT]."[27] Another evaluation concluded that the AVLB was not responsive primarily *because* it was not organic equipment nor available from other units.[28]

Clearly, the AVLB was vital to armored and mechanized operations in Vietnam. All of the reports plainly state the requirement for additional AVLBs to support armored operations in Vietnam. Colonel Starry states "squadron AVLB sections were generally not adequate to operational demands."[29] Colonel Starry's recommendations, as well as those of other armored and mechanized battalion commanders surveyed, indicate the requirement for AVLBs *appears* to be one per armored or mechanized company.

While the terrain posed many challenges to the armored units in Vietnam, mines posed the greatest threat to armored and mechanized mobility. During 1967 alone, 154 tanks hit mines with eight destroyed and 122 damaged twenty-four undamaged. Also, 378 APCs hit mines, with 118 destroyed and 242 damaged.[30] These figures show the significant impact of Viet Cong mines on U.S. armored operations.

During Operation Cedar Falls, 2-34 Armor encountered sixty-eight enemy anti-tank mines.[31] This was not atypical for armor battalions during operations. Other than hand-held mine detectors, countermine equipment was not available in Vietnam. Typically, heavy units either relied on engineer mine sweep teams or they conducted what became know as "thunder runs." Thunder runs were a field expedient that quickly opened routes with little risk to personnel, though with tremendous loss and damage to equipment. This technique employed three tanks, two driving on the shoulders of the road to disrupt wires leading to mines and one following in the center of the road to detonate pressure mines.[32] Clearly this expedient was never the preferred method of route clearance nor is it now.

Field Manual 20-32, *Mine/Countermine Operations*, establishes that minefields produce specific effects on enemy maneuver, thereby creating vulnerabilities.[33] Viet

Cong mining caused two noticeable effects in Vietnam. First, little traffic moved on the roads at night for fear of hitting unseen mines. Ironically, this was the Viet Cong's preferred time period to conduct mining. Limited visibility provided excellent cover for their mine warfare. Second, the Viet Cong's tactics forced the U.S. Army to clear the roads daily in order to resume logistical traffic. Studies done at the time concluded that "...mines have been the most effective obstacles employed by the enemy."[34]

Engineer Support Operations

In Vietnam, aside from alleviating many of the mobility problems mentioned above, the engineers also constructed base facilities and infrastructure required by deployed forces. The following sections examine engineer support to the 11th ACR, in detail, since it was the largest armored formation in Vietnam. The 919th Armored Engineer Company was the organic engineer company of the 11th ACR during Vietnam. A 11th ACR lessons learned report details that the 919th built base camps, cleared mines, destroyed fortifications, and constructed temporary bridging.[35]

The 919th Engineer Company was structured with three combat engineer platoons and a company headquarters. This company organization proved inadequate. It frequently broke platoons apart during operations because of over tasking. The 919th Engineer Company regularly task organized a platoon per cavalry squadron. The engineer platoons typically task organized an engineer squad per troop as well. In 1967, 11th ACR reported that "...during operations adequate and efficient engineer support is not always provided because the platoons are often fragmented."[36]

The engineer support to the 11th ACR increased as their service in Vietnam lengthened. By 1970, "...the 919th Engineer Company was augmented with a forth engineer platoon. This permitted deployment of one platoon with each squadron, and left a reinforcing capability for Regimental level engineer work with the company (-)."[37] However, even the addition of a fourth armored engineer platoon did not provide adequate engineer support to the regiment.

The 27th Engineer Battalion initially provided area support to the 11th ACR starting in 1966. The 27th Engineers built the 11th ACR's base camps and maintained their facilities. Interestingly, the 27th Engineers were never formally organized to support the 11th ACR. In Vietnam, engineers generally supported operational commanders.[38] This arrangement facilitated base construction, road upgrades and bridge building to support the force at large, but many times insufficiently supported the operations conducted by tactical units.

This engineer priority caused frequent disagreements between the engineer commanders and the Field Force (corps) commanders. In 1965, Major General Robert Polger, Commander, Engineer Command Vietnam, was "convinced that engineer units transferred to field force control would lose their... construction potential."[39] This command philosophy expedited base construction requirements, particularly early in the conflict. During the U.S. build up, between 1965 and 1969, there was a large requirement for base camp, port, and infrastructure construction. However, this priority requirement for the limited amount of engineers came at the expense of the tactical commander's flexibility.

By 1967, tactical units began to receive more engineer support. The 27th Engineer Battalion now fully supported the 11th ACR. During Operation Dam Tam 81 (December 1966), a reinforced combat engineer company supported 1st Squadron.[40] This documented the first case of an engineer company fully supporting a battalion-size task force in Vietnam. During Operation Paddington (June-July 1967), the 11th ACR was supported by "...the 919th Engineer Company with elements of the 595th Engineer Company , 27th Engineer Battalion and the 15th Engineer Battalion."[41] Significantly, these operations' after action reports referred to not a signal instance of inadequate engineer support.

Examination of Adequacy

During Vietnam engineer forces supporting armored units faced a myriad of challenges. They conducted daily mine sweeps of all roads in the area of operations. They constructed hasty, tactical and fixed bridging, destroyed enemy tunnel complexes and fortifications, and also built and fortified friendly base camps and facilities. Several trends in engineer support present themselves in the archival information.

Firstly, construction of living facilities and logistical lines of communication required a massive engineer effort. In Vietnam, MACOV had no less than 25 engineer battalions in general support.[42] Twelve of these were combat engineer battalions that did both construction and direct combat support. The 27th Engineers' support to the 11th ACR falls within this category.

Secondly, the armored and mechanized forces needed a rapidly emplaced, armored bridge to facilitate operations over Vietnam's extensive hydrology and poor road network. The AVLB provided the solution, unfortunately fielding never increased over two per tank battalion or armored cavalry squadron. Mechanized infantry battalions continued to receive AVLBs only on a temporary basis and this problem continued until the end of the American involvement. The fielding of an AVLB platoon to divisional engineer battalions alleviated some of the mobility problems faced in Vietnam. As referred to earlier, Colonel Starry's recommendations, as well as those of the commander of 1-63 AR, seem to point to a requirement for four AVLBs per tank battalion provided better combat support for independently operating tank companies.[43]

Thirdly, increased introduction of armor to Vietnam increased the Viet Cong's use of antitank mines.[44] Countermine operations continued to pose significant problems throughout the U.S. involvement. Engineer mine sweep teams were very effective, but extremely slow and deliberate. The speed of these dismounted engineers frequently dictated the speed of military traffic. As the conflict progressed, the force tried several techniques to quickly clear the roads of mines. The theater received tank rollers, but found them ineffective because of the soft soil and muddy road systems. As discussed earlier, the "thunder run" quickly cleared the road, but was very costly in materiel. Other than deliberate hand clearing, countermine operations were never truly effective in Vietnam.

Finally, engineer command and control never fully matured in a tactical sense. The Vietnam engineer command consisted of two engineer brigades and five engineer groups assigned geographic areas of responsibility. However, these engineer headquarters did not align themselves with tactical unit areas of operations. The 18th Engineer Brigade, for example, supported both Field Forces I and II while the 20th Engineer Brigade supported Field Forces III and IV.[45] The engineer groups similarly crossed over divisional areas of operations with no formal command and control relationships with these tactical units. This is exemplified by the 11th ACR's engineer command relationship during Operation Manhattan. The regimental engineer, a major, planned engineer missions for two engineer battalions (with two lieutenant colonels commanding) that directly supported the regiment. This robust engineer organization "vigorously" supported the 11th ACR.[46]

However, the lack of a multiple engineer battalion command and control apparatus probably exceeded the span of control capability of the regimental engineer section. Field Manual 5-71-3, *Brigade Engineer Combat Operations (Armored),* states that "effective engineer command and control enables the commander to integrate engineer operations and support the brigade's [regiment's] scheme of maneuver." [47] The 11th ACR never had a single command and control organization to adequately control the nine engineer companies supporting it during Operation Manhattan.

Stability Operations Case Study - Bosnia

The U.S. Army entered Bosnia as part of a multinational peacekeeping force on December 30, 1995. The 1st Armored Division crossed the Sava River during what would become "... the largest operationally required river crossing since World War II."[48] It is symbolic that Operation Joint Endeavor started with a tremendous engineer undertaking. To quote one of the brigade commanders, "the engineers have never worked as hard as they do in this sector... with mine clearance overwatch, route clearance, construction of containment areas [and] base camps."[49]

The engineers supporting Operation Joint Endeavor faced many of the same challenges as faced in Vietnam. Bosnia offered "... limited infrastructure, adverse weather, and the widespread use of mines [which] severely limited available terrain."[50] In order to understand the engineering challenge, it is germane to understand the mission of the 1st Armored Division and the challenges of Operation Joint Endeavor.

The General Framework Agreement for Peace (GFAP), better known as the Dayton Agreements, was signed by the Former Warring Factions (FWF) on 14 December 1995. Colonel(P) Hans Van Winkle briefed the 1995 Engineer Commander's Conference, that the U.S. forces in Bosnia monitored the zone of separation, ensured freedom of movement, established procedures for airspace control, monitored heavy weapons and status of forces, established conditions for free and fair elections, and responded to violence.[51] Accordingly, he also defined the engineer missions. These missions included: maintaining mobility over routes, conducting countermine operations, conducting sustainment engineering, destroying bunkers and fortifications in the Zone of Separation (ZOS), acquiring real estate, building base camps, conducting bridging operations, and building bunkers, towers, and fortifications.[52]

Interestingly, these missions closely parallel those of Army engineers in Vietnam. In "peacekeeping operations [engineer support] covers a wide range of activities, from constructing or maintaining facilities to marking or clearing minefields."[53] Major David Treleaven deployed to Bosnia as a United Nations Protection Force (UNPROFOR) augmentee. He offers that:

> Bosnia has tested engineers across the full range of mobility missions: bridging, route clearance, route maintenance, countermine operations, and obstacle reduction. The complexity of Operation Joint

> Endeavor has taxed engineer capabilities and resources, demanding more versatility than any other combat support force in theater.[54]

The 1st Armored Division and their engineers faced three substantial challenges. Initially, they conducted a major river crossing to move into sector. Secondly, the division separated the FWF in accordance with the GFAP. Finally, the engineers cleared roads of mines, emplaced or repaired bridges and built base camps. To accomplish the engineer missions required, the 1st Armored Division's engineer brigade was vastly augmented. The brigade ultimately commanded and controlled three Army combat engineer battalions, one Army construction battalion, one Navy construction battalion, two Air Force construction squadrons, two Medium Girder Bridge (MGB) companies, and two Combat Support Equipment (CSE) companies.

It also initially exercised operational control over two Assault Float Bridge companies on the Sava River. Task Force Eagle (TFE) ultimately received support from the 130th Engineer Brigade, V Corps. Following their deployment, the 130th took control of the Sava River crossing area, the responsibility for building the Intermediate Staging Base (ISB) in Tazsar Hungry, and the maintenance of the main supply routes (MSR) from the ISB to the river line.[55]

Engineer Support Operations

Crossing the Sava River, during the winter, was the first major hurdle for the 1st Armored Division. This task was extremely arduous. All of the major bridges over the Sava were destroyed during the hostilities, and "... the only option was to initially cross the SAVA with an assault float bridge and then follow up the crossing with a fixed bridge of some type."[56]

Two assault float bridge companies worked to cross the Sava River during harsh winter weather. The 502d Assault Float Bridge (AFB) Company emplaced a 600 meter bridge on 31 December 1995. 586th AFB Company emplaced an additional 380 meter bridge on 17 Jan 1996. Both units were supplemented with War Reserve interior bays, ramps, boats, and transporters.[57] Crossing the Sava required all of the theater's float bridging assets, including 29 bays brought from a depot in Germany.[58] This crossing also marked the first operational use of the ribbon bridge.

Following the Sava River crossing, the 1st Armored Division opened MSRs from the Sava to their area of operations. The division opened supplemental routes to each of its brigades combat teams. This effort required a substantial amount of tactical bridging. As in Vietnam, the AVLB reinforced existing bridges, replaced blown bridges, and spanned dry gaps.[59] The divisional engineer brigade is normally equipped with thirty-six AVLBs. If needed, one AVLB could support every armored or mechanized company in the division. This represents over double the number of AVLBs found in the Vietnam era armor division and a quantum improvement in tactical mobility.

However, in Bosnia, "TFE had 64 ... AVLBs."[60] This increase in AVLBs stems in part because "stocks of replacement bridging for both Bailey and Medium Girder Bridge (MGB) are low due to shipments to Somalia and [the amount of] damaged bridging [in Bosnia]."[61] It appears that sixty-four AVLBs were sent to Bosnia because of the shortage of tactical bridging. The AVLB provided the only feasible bridging alternative until additional bridging became available.

The MGB ultimately replaced many AVLBs. The MGB was "initially used but removed once most of the force was in sector. The intent was to minimize the use of the bridge and hold them in reserve".[62] The Bailey Bridge replaced the MGB along many routes. Ultimately, "there were 9 sets of Bailey Bridge sent to Bosnia."[63] The redoubtable Bailey Bridge was introduced in World War II and used in Korea, Vietnam, and Bosnia. Many militaries world wide continue to use this great, but dated, bridge.

The extraordinary number of mines in Bosnia caused mine clearing to influence all levels of the operation.[64] During the Yugoslavian Civil War, Bosnian troops laid millions of mines over large areas. Exacerbating this problem, many FWF troops randomly laid mines as they retreated.[65] The dynamic situation along the Zone of Separation (ZOS) and the random use of mines made the TFE area of operation an extremely dangerous place. Mine fields, craters, tank ditches, berms, and bunkers blocked the majority of the roads in the area.[66] The 1st Armored Division required these routes cleared to conduct operations and to re-establish freedom of civilian movement.

The 1st Armored Division found itself in a heavily mined environment similar to that faced by the 11th ACR in Vietnam. However, unlike Vietnam's randomly mined routes, Bosnia offered densely mined areas. MG David Grange, Commander of the U.S. Stabilization Force (SFOR) in Bosnia, confirmed "that much more must be done to rid the region of 750,000 land mines buried [in the U.S. sector]."[67] Unlike the 11th ACR, the better equipped 1st Armored Division dealt better with the mine threat. Modern mine plows, mine rollers, robotic mine roller vehicles, robotic "mini-flails", plus many developmental systems provided an impressive suite of countermine equipment to the 1st Armored Division.

The 1st Armored Division heavily used mine rollers in Bosnia. Approximately one tank roller was allocated per company team in Bosnia and one "Panther" (a robotic tank with mine roller) per engineer company. Because of these improved systems, TFE suffered only ten mine strikes, between 30 December 1995 and 19 February 1996.[68] During a similar time period, eleven 11th ACR tanks and fifty-two APCs struck mines in Vietnam.[69] Improved countermine systems provided a quantum improvement over the "thunder runs" of Vietnam and allowed quicker, safer route proofing.

In order to carry out its assigned missions, the 1st AD needed immediate facilities in Bosnia. The Center for Army Lessons Learned Team concluded that, "the severely damaged [Bosnian] ... infrastructure required that deploying forces provide many of their own facilities and services. The rapid introduction of military forces further dictated that most of the initial construction would be completed by military engineer units."[70] This necessitated an intensive construction program. Major Andrew Goetz relates, "the primary engineer mission during my stay in Bosnia was construction."[71] In total, TFE engineers built twenty-three base camps. The Logistics Civil Augmentation Program (LOGCAP) contractor constructed nine camps, the 133rd Naval Construction Battalion (Seabees) built six, the 40th Engineer Battalion (Combat) assembled two, the 823rd Air Force Redhorse Squadron built three, 94th Engineer Battalion (Combat Heavy) with the 823rd Redhorse built two together, and the 94th with the Seabees built another two.[72]

By 1 April 1996, the joint engineer force completed all base camp construction. Amazingly, the engineers built twenty-four base camps and renovated five installations, housing 27,000 soldiers, in 104 days.[73] This marked a substantial improvement over construction efforts in Vietnam. Bosnia showcased the synergistic effects of joint engineering capabilities coupled with civilian contracting. LOGCAP-contracted construction proved a winner in building several camps, thereby freeing military engineer units to focus on bridging, force protection construction, and mine clearance.

The urgent need for base camp development required combat engineer leaders to become heavily involved in sustainment engineering. Combat engineer battalion commanders and their staffs were actively involved in selecting base camp sites.[74] The immediate need for base camps also required combat engineers to join the construction effort. Unfortunately, the U.S. Army's current divisional engineer battalions are not equipped nor trained in heavy construction. However, when augmented by LOGCAP contractors and construction engineering detachments, aggressive divisional engineer battalions successfully joined the immense base camp construction program. As an example, the 40th Engineer Battalion, 1st Armor Division built two of the 2nd Brigade's base camps using Force Provider (a containerized, modular, rapidly constructed base camp) housing modules.[75]

Divisional battalions, by design, can attempt only rudimentary combat construction work. Their equipment includes the M9 ACE, a light armored earth mover, and the SEE, a light excavator, as well as some squads and platoon carpentry and pioneer tool kits. However, when augmented with construction equipment or assigned to build prepackaged base camp modules, the divisional battalions have adequate construction capability. The 23rd Engineer Battalion, 1st Armored Division exemplified this capability in rebuilding the railroad from Tuzla, Bosnia north to the Sava River, to include a railway bridge.[76] Not since World War II have divisional engineer battalions built railroads.

Examination of Adequacy

Several engineer related trends are evident from Operation Joint Endeavor. First, it appears that a heavy division requires the support of at least one float bridge and two fixed bridge companies in deployments to temperate areas with extensive hydrology. Secondly, the division requires at least a construction battalion to fix or build infrastructure (roads and bridges). Construction and bridging units are not normally organic to the division. In the case of Operation Joint Endeavor, four construction battalion equivalents and four separate bridge companies reinforced the 1st Armored Division.

Thirdly, a division-level organization is vital to control and direct these additional forces. The presence of a division engineer brigade headquarters enabled effective command and control of seven battalion sized elements and six separate companies in Bosnia. This represents over four times the typical engineer support for a division in Vietnam. 11th ACR, at best, had precarious engineer command and control when supported by more than the 27th Engineers. The 1st Armored Division engineer command and control apparatus in Bosnia was a more responsive, efficient, and effective support than that available or the 11th ACR in Vietnam.

Finally, effective countermine operations are critical in stability operations. Countermine operations in Bosnia are much improved greatly over Vietnam. U.S. forces faced more mines in Bosnia than in Vietnam, but were affected less by this weapon. Unlike in Vietnam, mine rollers worked well in Bosnia in proofing roads ahead of convoy traffic. The countermine systems available to the 1st Armored Division represented a marked improvement over 11th ACR's use of "thunder runs" in Vietnam.

Stability Operations Conclusions

Stability operations require extensive engineer support. The previous two case studies highlight engineer support requirements for armored forces in two divergent situations. The 11th ACR, in Vietnam, fought an elusive enemy over terrain characterized by excessive hydrology and primitive infrastructure. The 11th ACR also contended with the extensive use of mines by the Viet Cong to attack their lines of communications. Its engineer support matured from one engineer company in 1965 to over a battalion by 1968. In contrast, the 1st Armored Division deployed to Bosnia supported by a robust engineer organization built around the divisional engineer brigade. Though the division did not face an enemy mine warfare program, it did enter a heavily mined area of operations with similar terrain and infrastructure.

Both case studies, indicate that one engineer battalion per brigade-size maneuver element provides adequate combat engineer support. Both case studies also indicate that each company/team-size element requires the support of, at least, one AVLB and one mine roller. This equipment allocation supports independent company level operations. The current engineer brigade organization provides this level of support.

The division support base requires the support of an additional two to three battalions of construction engineers to repair infrastructure and build base camps. Additionally, both case studies indicate that divisional or regimental combat engineers retain a modicum of proficiency in construction planning and execution.

Effective command and control this contingent of engineers requires a robust, division level command and control system. Major Goetz states it best: "the benefits of having an engineer brigade commander and staff at division level, and battalion commanders and staffs supporting maneuver brigades cannot be overemphasized." He goes on to state that "the ability... to receive diverse engineer units and to synchronize their efforts...is a force multiplier that cannot be replaced by an ad hoc or nonorganic headquarters."[77] Given the complexity and diversity of the engineer operations, an adaptive and robust engineer brigade command and control structure is vital to the success of the operation.

Section III. High Intensity Operations

As mentioned in the introduction, U.S. Army forces must prepare to fight and win the nation's higher intensity, theater-level wars. The following two case studies examine the nature of engineer operations in high intensity operations. Specifically, these case studies focus on operations in Europe during World War II, and in Southwest Asia (SWA) during Operation Desert Storm. As in the two previous examples, the monograph judges heavy divisional engineer support organizations based on their capacity to tactical bridge, clear mines and obstacles, construct and repair infrastructure, and command and control allocated engineers.

High Intensity Operations Case Study - World War II

This monograph section examines engineer support in the European Theater of Operations (ETO). World War II also marked the largest engineer force ever fielded. Over 600,000 soldiers swelled the Corps of Engineers to record numbers between 1939 and 1945. Armored division engineers, augmented by corps and army engineers, supported World War II fast moving "tankers." World War II validated "that the organic armored engineer... [facilitated] maneuver to the point... [of] action".[78]

Engineer Support Operations

Armored engineers counter terrain and the enemy's modification of that terrain. World War II engineers faced the same challenges presented in Vietnam and Bosnia: severely restricted terrain, extensive hydrology, war torn infrastructure, and serious mine threats. As such, in armored "divisions, the inability of armored vehicles to negotiate weak bridges, obstacles, and mine fields placed increasing emphasis on the tactical role of the organic engineer units."[79]

Divisional armored engineer battalions were organized with four combat engineer companies and a treadway bridge company. This organization supported a division of two tank regiments and one mechanized infantry regiment. Most World War II armored divisions internally reorganized into three combat commands; CCA, CCB, and CCR (Reserve). As an example of typical divisional engineer support, from 4-8 August 1944, the 17th Armored Engineers, 2d Armored Division had Companies A and B with CCA and CCB respectively, Company D attached to the 82d Reconnaissance Battalion, and Company C under division control.[80] However, "the division engineer battalions did not have the strength and equipment to meet all requirements of their divisions... ."[81]

As in the two previous case studies, World War II engineers faced extensive enemy mine threats. Enemy "mine [warfare] caused considerable problems...the war ended with the engineers still relying on the one method of mine sweeping used from the start: a sharp eyed veteran probing with a bayonet... ."[82] This same technique continues in use today. The only significant change is the use of fiberglass rods instead of bayonets.

The Germans extensively mined and booby-trapped during World War II. In Italy particularly, the Germans constructed a series of thick defensive belts along the length of the Italian Peninsula.[83] As the Allied forces attacked north, they ran into increasingly dense minefields, road craters, and elaborate German defenses. World War II mine clearing was a slow, meticulous process requiring many men and involving great risks. For example, the 10th Engineer Battalion, 3d Infantry Division "suffered fifty-seven casualties... in clearing 20,000 mines... during a period of sixteen days."[84] Similarly, the 16th Engineers cleared mines from over 900 miles of road for the 1st Armored Division.[85] Unfortunately, none of the many mine clearing expedients tested during World War II proved effective. Consequently armored and infantry division attacks frequently moved at the speed of their dismounted engineer mine clearing teams.[86]

Similarly, rivers and destroyed roads or bridges regularly stopped attacks. Engineer battalions, at all echelons, built bridges to cross streams, rivers, road craters and destroyed culverts. In Italy, for example, engineers constructed over 3000 Bailey Bridges in a twenty month period.[87] The speed of bridge construction frequently determined the tempo of allied operations.[88]

During the Italian campaign engineers developed a standard operating procedure to maximize engineer work and force mobility. Divisional engineers expediently crossed streams. Corps engineers followed, replacing expedient fills and bypasses with culverts and Bailey Bridges. Finally, Army engineers replaced temporary crossing expedients with permanent fixed bridging.[89]

France and Germany offered similar gap crossing challenges. Multiple streams, rivers, and gaps traverse both countries necessitating many military crossings. For example, VII Corps constructed over 200 bridges between 6 June 1944 and VE-Day. The Corps' tanks required that over 80% be heavy Class 40 bridges, a significant achievement since the Germans destroyed most bridges and culverts during their withdrawal.[90] XIX Corps engineers built 262 bridges during the same time period.[91] These were only two corps' requirements for bridging; indeed sustained combat operations in Europe required massive amounts of bridging. Except for North Africa, all sub-theaters in the ETO required frequent major river crossings.

The Ninth Army planned extensively for the Rhine River crossing and considered detailed river characteristics, photo intelligence, and flood prognostication (including data back to 1812) in deciding on the crossing area and in determining the required engineer effort. Ninth Army planned to cross with two corps, each with two assaulting battalions.[92] The Ninth Army engineer's plan called for building two Class 40 bridges and one Class 25 bridge in each division sector. The construction of one semi-permanent, two way Class 40 bridge and a one way class 70 pile bridge would follow the construction of assault bridges.

One corps with five battalions actually assaulted across the Rhine. In the process, engineers constructed seven Class 40 float bridges and two 25-ton ponton bridges to support the assault; they also constructed follow-on fixed bridging as planned.[93] Between 26 March and 23 April 1945, the Ninth Army engineers crossed approximately two and a half million vehicles over the Rhine on seven bridges supporting two divisions. By the third day of the assault, over 185,000 vehicles a day crossed these bridges.

The Rhine River crossing was the largest river crossing undertaken by U.S. engineers during World War II. In preparation to cross the Rhine, the assaulting divisions and their supporting engineers left the line and conducted river crossing training and rehearsal. The 1153d and the 1148th Engineer Combat Groups joined the 30th and the 79th Infantry Divisions, respectively, to train for the assault crossing.[94] Two key points should be noted: a brigade-sized engineer element was task organized to a division; and second, the divisions and their engineer groups were pulled from the line in order to train and rehearse the crossing together.

Even short, dry gaps impeded movement. It took a trained squad eleven minutes to emplace a 36-foot span, and only if the bridging was already on site, in order to allow tanks to continue their advance.[95] "Bridging, from a major tactical standpoint, completely predominated all other armored engineer missions during the [Central Europe exploitation] campaign."[96]

Engineers also built the infrastructure required for sustainment purposes. High intensity combat in Europe did not require the extensive base camp facilities required for Bosnia or Vietnam; however, Army level engineers did significant construction and facilities renovation, particularly of ports. Division and corps level combat engineers primarily constructed and maintained roads and nonstandard timber bridges.[97] Main supply route construction "determined in major part the utilization of engineer troops."[98] Major General C. R. Moore, Chief Engineer, European Theater of Operations, recommended the allocation of three engineer construction battalions to support each three division corps (or one per committed division).[99] A Fort Knox study of ETO armored engineers confirmed that the task of road repair and construction never ended.[100]

The most significant engineer issue during World War II was the command and control of large numbers of engineers supporting each division. Three corps engineer organizations alleviated inadequate divisional engineer structure. A corps combat engineer regiment (or engineer group) directly reinforced each division with combat engineers. A general service engineer regiment built combat support bridging, maintained roads and railroads, and provided general engineer support for corps sustainment operations. Finally, a corps ponton bridge company maintained a pool of bridging equipment and boats for assault crossings.[101]

Examination of Adequacy

As mentioned earlier, an engineer battalion adequately supports each brigade, and each committed division requires at least an additional two engineer battalions and two bridge companies to enjoy a modicum of mobility. In World War II "each attacking division had a corps engineer regiment in support."[102] Each attacking regiment typically received an engineer battalion in support. The 299th Engineer Battalion's support to the 16th Infantry Regiment during the Normandy Invasion exemplifies this.[103] Engineer companies also frequently supported infantry and armor battalions. As the war progressed the engineers became the largest single divisional slice component.[104]

The divisional engineer battalion, as mentioned earlier, could not adequately provide this level of support. This created a command and control dilemma. MG Moore observed, "the staff prescribed by the present T/O is inadequate."[105] He recommended fielding a corps engineer brigade commanded by a general officer (07). During World War II, the Corps Engineer was a staff officer without formal command authority. Though he informally led and controlled all engineers in sector, he was neither organized nor formally given command to perform the task adequately, a shortcoming rectified by the formation of the corps engineer brigade.

Similar command and control problems occurred when engineer groups directly supported divisions. The supporting engineer organizations were frequently commanded by higher ranking officers with staffs more robust than the division engineer staffs. The command and control structure of the division engineer became severely strained and just could not adequately integrate supporting army and corps-level engineers. This led MG Moore to recommend, consistent with his corps level recommendation, that divisions needed a engineer regimental structure in order to exercise adequate divisional engineer command and control.[106]

The organic divisional engineer structure inadequately provided this level of command and control, necessitating corps-level headquarters augmentation. Though not desirable, this ad hoc C2 organization proved adequate. Finally, MG Moore suggested that the regimental organization probably supported the division better than the divisional battalion and corps engineer group combination.[107] His suggested World War II organization bears a striking resemblance to the current divisional engineer brigade structure.

High Intensity Operations Case Study - Operation Desert Storm

Operation Desert Storm is the U.S. Army's latest experience in large scale armored warfare. Three U.S. armored divisions, two mechanized infantry divisions, and two armored cavalry regiments fought in the Gulf War. Supporting these organizations were two corps engineer brigades and three "provisional" divisional engineer brigades. The Gulf War saw the reintroduction of a division-level, brigade-size, engineer headquarters.

Engineer Support Operations

Bridging and base camp construction were not priority missions for the deploying engineers because of the area's open topography and pre-established facilities. Saudi

Arabia, Iraq, and Kuwait offered few of the natural water obstacles associated with operations in Vietnam, Bosnia, or World War II Europe. The Euphrates River was the only significant river in the entire theater. Also, due to over forty years of military construction, the Saudi Arabian infrastructure more than adequately supported deploying U.S. units.[108] Bridge units down loaded their bridges and augmented the logistical transportation system because of the limited bridging requirement.

Similarly, many AVLBs downloaded their bridges in order to carry the Mine Clearing Line Charge (MICLIC). Called AVLMs, the AVLBs with MICLICs were great field expedients in overcoming the MICLIC trailer's limited cross-country mobility. The 1st and 2d Marine Divisions used MICLICs to breach minefield lanes into Kuwait. However, the Army did not extensively use MICLICs during the war.

Ten combat heavy battalions built roads and trails throughout the theater significantly augmenting the existing road system.[109] These additional roads enabled the enormous logistical effort required by the heavily armored force. Both VII and XVIII Corps attacked through the roughest and most underdeveloped parts of Iraq where the existing road system was practically nonexistent. Engineer construction units built the MSRs for both corps' sustainment efforts.[110]

As in the other case studies, mines posed a significant threat. The Iraqi border defenses posed the most significant engineer problem of Desert Storm. Norman Friedman, in *Certain Victory*, considered the Iraqi combat engineers experienced and generally highly rated.[111] They constructed a complex network of defensive positions, minefields, fire trenches, and anti-tank obstacles representing one of the most densely mined defenses since World War II.[112]

The U.S. Army fielded provisional engineer headquarters to breach this complex obstacle system. The 1st Infantry Division deployed to Southwest Asia (SWA) with its organic divisional engineer battalion and as part of the U.S. VII Corps. As VII Corps' primary breach force, the "Big Red One" was allocated three corps combat engineer battalions commanded by a provisional engineer brigade. This concept was known at the time as E-Force, for Engineer Force.

The VII Corps used the E-Force concept with all of its divisions in Southwest Asia.[113] The VII Corps tested E-Force during REFORGER 90 and it preceded the Engineer Restructuring Initiative (ERI). E-Force placed a division level engineer brigade structure with an engineer battalion in direct support of each maneuver brigade. Provisional engineer brigades saw service in the Gulf War with the 1st Infantry, 1st Armored, and 3rd Armored Divisions.

Examination of Adequacy

The Desert Storm provisional engineer brigade negated the need for an ad hoc command and control organization. The provisional engineer brigade provided a flexible and adaptable engineer command and control component for the division. The wartime S3 of the 16th Engineer Battalion offered that the new engineer brigade concept, "...really works. No other reasonable force structure could place sufficient combat engineers, properly armed and equipped, on the battlefield to support heavy mechanized or armored divisions."[114]

The provisional engineer brigade proved to be a significant innovation and was key to the 1st Infantry Division's successful breach. Correspondingly, new specialized engineer equipment made the task of breaching quicker and more efficient. The armored combat earthmover (ACE) and track-width, tank-mounted, mine plow collapsed Iraqi trenches and cleared lanes through minefields.[115] These new systems were fielded just prior to Operation Desert Storm.

The M9 ACE furnished an armored earthmover capable of advancing with tanks. Leading the breaching effort, 1st Infantry Division ACEs cut twenty lanes through the Iraqi border anti-tank berm.[116] The ACE proved instrumental in trench clearing by burying enemy soldiers continuing to fight from their trenches.[117] This saved the division from a costly, dismounted trench battle and preserved the 1st Infantry Divisions' tempo. The 1st Armored Division's senior leaders were amazed with the ACEs versatility.[118] Another report stated that, "...the ACE quickly and effectively performed its missions".[119]

The track width mine plow enabled maneuver forces to rapidly breach on the move. The sandy soil and relatively flat terrain offered ideal ground for tank plows. The "Tiger" Brigade, (1st Brigade 2d Armored Division) used their mine plows to widen lanes breached by 2nd Marine Division MICLICs.[120] The tank plow provided Desert Storm heavy divisions an effective counter to enemy mines. The *Conduct of the Persian Gulf War, The Final Report to Congress* states that, "the [mine plow]... was an effective tool, creating easily visible lanes for follow-on forces."[121]

Most importantly, Operation Desert Storm introduced a major change to the divisional-level engineer organization. A study done just prior the war "concluded that combat engineer support in divisions ought to be increased by over 200%."[122] The 1st Infantry Division's wartime allocation of five engineer battalions (four combat, one construction) demonstrates the validity of this study. The provisional engineer brigade demonstrated the ability to command and control a force of this size across the breadth of the battlefield.[123]

High Intensity Operations Conclusions

War against similarly armed and equipped foes represents the most hazardous scenario the U.S. Army faces in the future. The previous two case studies emphasize several key capabilities that armored engineers need on the high intensity battlefield. In World War II, fledgling armored divisions attacked across Europe in pursuit of the German Army. However these divisions frequently had to stop before enemy minefields, destroyed roads, blown bridges, and natural terrain obstacles.

The divisional engineer structure in World War II did not adequately support fast-paced armored operations. Therefore, engineer groups of two to three battalions normally augmented divisions. The divisional battalion and engineer group configuration proved adequate but not optimal. Several command and control concerns arose from this configuration. The removal of divisional engineer regiments (prior to the war) left divisions with inadequate engineer support as well as the inability to command and control multiple engineer battalions. Engineer groups were fielded in an attempt to fill that void.

As mentioned in an earlier example, the 30th and the 79th Infantry Divisions were each allocated an engineer group for crossing the Rhine.[124] In World War II, a brigade-size engineer organization clearly provided adequate support to an armored division. Interestingly, MG Moore, the theater engineer, concluded the same thing. He opined that the organic engineer regiments better supported divisions and were preferable to the battalion and group combination.[125] He goes on to recommend a division allocation of four combat engineer battalions and one construction battalion.

Bridging was the hallmark of the engineers in World War II. The war saw the development of the Bailey Bridge as well as other dependable bridging systems. These spans were a necessity for rapidly moving armored forces, particularly in Italy. The fast moving armored divisions' logistical traffic also depended on engineer emplaced bridging. Thousands of bridges were built in Europe. However, the force had no rapidly emplaced bridging. No AVLB equivalent existed allowing rapid crossing of small gaps and streams. Though a recommendation for a tank based bridge was made toward the end of the war, none was fielded until the early 1960s.

Operation Desert Storm saw improvements in all of the areas discussed above. The engineers received the MICLIC and full-width mine rakes for the Combat Engineer Vehicle (CEV). Fielded in Vietnam, the CEV "mounting the... [full width mine rake] provided the only full-width breaching capability for the US Army."[126] Both proved effective during the Gulf War.

More importantly, the Gulf War reintroduced the provisional engineer regiments. Now called engineer brigades, these units performed admirably during the war and became the model for the present day divisional engineer brigades. The Engineer Restructuring Initiative grew directly from the experience in the Gulf War. It marked the first organic, brigade-size, engineer organization, in a division, since 1935. The divisional engineer brigade solved the command and control problems faced by the engineers in both World War II and Vietnam, particularly those brought about by ad hoc, temporary headquarters. A U.S. Army Engineer School complex breach computer simulation demonstrated, as well, that the divisional engineer brigade "gives the division more command and control over its organic engineers and other allocated engineers from corps."[127]

Section IV. Evaluation of Force XXI Designs

As mentioned in this monograph's introduction, the National Security Strategy directs the U.S. Army to prepare for both high intensity war and stability operations. Since the American Revolution, the U.S. Army has fought in four total wars, six limited wars, thirteen contingency operations, and over twenty "other" military operations.[128] Clearly, engagements, other than total war, are most likely for U.S. Forces; but paradoxically, the Army must vigilantly prepare to fight at the high end of the conflict spectrum.

Criteria

Each case study offers engineer support lessons for heavy forces. Several themes run through all four case studies. All indicated the need for tactical bridging, rapid and effective countermine capability, and combat construction. All case studies also indicated that "adequate" engineer support for a heavy division normally equates to three or more engineer battalions under a division level brigade structure. These case study lessons form the basis for the analysis criteria.

Tactical Bridging

Force XXI operations forecast decentralized maneuver capitalizing on increased situational awareness. Decentralized maneuver requires rapidly emplaced tactical bridging at the lowest possible echelon. All four case studies indicated a need for robust tactical bridging. Clearly, decentralized maneuver requires at least one AVLB per company-size element. Therefore, the ability to rapidly overcome short gaps, and streams with one AVLB-type vehicle per maneuver team provides the first analysis criterion.

Fixed and Float Bridging

With the exception of the Gulf War, all of the case studies indicate a requirement for rapidly emplaced float bridging. The 600 meter float bridge across the Sava River, during Operation Joint Endeavor, demonstrates the continuing requirement to cross large rivers with heavy divisions. The Ninth Army's crossing of the Rhine River during World War II highlighted the same requirement.

Logistical traffic requires fixed bridging to span gaps in the corps and division area until the construction of more permanent bridges. Fixed bridge construction relieves AVLBs for continued use further forward. During World War II and Vietnam, the Bailey Bridge alone filled this role. Currently, the MGB and the aging Bailey Bridge fill this role. In Bosnia, both bridges were used, though a modern, commercial version of the Bailey Bridge has since replaced the MGB.

The case studies indicate clearly that at least one bridge company supported each division. In the future, bridging units from corps will augment heavy divisions. Therefore, the second criterion analyzes the divisions ability to integrate, command and control additional corps bridge units.

Countermine/Breaching Capability

Doctrinally, when attacking through obstacles, every battalion/task force requires two breach lanes. To ensure these two lanes, the breach force must be capable of establishing three lanes; it must have at least 50% redundancy in breach assets. In stability operations, division engineers clear routes of mines rather than breach lanes through obstacles; nonetheless, they require both capabilities. Military traffic requires mine free routes and properly maintained roads to sustain tempo.

World War II dismounted engineers manually cleared routes of mines and frequently set their division's tempo. In Vietnam, dangerous "thunder runs" rapidly cleared routes, at the expense of many casualties and lost equipment. The Gulf War introduced tank plows and rollers, MICLICs, and CEV mine rakes. These four systems enabled rapid breaching of the extensive Iraqi minefields without substantial loss of momentum. Accordingly, the third analysis criterion examines the capability to rapidly clear routes of mines and provide two complex-obstacle breach lanes per divisional task force.

Combat Construction

Each case study demonstrated the need for some level of construction capability. Construction requirements included maintenance and construction of base camps and roads. In Bosnia, the 1st Armored Division received support from three construction battalions. In Vietnam, the 11th ACR received general construction and combat engineer support from one. These engineer battalions built and maintained both the heavy units' facilities and MSRs. Each World War II division received road and bridge construction support from both its supporting engineer battalions, both divisional and corps. All World War II engineer battalions could build and maintain roads. Each attacking heavy division in Desert Storm was supported by at least two corps combat battalions and one combat heavy (construction) battalion. Construction troops typically are corps or army assets, hence the fourth analysis criterion examines the division's ability to integrate, command and control corps or other echelon construction units.

Division Level Engineer Command and Control

A heavy division requires a substantial amount of engineer support. The Gulf War demonstrated that an engineer company supported each task force, and an engineer battalion supported each brigade. Furthermore, divisions typically required the additional support of at least one, if not three or more, engineer battalions. This level of support mirrors that required during World War II, Vietnam, and Bosnia.

The large number of engineers required to support heavy divisions generate the need for a corresponding division level command and control structure. The spares and ad hoc Vietnam and World War II command and control organizations proved inflexible and, at times, constraining. Post-World War II recommendations indicate that an "engineer regiment" is the optimal division level command and control organization. In Operation Desert Storm, provisional engineer brigades supported the VII Corps' divisions and validated post-World War II recommendations. Operation Joint Endeavor further demonstrated the desirability of a regimental/brigade level engineer headquarters.

The 1st Armored Division's engineer brigade commanded three combat engineer battalions, one Army construction battalion, one Air Force construction squadron, one Navy construction battalion, and five separate engineer companies. It is not surprising that General (Ret.) Cavazos, the Senior Observer for the Battle Command Training Program, stated that "the single greatest improvement in the heavy division in the past ten years has been the addition of an Engineer Brigade."[129] Consequently, the final analysis criterion examines the division's engineer headquarters and its capability to command and control both organic and augmenting engineer units.

Figure One highlights the historical engineer support requirements.

	Vietnam	World War II	Gulf War	Bosnia
Adequate tactical bridging capability	No 2 AVLBs per tank bn.	No No tactical bridging	Yes 36 AVLBs per division	Yes 64 AVLBs
Integrate corps bridging units	Yes ad hoc Eng. HQ	Yes ad hoc Eng. HQ	Yes Adequate command and control	Yes Adequate command and control
Adequate countermine capability	No "thunder runs"	No dismounted	Yes plows, rollers, MICLICs, Eng. Co. per TF	Yes plows, rollers, MICLICs, Panthers, Eng. Co. per TF
Integrate construction units	Yes ad hoc Eng. HQ	Yes ad hoc Eng. HQ	Yes Adequate command and control	Yes Adequate command and control
Adequate engineer command and control headquarters	No ad hoc	No ad hoc	Yes	Yes

Figure One. Historical Engineer Support Requirements

Force XXI Engineer Designs

Two divisional engineer designs have been proposed for the Force XXI Division. Both designs attempt to provide adequate engineer support to the future division while reducing the engineer force structure. Both designs incorporate the same engineer battalion organization.

The Force XXI division has two primary designs. One is more traditionally designed with three maneuver brigades, division artillery, division support command, aviation brigade, and an engineer group. The engineer group has two assigned engineer battalions of three companies each. For the purpose of this discussion, Design One refers to this engineer group (See page 54).

The second Force XXI division design is based upon three combined arms brigades, division artillery, and an aviation brigade. In this design, there is no division level engineer headquarters and the engineer battalions are assigned to the combined arms brigades. Design Two refers to this combined arms brigade design format (See page 55).

The Force XXI Engineer Company

Both designs share a common engineer company design (See page 57). The Force XII engineer company organization includes a company headquarters, two obstacles reduction platoons and one assault platoon (See page 58). All three platoons can create one lane through a complex obstacle. The "reduction" platoons breach minefields with M1 tank-based breachers, cross small gaps with M1 tank-based Heavy Assault Bridges (HABs), and maintain routes with M9 ACEs; they each have one combat engineer squad mounted in Bradley Engineer Squad Vehicles (BESV). The company's third platoon, the "assault" platoon conducts actions on the objective and reinforces the reduction platoons. The assault platoon fields an additional combat engineer squad and an additional HAB and ACE. The assault platoon breaches minefields with MICLICs instead of M1 breachers and conducts route mine clearance with two Panthers (robotic roller tanks).

Each engineer company, by design, supports a tank or mechanized task force. Based on the criteria established in the case studies, this company can provide a HAB per maneuver company, plus an additional HAB, for redundancy. The company can do minor road repair for the task force, though this involves only filling holes and building hasty by-passes.

Each company can breach the doctrinally required two lanes per TF per complex obstacle. There are two Panther robotic mine clearers, and two MICLICs per company. These systems allow the engineer company to clear MSRs of mines and reinforce minefield breaching operations quickly, safely, and effectively. With tank plows and rollers complementing breaching capability, the Force XXI engineer company clearly meets the criteria for adequate engineer support for the armored or mechanized task force.

Design One

Design One has a division-level engineer command and control organization commanded by an engineer colonel. The engineer group design has two subordinate engineer battalions. Design One fields six engineer companies.

Bridging

Design One fields twenty-four HABs. The HAB is capable of spanning twenty-four meter gaps in five minutes while traveling at comparable speeds to the divisions' tanks. Criteria One calls for the one AVLB type vehicle per company/team-sized element. Design One's parent division fields thirty company-sized maneuver units (three recon, nine mechanized, and nine armor companies). Design One fields an inadequate number of HABs to support decentralized company level operations.

Design One does not have an organic bridge company. The corps Multi-Role Bridge Company (MRBC) replaces both assault float and fixed bridge companies and is capable of emplacing both types of bridging. Design One, with its divisional engineer headquarters, can easily integrate and synchronize augmenting bridge companies into division operations. It is clearly an adequate design in terms of criterion two.

Countermine/Breaching Operations

Design One has twenty-four breachers and twelve MICLICs. This gives it the capability to create twenty-four lanes (with 50% redundancy) though a complex obstacle. In other words, Design One can technically support twelve simultaneously breaching battalion task forces. The division fields nine battalion task forces. Based strictly on equipment numbers, Design One is adequate.

Design One fields twelve Panthers. This gives it the capability to "sweep" six MSRs or other routes for mines. Robotic Panthers provide each support battalion with mine clearance sweeps on two routes moving at convoy speeds. This capability nominally supports division operations.

However, six engineer companies only effectively (and doctrinally) support six task force breaches. Breaching on a broad front requires Design One engineer companies to split apart their platoons to create the minimum two lanes per task force. Neither current engineer doctrine nor Design One's organization support this paradigm. Nonetheless, few divisions simultaneously attack with all their available battalions. Consequently, Design One marginally supports division offensive maneuver but only if at least three battalion task forces are held in reserve or committed without engineers.

Division Engineer Command and Control Capability

As mentioned earlier, divisions typically receive support from augmenting corps engineer battalions. Design Ones' divisional group headquarters can effectively integrate both augmenting construction and combat engineer units into the division. This capability ameliorates its organizational shortfalls. Integration of just one corps combat engineer battalion places engineer companies with every battalion task force in the division. Design One is clearly adequate in its ability to integrate and command and control augmenting construction, bridge and combat engineer units.

Design Two

Design Two has three separate engineer battalions, one assigned to each combined arms brigade. Design Two has no division-level command and control organization but has a reinforced division-level engineer staff led by a lieutenant colonel. In Design Two the Division Engineer has no command authority over the divisional engineers. Design Two fields nine engineer companies.

Bridging

Design Two fields thirty-six HABs. Design Two's parent division also fields thirty company-sized maneuver units. Design Two supports decentralized company level operations with tactical bridging, while providing six additional HABs to support other bridging requirements. Like Design One, Design Two does not have an organic bridge company. Design Two, without a divisional engineer headquarters, must either task organize the MRBC under one of the three engineer battalions, or receive additional engineer headquarters augmentation from corps. Design Two adequately supports tactical bridging, but is not adequately designed to plan or synchronize division-level river crossing operations.

Countermine/Breaching Operations

Design Two has thirty-six breachers and eighteen MICLICs. It can create thirty-six lanes (with 50% redundancy) though complex obstacles. Design Two supports eighteen simultaneously breaching battalion task forces. The division fields nine battalion task forces. Again, based strictly on equipment, Design Two is adequate.

Design Two fields eighteen Panthers. It has the capability to "sweep" nine routes for mines or three routes per support battalion. This capability adequately supports division sustainment operations with one mine swept route per divisional task force.

Nine engineer companies support nine task force breaches. Design Two allocates a divisional engineer company to each divisional task force. Design Two does not require companies to split engineer platoons in order to adequately breach two lanes per task force. As a result, Design Two adequately supports division offensive maneuver across a broad and decentralized front.

Division Engineer Command and Control Capability

Design Two, without a divisional engineer headquarters, cannot effectively integrate any additional engineer battalions. Each combined arms brigade controls five battalions (including the assigned engineer battalion) and five specialized companies. A doctrinal "rule of thumb" states a headquarters can effectively command and control three to five subordinate elements. The combined arms brigade, under this design, commands and controls ten. Allocating additional engineer battalions or MRBCs to this organization would only further deteriorate its overloaded command and control. The historical case studies indicate these situations lead to the formation of ad hoc command and control headquarters.

Design Two cannot effectively integrate augmenting construction, bridge and combat engineer units. In order to effectively control additional allocated engineer units, Design Two requires either an additional engineer headquarters or creation of an ad hoc engineer headquarters. Design Two clearly is inadequate in its ability to integrate and command and control augmenting engineer units.

Comparison of Designs

Bridging

Design Two better supports the Force XXI division with tactical bridging support. Design One does not field enough HABs to support decentralized company team operations. However, Design one easily accepts augmenting brigade companies as well as additional engineer battalions (with their own HABs).

The Multi-Role Bridge Company provides LOC and assault float bridging to both designs. Design One facilitates division control of the MRBC. Design Two does not. Design Two reduces division river crossing flexibility necessitating allocation of an additional engineer headquarters to conduct major river crossings. Design One clearly can conduct division level river crossing without corps headquarters augmentation.

Though Design Two has a quantitative advantage, Design One has a qualitative advantage primarily because of the division engineer headquarters. Design One better supports the division bridging because of its superior command and control capability and its ability to execute major river crossings with minimal augmentation.

Countermine/Breaching Operations

Again Design Two, quantitatively better supports division countermine operation. It supports all of the division's task forces with engineer companies where Design One only supports six of nine. Design One quantitatively creates the required number of lanes and provides the minimum number of mine cleared MSRs. However, Design One must break apart platoons to achieve an adequate number of lanes. Design Two is qualitatively and quantitatively the more adequate design.

Division Engineer Command and Control Capability

Design One is clearly more flexible from a division level command and control perspective. The historical case studies point to the fact that corps engineers routinely reinforce divisions. Design One's division level command and control capability adequately accepts reinforcement under a single headquarters. The Division Engineer in Design One is the engineer commander. Therefore, he allocates engineers based on the division's plan.

Design Two provides maximum flexibility at brigade level. The division engineer is NOT a commander in this case. He may recommend where engineers go in the division, but not formally task them. Also, without the division-level engineer headquarters, no single agency commands and controls reinforcing engineers. From a command and control perspective, Design One is superior.

Neither design adequately does heavy construction and both require construction augmentation. All four case studies showed that construction battalions augmented divisions. Design One's divisional engineer headquarters better integrates and synchronizes reinforcing construction (and other type) battalions.

Overall, Design One offers a qualitative advantage over Design Two because of its superior ability to command and control additional engineer units and expand based on mission requirements. Design Two offers quantitative advantages in tactical bridging, countermine, and engineer company headquarters. Neither design is fully adequate when judged by all criteria.

Section V. Conclusions

Recommendation

A design recommendation is offered below. Design Three (See page 58) offers both qualitative and quantitative adequacy. Design Three fields three engineer battalions of three companies each, organized along similar lines as the ERI engineer brigade, a proven winner. However, Design Three uses the Force XXI engineer company design. Design Three provides the tactical capability of Design Two and the expandability and superior command and control of Design One.

Design Three's engineer troop strength is 952 soldiers. This compares to the 1366 soldiers in the ERI brigade and the 3135 soldiers in the Desert Storm provisional brigade. Design Three adequately provides the required tactical bridging and easily integrates the MRBC, strong points of the other designs. Design Three has the same countermine/breaching capability as Design Two, but the capability to integrate additional supporting engineer units, the strongest point of Design One.

Figure Two compares the two Force XXI designs with the recommended design.

	Design One	Design Two	Design Three
Adequate tactical bridging capability	No 24 HABs-30 co/tms	Yes 36 HABs-30 co/tms	Yes 36 HABs-30 co/tms
Integrate corps bridging units	Yes Adequate command and control	No Inadequate command and control	Yes Adequate command and control
Adequate countermine capability	No 12 (2 lane) breaches for 9 TFs 6 Co. HQs limits numbers of	Yes 18(2 lane) breaches for 9 TFs 9 Co. HQs allow one Engineer Co.	Yes 18(2 lane) breaches for 9 TFs 9 Co. HQs allow

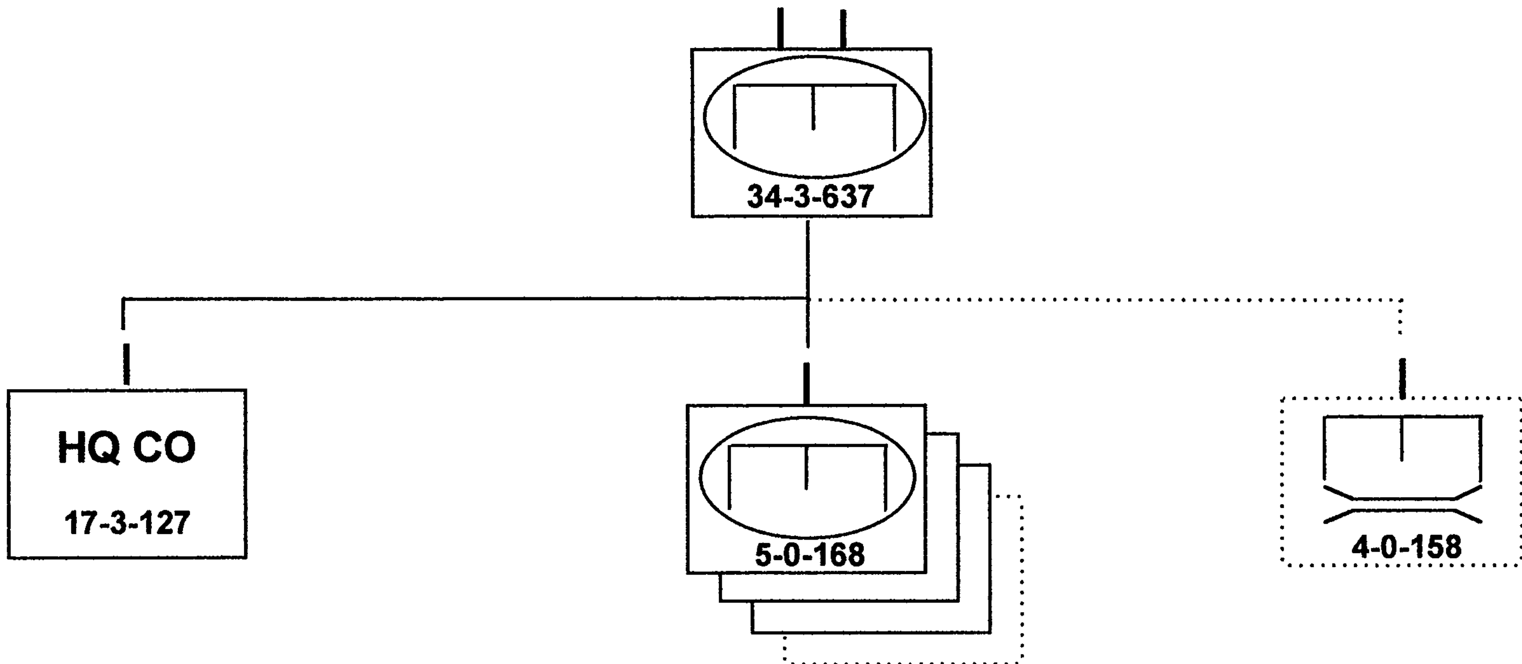
	breaches without breaking apart plt.	per TF	one Engineer Co. per TF
Integrate construction units	Yes Adequate command and control	No Inadequate command and control	Yes Adequate command and control
Adequate engineer command and control headquarters	Yes Divisional Eng. Grp.	No No Divisional Eng. HQ	Yes Divisional Eng. HQ

Figure Two. Engineer Support for the heavy task force

Force XXI operations envisage high operational tempo and decentralized operations. In short wars, such as the Gulf War, Design Two might adequately support the division. However, Designs One and Three provide the most division-level flexibility. Design Three combines the best points of the other two designs. The flexibility offered through a division level engineer headquarters can not be underestimated. The major complaint about engineer force structure from the Vietnam and World War II case studies stemmed from the lack of an adequate engineer command and control structure. The provisional engineer brigade of Desert Storm and the present day ERI brigade of Bosnia clearly demonstrate this vital capability. In both the latter cases, engineers easily moved around the division and in and out of the division based on support requirements. Design Two does not provide this critical capability.

Bosnia and Vietnam illustrate the most likely type U.S. Army operations. High and mid-intensity conflict exemplified by World War II and the Gulf War are the least likely. However, Design Three suits both division-level stability operations and theater level war.

Divisional Armored Engineer Battalion 1944



Major Functions:
- Support Combat Command operations
- Plan Engineer Support Operations
- Reduce Obstacles
- Engineer Actions on the Objective
- Emplace Obstacles
- Support 3 Regimental Combat Teams
- Integrate Additional Assets As Needed

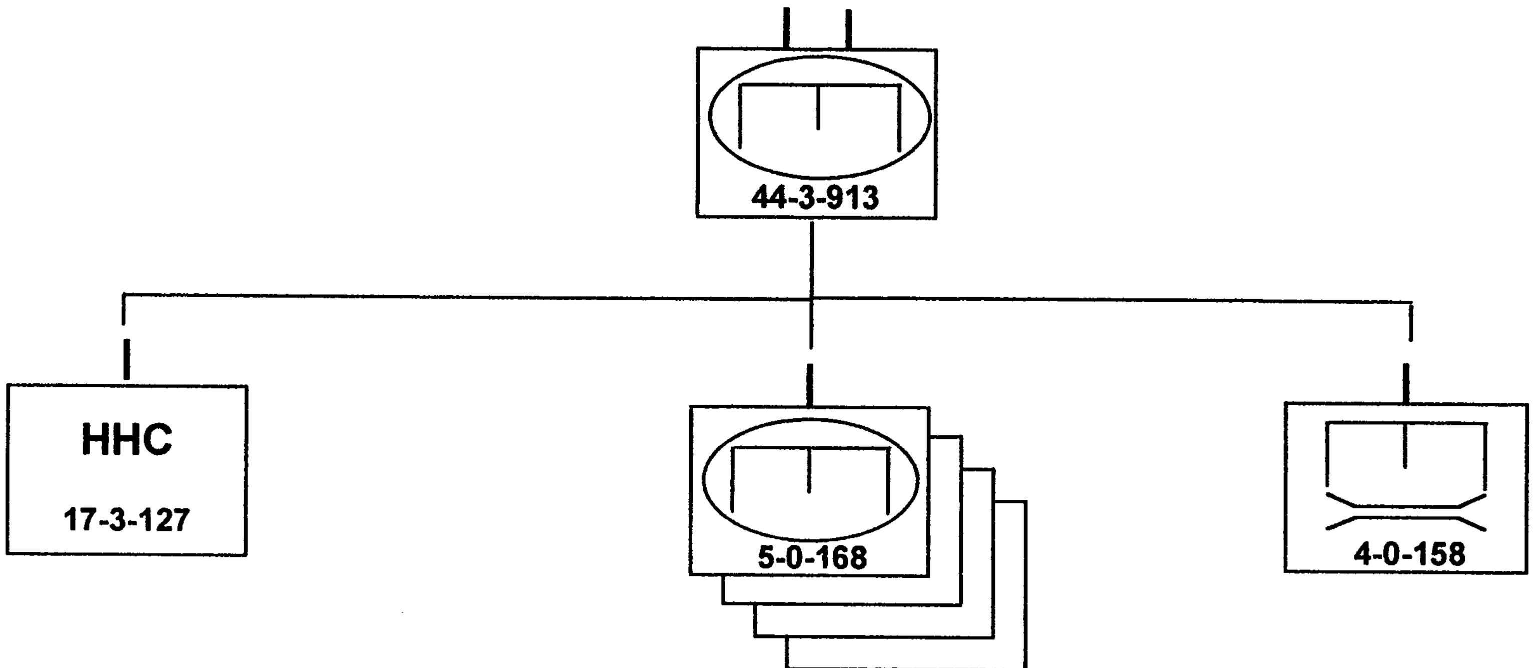
Equipment Recapitulation

57 - Half Tracks
5 - Dozers
2 - Cranes

T/O 5-215 [43-2-1159] (1942)

Divisions With 4 Armored Regts Have 4 Combat Engineer CO. Plus a Treadway Bridge Company

Divisional Mechanized Engineer Battalion 1963



Major Functions:
- Support Division operations
- Plan Engineer Support Operations
- Reduce Obstacles
- Engineer Actions on the Objective
- Emplace Obstacles
- Support 3 Brigades
- Integrate Additional Assets As Needed

Equipment Recapitulation

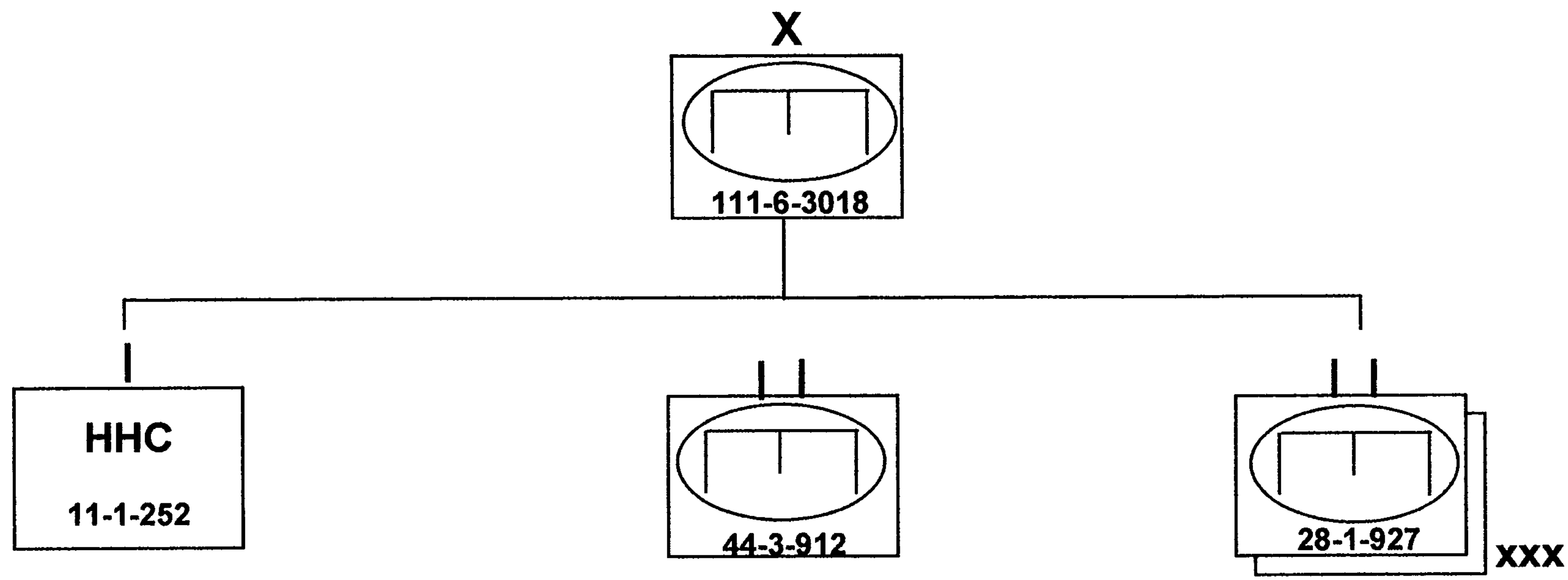
41 - APC
8 - Dozers
3 - Cranes
4 - Graders
4 - AVLB
8 - CEV
12 - Bucket Loaders

TOE 5-145

TOE for Mechanized Infantry and Armor Divisions the same

Figure 4

Divisional Engineer Brigade
"Provisional" 1991 Operation Desert Storm (ODS)



Major Functions:
- Support Division operations
- Plan Engineer Support Operations
- Reduce Obstacles
- Engineer Actions on the Objective
- Emplace Obstacles
- Support 3 Brigades
- Integrate Additional Assets As Needed

Equipment Recapitulation

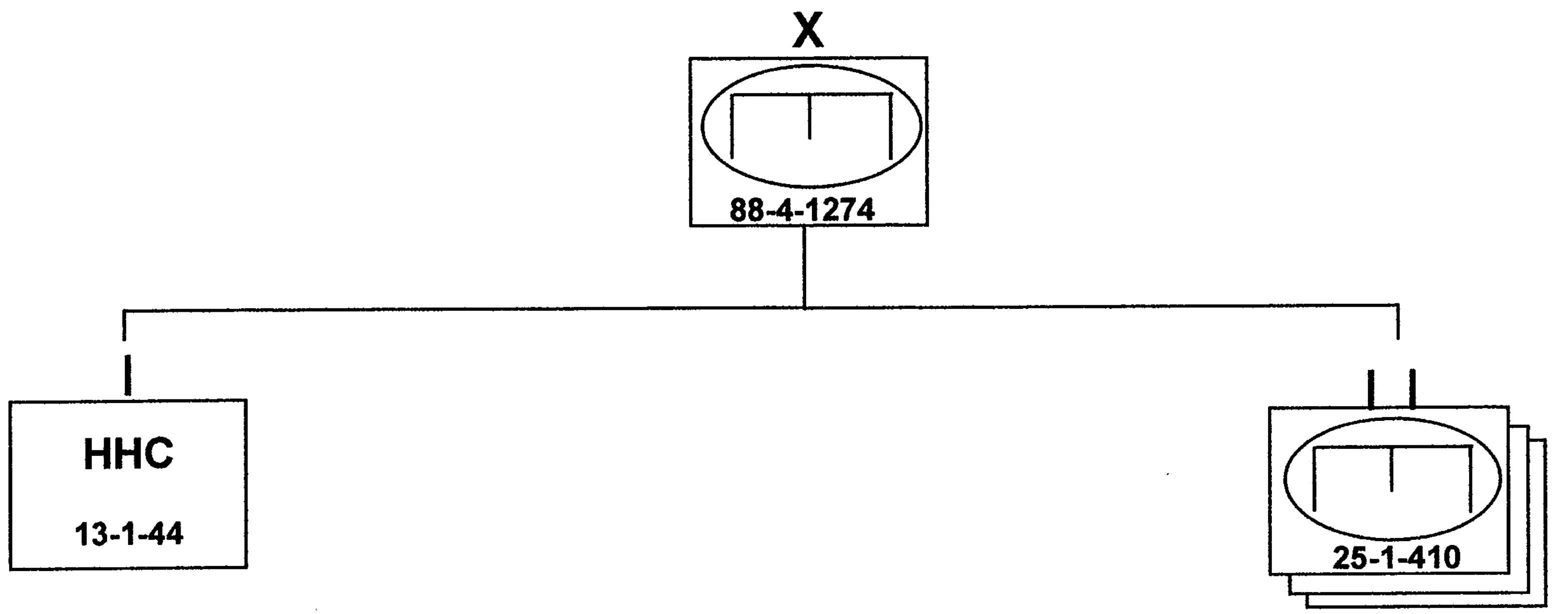
104 - APC	16 - AVLB
16 - Dozers	8 - CEV
28- ACE	16 - Bucket Loaders
36 - MICLIC	4 - Graders
4 - Cranes	

TOE 5-145

Provisional Engineer Brigade formed by attaching two corps combat battalions to the Division under an ad hoc headquarters

Figure 5

ERI Engineer Brigade
1995



Major Functions:
- Support Division operations
- Plan Engineer Support Operations
- Reduce Obstacles
- Engineer Actions on the Objective
- Emplace Obstacles
- Support 3 Brigades
- Integrate Additional Assets As Needed

Equipment Recapitulation

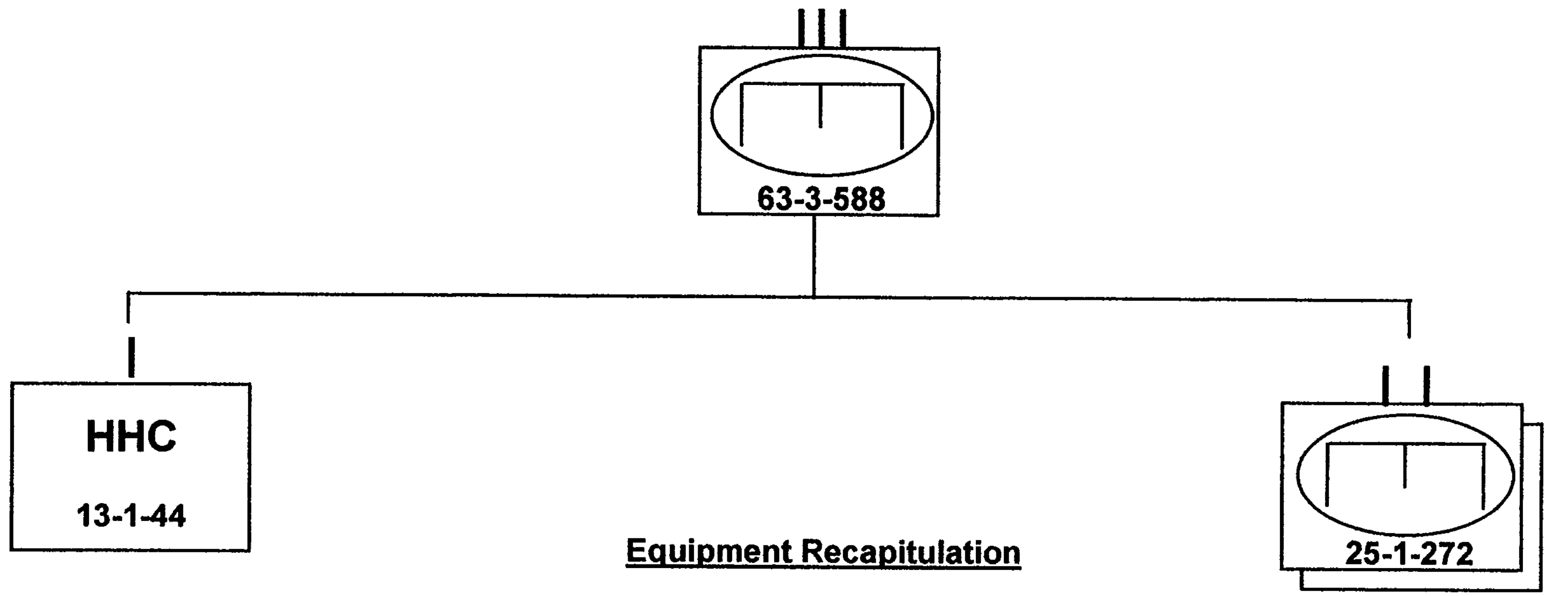
87 - APC
63- ACE
36 - MICLIC
18 - VOLCANO
36 - AVLB
18 - CEV
18 - SEE

TOE 5-145

ERI Brigade for Bosnia augmented with 1 corps combat, 3 construction engr. battalions, and 3 bridge companies.

Figure 6

Force XXI Design One
1997



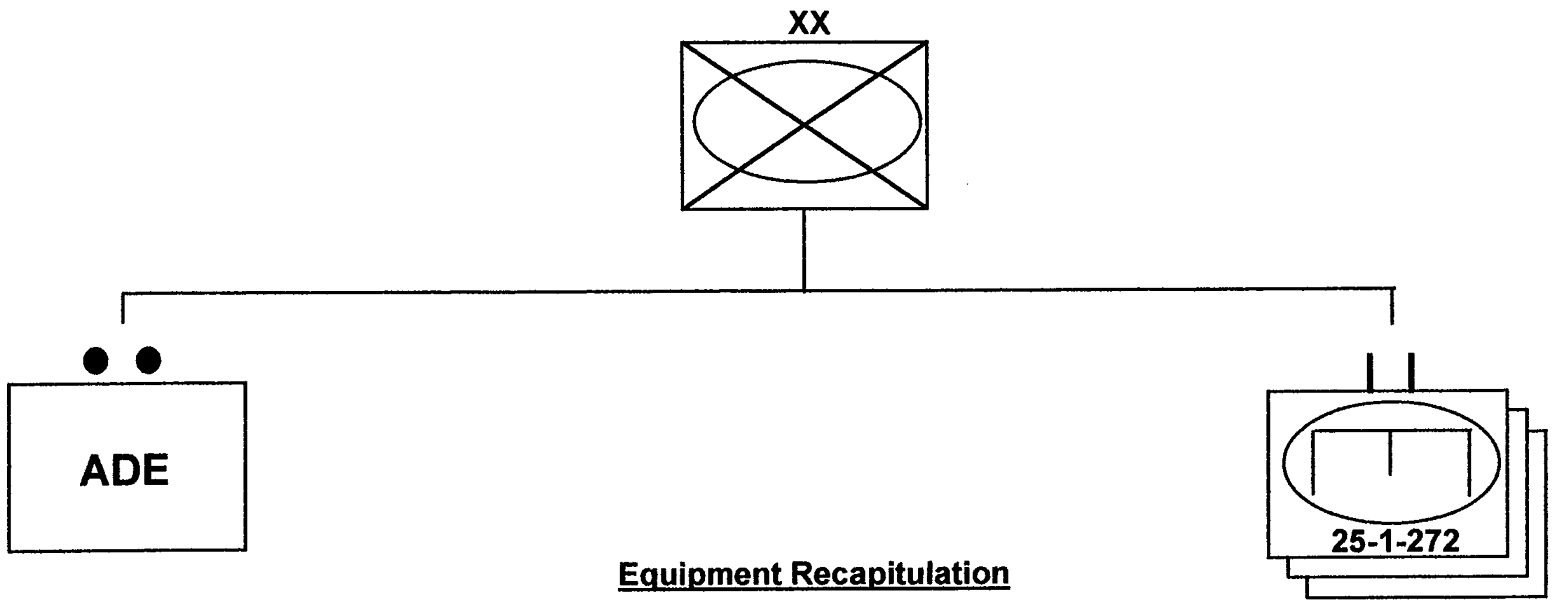
Equipment Recapitulation

48- M2	24- HAB
16 - M2 CMD	24- Ace
24 - M1 Breacher	12 - MICLIC
12 - Volcano	

Force XXI Engineer Group has six engineer companies organized into two battalions

Figure 7

Force XXI Design Two
1997



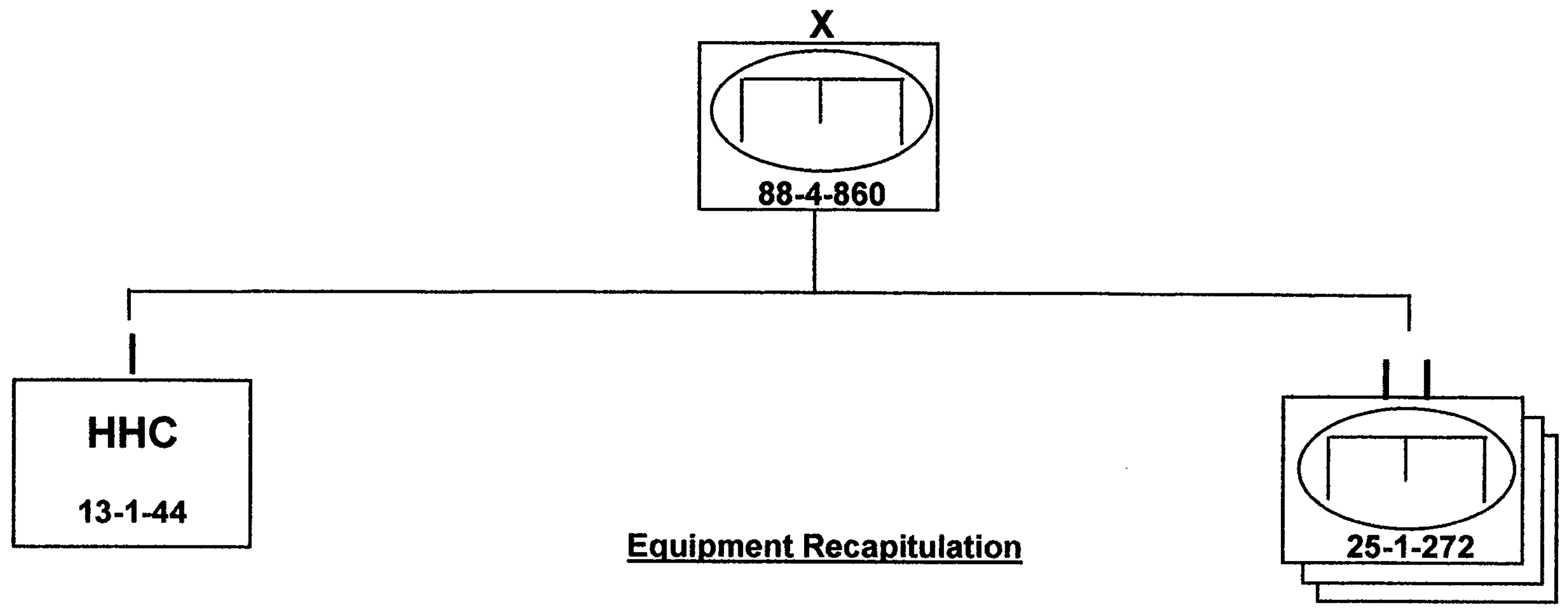
Equipment Recapitulation

72- M2	36 - HAB
18 - M2 CMD	36 - ACE
36 - M1 Breacher	14 - MICLIC
18 - Volcano	

Force XXI "Brigadist" design has nine engineer companies organized into three battalions. The battalions are assigned to the three maneuver brigades

Figure 8

Recommendation Design Three



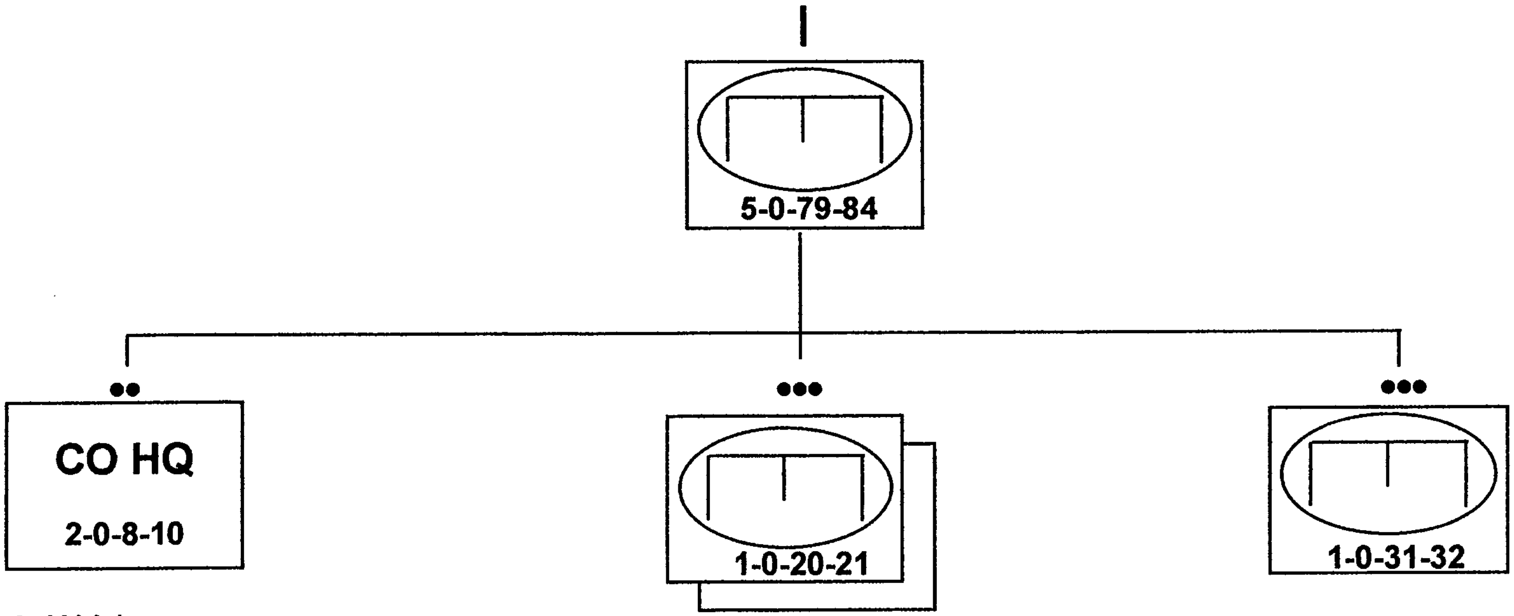
Equipment Recapitulation

72- M2
24 - M2 CMD
36 - M1 Breacher
18 - Volcano
36- HAB
36- ACE
18 - MICLIC

Design Three offers an adequate divisional engineer structure

Figure 9

Divisional
Force XXI Engineer Company



2 X Volcanoes
2 X M2 (CMD)
2 X M998

Major Functions:
- •Support Task Force Operations
- •Plan Engineer Support to Task Force Operations
- •Reduce Obstacles
- •Engineer Actions on the Objective
- •Emplace Dynamic Obstacles
- •Support 3 CO/Tms
- •Integrate Additional Assets As Needed

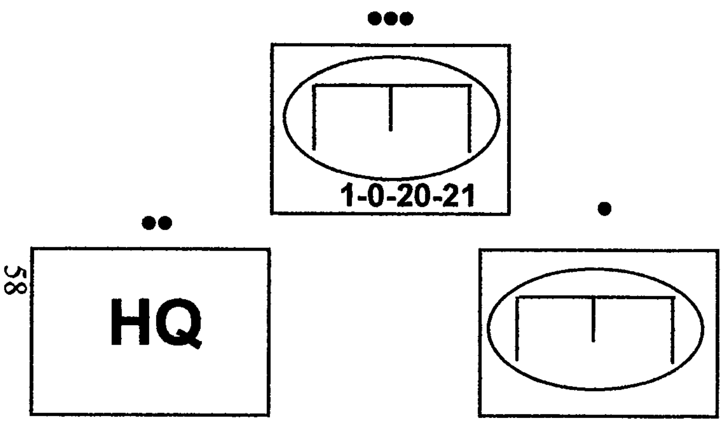
Equipment Recapitulation

8 - M2	4 - Wolverine
2 - M2 CMD	4 - Ace
4 - Grizzly	5 - Hmmwv
2 - Volcano	2 - MICLIC

Figure 10

Force XXI Engineer Platoons
Mechanized Company
Heavy Division

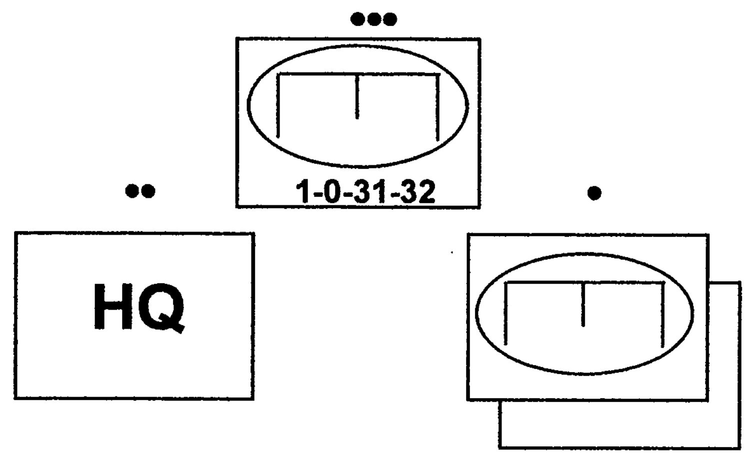
Reduction Plt
X 2 Per Company



Primary Function:
-Create Lane in Complex Obstacle

2 X M2 (SIX Dismounts) One Sqd in Two Vehicles
2 X GRIZZLY
1 X WOLVERINE
1 X ACE
1 X M998

Assault
Platoon



Primary Function:
-Actions on the Obj
-Defeat Protective Obstacles
-Reinforce Reduction Platoon

4 X M2 (12 Dismounts) Two Sdqs in Four Vehicles
2 X WOLVERINE
2 X ACE
1 X M998
2 X PANTHER
2 X MICLIC

Figure 11

Endnotes

[1] Hildenbrand Mark *The Heavy Division Engineer Regiment A Key To Tactical Freedom Of Action* School of Advanced Military Studies Monograph, Fort Leavenworth KS, 20 December, 1991. p 25 The author served as a pre-ERI task force engineer as a 2nd Lieutenant and as a post ERI task force engineer as a Captain. Interestingly, a quantum leap in engineer support capability was realized increasing TF level support from 25 man platoons to 200 man companies.
[2] ibid. p25
[3] Technical Report TRAC-TR-0396, *Force XXI Division Design Analysis: Phase I Final Report* Fort Monroe, Virginia. March 1996. p. 7.
[4] Ibid. pp. 6-7
[5] Ibid. p 33
[6] Ibid. p 61
[7] Clinton, William J. *A National Security Strategy For A New Century* Washington D.C. May 1997. p 12
[8] Ibid. p. 12
[9]U.S. Department of the Army. Field Manual 71-100 *Division Operations*. Washington D.C.: Government Printing Office, June 1996. p 1-1
[10] Ibid. p. 1-4
[11] U.S. Department of the Army. Field Manual 5-71-100 *Division Engineer Combat Operations*. Washington D.C.: Government Printing Office, April 1993. p. 1-1
[12] U.S. Department of the Army, Field Manual 100-5 *Operations*, (Washington D.C.: Government Printing Office, June 1993), p. 13-0.
[13] Interestingly, the Vietnam "War" falls into the upper end of this spectrum. FM 100-5 would characterize this conflict as primarily a "Support for Counterinsurgencies" operation.
[14] Field Manual 7-98 *Operations in a Low-Intensity Conflict*, (Washington D.C.: Government Printing Office, 19 October, 1992), p. 1-2.
[15] Starry, MG Donn A, *Mounted Combat in Vietnam*, (Washington D.C.: Government Printing Office, 1978), p. 6.
[16] Ibid., p. 9.
[17] *Initial Impressions Report, Operation Joint Endeavor*, (U.S. Army Training and Doctrine Command, Fort Leavenworth, Kansas, May 1996), p. 130.
[18] Starry, p. 58.
[19] Niedringhaus, CPT David A, *US ARMY Armor in Limited War: Armor Employment techniques in Korea and Vietnam*, (Masters Thesis, Ohio State University, Columbus Ohio, 29 May 1987), p. 61.
[20] U.S. Army Vietnam, *Mechanized and Armor Combat Operations in Vietnam* 28 March, 1967, p 19
[21] Ibid., p 19.
[22] Field Manual 34-130 *Intelligence Preparation of the Battlefield*, (Washington D.C.: Government Printing Office, 8 July, 1994), p. 2-15.
[23] U.S. Army Vietnam, *Mechanized and Armor Combat Operations in Vietnam*, p. 23.
[24] U.S. Army Vietnam, *Evaluation of U.S. Army Mechanized and Armored Combat Operations in Vietnam, Volume Seven: Essential Elements of Analysis*, 28 March, 1967, p. VII-B-19.
[25]U.S. Army Vietnam. *Evaluation of U.S. Army Mechanized and Armored Combat Operations in Vietnam, Volume One: Basic Report*, 28 March, 1967, p. I-C-8, Fig I-C-1-D.
[26] U.S. Army Vietnam, *Senior Officer Debriefing Report-Colonel Donn A. Starry*, 1 August, 1970, p. 57.
[27] U.S. Army Vietnam, *Mechanized and Armor Combat Operations in Vietnam*, p. 161. The Vietnam era tank battalion, AVLB section was equipped with two AVLBs, a command and control vehicle and 6 personnel.
[28] U.S. Army Vietnam. *Evaluation of U.S. Army Mechanized and Armored Combat Operations in Vietnam, Volume Seven: Essential Elements of Analysis*, 28 March, 1967, pp. VII-B-40-41. As a 2nd Lieutenant the author dragged two AVLBs from his supported tank battalion as these assets were incorporated into the

divisional engineer battalion. At the time, it was determined that the engineers could better maintain the fleet in a consolidated manner. This proved to be true. The authors' unit found operational readiness rates rose from near zero to over 70 % for the systems following this consolidation.

29 U.S. Army Vietnam, *Senior Officer Debriefing Report - Colonel Donn A. Starry*, 1 August, 1970, p 51.

30 U.S. Army Vietnam. *Evaluation of U.S. Army Mechanized and Armored Combat Operations in Vietnam, Volume Seven: Essential Elements of Analysis*, 28 March, 1967, pp. VII-B-47-50.

31 2-34 Armor, *Operational Report: Lessons Learned*, 19 May 1967, p. 12.

32 U.S. Army Vietnam, *Mechanized and Armor Combat Operations in Vietnam*, p. 112.

33 Field Manual 20-32 *Mine-Countermine Operations*, (Washington D.C.: Government Printing Office, 30 September, 1992), p. 2-1.

34 Ibid., pp. VII-B-51.

35 11th ACR, *Operational Report: Lessons Learned, 1 August 1967, thru 31 October 1967*, 19 December 1967, p. 60.

36 11th ACR, *Operational Report: Lessons Learned, 1 November 1966, thru 31 January 1967*, 19 June 1967, p. 65.

37 U.S. Army Vietnam, *Senior Officer Debriefing Report - Colonel Donn A. Starry*, 1 August, 1970, p 37.

38 Polger, MG Robert R, *U.S. Army Engineer 1965-1970*, (Washington D.C.: Government Printing Office, 1974), p. 142.

39 Ibid., p. 140.

40 11th ACR, *Operational Report: Lessons Learned, 1 November 1966, thru 31 January 1967*, 19 June 1967, p. 111. 1/11 ACR's task organization during this operation was B Company 27th Engineer Battalion and 1st Platoon 919th Engineer Company.

41 11th ACR, *Operational Report: Lessons Learned, 1 May 1967, thru 31 July 1967*, 14 February 1968, p. 8.

42 Polger, p 135.

43 1-63 Armor, *Operational Report: Lessons Learned, 5 April 1967*, p. 8.

44 U.S. Army Vietnam, *Mechanized and Armor Combat Operations in Vietnam*, p. 109.

45 Ibid., p 135.

46 11th ACR, *Operational Report: Lessons Learned, 1 May 1967, thru 31 July 1967*, 14 February 1968, p. 8.

47 Field Manual 5-71-3 *Brigade Engineer Combat Operations (Armored)*, (Washington D.C.: Government Printing Office, 3 October 1995), p. 2-1.

48 Treleaven, MAJ David L., "Engineers in Bosnia: An Overview", *Engineer Magazine*, March 1996, p. 19.

49 U.S. Army TRADOC, *Initial Impressions Report. Operation Joint Endeavor*, May 1996, p. 54.

50 Ibid., p 35.

51 COL(P) Hans Van Winkle's briefing Engineer Commander's Conference, April 1996, Slide 1. This briefing can be found at http:\\www.wood.army.mil under the Center for Engineer Lessons Learned webpage. COL(P) Van Winkle served during the deployment as the Deputy Chief of Staff - Engineer for the U.S. Army Europe.

52 Ibid., Slide 5.

53 Houck, MAJ Boyd D., "Engineer Support to Peacekeeping," *Engineer Magazine*, August, 1993, p. 12.

54 Treleaven, p18-19.

55 COL Steve Hawkins' briefing Engineer Commander's Conference, April 1996, Slide 4, COL Hawkins commanded the 1st Armored Division Engineer Brigade during the deployment and through the redeployement of the division.

56 Headquarters USAEUR, DCSENG, *Operations Joint Endeavor, Fixed Bridging Overview*, http:\\ www.dcsengr.hqusareur.army.mil. Accessed 19 October, 1997, p. 1.

57 Van Winkle, Slide 12.

58 U.S. Army TRADOC, *Initial Impressions Report, Operation Joint Endeavor*, May 1996, p. 130.

59 Treleaven, p 19.

60 Headquarters USAEUR, DCSENG, *Operations Joint Endeavor, Fixed Bridging Overview*, p 2.

[61] Brown, MAJ David R., "Bosnia: Engineer Planning for Stability Operations," *Engineer*, November 1993, p. 4.
[62] Headquarters USAEUR, DCSENG, *Operations Joint Endeavor, Commanders Critical Information Requirements (CCIR) for DCSENGR* 1 JAN 96 (C+30), http:\\ www.dcsengr.hqusareur.army.mil. Accessed 9 October, 1997, p. 2.
[63] Ibid., p. 2.
[64] U.S. Army TRADOC, *Initial Impressions Report, Operation Joint Endeavor,* May 1996, p. 132.
[65] The author was directly involved in predeployment planning for Operation Joint Endeavor at Vincenza, Italy, 15-25 October, 1995.
[66] U.S. Army TRADOC, *Initial Impressions Report, Operation Joint Endeavor,* May 1996, p. 130.
[67] The Associated Press, "Intensive campaign urged to clear out mines form Bosnia", *The Kansas City Star*, October 6, 1997, p. A-9.
[68] Hawkins, Slide 22. The only fatality was due to an NCO miss-handling an anti-personnel mine in a marked minefield. This unnecessary death occurred through a lapse in discipline.
[69] U.S. Army Vietnam, *Evaluation of U.S. Army Mechanized and Armored Combat Operations in Vietnam, Volume Seven: Essential Elements of Analysis,* 28 March, 1967, pp. VII-B-47-50.
[70] U.S. Army TRADOC, *Initial Impressions Report, Operation Joint Endeavor,* May 1996, p. 167.
[71] Goetz, MAJ Andrew, "Photo-Essay from Operation Joint Endeavor - Part II," *Engineer*, December, 1996, p. 20.
[72] Hawkins, Slide 16.
[73] Van Winkle, Slide 16.
[74] U.S. Army TRADOC, *Initial Impressions Report, Operation Joint Endeavor,* May 1996, p. 168.
[75] Hawkins, Slide 16, Force Provider system is similar to the Air Force Harvest Eagle system. Both are designed to provide a rapid base camp capability in an austere environment. Harvest Eagle debuted in Desert Storm. Force Provider debuted during Joint Endeavor. Both are outstanding systems!
[76] COL Steve Hawkins, Commander 1st Armored Division Engineer Brigade Commander, Operation Joint Endeavor, personal interview between the author, April, 1996.
[77] Goetz, p. 22.
[78] U.S. Armor School. *Operation of Armored Engineer Battalions in ETO.* May 1950. p. 25.
[79] Ibid. p 14.
[80] Ibid. p 110.
[81] *Engineer Operations By the VII Corps in the European Theatre* [sic] Vol. 1-7 23 March, 1949. p. 5.
[82] Beck, Alfred M.; Bortz, Abe; Lynch, Charles W; Weld, Ralph F. *The Corps of Engineers: The War Against Germany; U.S. Army in World War II.* Washington D.C.: Government Printing Office, 1985. p 564.
[83] U.S. Armor School. *Operation of Armored Engineer Battalions in ETO.* May 1950. p. 4.
[84] Beck. p. 181.
[85] U.S. Armor School. *Operation of Armored Engineer Battalions in ETO.* May 1950. p. 78.
[86] Ibid. p. 54.
[87] Fowle, Barry W. *Builders and Fighters: U.S. Army Engineers in World War II.* Fort Belvior, Virginia: U.S. Army Corps of Engineers, 1992. p. 191.
[88] Beck. p. 185.
[89] Beck. p. 169.
[90] *Engineer Operations By the VII Corps in the European Theatre* [sic] Vol. 1-7 23 March, 1949. Exactly 202 bridges were constructed by VII Corps engineers. Data complied from the "Tabulation of Data on Stream Crossing" compiled from each volume.
[91] XIX Corps Engineers, *Unit History of combat operations in the ETO*, August 1945. p. 21.
[92]Ninth U.S. Army, *Ninth Army Engineer Operations in Rhine River Crossing*, June 30, 1945. p. 7.
[93] Ibid. p. 7.
[94] Ibid. p. 12.
[95] U.S. Armor School. *Operation of Armored Engineer Battalions in ETO.* May 1950. p. 152. Thirty-six feet approximates an AVLB span (12 meters verses 15 meters). The fielding of the AVLB enabled the

replacement of a highly trained, dismounted, squad with two soldiers protected by armor. Interestingly, *Engineer Operations By the VII Corps in the European Theatre* [sic] Vol. 1-7 23 March, 1949. (pp. 24-25.) "recommended [in 1945] that experimentation continue to perfect a standard device/method for employing a tank... to launch [a] future tank bridge

[96] U.S. Armor School. *Operation of Armored Engineer Battalions in ETO.* May 1950. p. 190.

[97] Ibid. p 19.

[98] *Engineer Operations By the VII Corps in the European Theatre* [sic] Vol. 1-7 23 March, 1949. p. 3.

[99] *Final Report of the Chief Engineer European Theater of Operations 1942-1945.* p. 135.

[100] U.S. Armor School. *Operation of Armored Engineer Battalions in ETO.* May 1950. p. 84.

[101] Coll, Blanche D.; Keith, Jean E.; Rosenthal, Herbert H. *The Corps of Engineers: Troops and Equipment; U.S. Army in World War II.* Washington D.C.: Government Printing Office, 1958. p 16.

[102] Fowle, Barry W. *Builders and Fighters: U.S. Army Engineers in World War II.* Fort Belvior, Virginia: U.S. Army Corps of Engineers, 1992. p. 413.

[103] Ibid. pp. 436-437.

[104] Beck. p. 556.

[105] *Final Report of the Chief Engineer European Theater of Operations 1942-1945.* p. 139.

[106] Ibid. pp. 139-140.

[107] Ibid. p. 135.

[108] Brinkerhoff, John R., *United States Army Reserve in Operation Desert Storm, Engineer Support at Echelons Above Corps: The 416th Engineer Command, Washington D.C.,* 18 May, 1992, p. 2. The Corps of Engineers began construction work in 1951 with the building of the Dhahran Air Base. Three Military Cities, including King Khalid Military City (KKMC) were built in the early 1970's.

[109] Ibid., p. 11.

[110] Scales, BG Robert H., *Certain Victory: The U.S. Army in the Gulf War,* (Washington D.C. U.S. Army CGSC Press, 1993), p. 77.

[111] Friedman, Norman, *Desert Victory The War for Kuwait,* (Annapolis Maryland: Naval Institute Press, 1991), p. 113.

[112] Craft, Douglas W., *An Operational Analysis of the Gulf War,* (U.S. Army War College, Carlisle, PA, August 31, 1992), p. 6.

[113] Brinkerhoff, p. 19.

[114] Kirch, LTC Robert S and CPT Thomas H. Magness, "Iron Sappers," *Military Engineer,* November 1991, pp. 25-26.

[115] Scales, p 227.

[116] Tice, "Coming Through, The Big Red raid," p. 20.

[117] Atkinson, Rick, *Crusade,* (New York: Houghton Mifflin Company 1993), p. 396.

[118] Kirsch, p. 26.

[119] *Conduct of the Persian Gulf War: Final Report to Congress,* Volume 3, Appendix T, Washington D.C. April, 1992, T-135.

[120] Scicchitano, J. Paul, "Eye of the Tiger," *Army Times* June 10, 1991, p. 18.

[121] Ibid., p. T-134.

[122] Brinkerhoff, p. 18.

[123] Coleman, BG Richard E; COL David F. Melcher, COL Robert Shirron, and COL Gilbert L. Van Sickle, "Restructuring the Initiative, A proposal for Engineer C2 in the Division Fight," *Military Review,* 11 July, 1997. This article was accepted for publication by *Military Review.*

[124] Ninth U.S. Army, *Ninth Army Engineer Operations in Rhine River Crossing,* June 30, 1945, p. 12.

[125] Chief of Engineers ETO, p. 135.

[126] *Conduct of the Persian Gulf War,* p. T-135.

[127] USAES Technical Report No. 1, *Quick Reaction Analysis Combined Arms Deliberate Breach of a Complex Obstacle,* 29 December, 1990, p. 43-44. This was a JANUS based simulation based on the Iraqi border defenses during the Gulf War. The analysis found that a reinforced engineer company was required for each Task Force and that an Engineer Battalion was required for each Brigade. This TRADOC sponsored study, combined with the E-Force test in Europe, and the positive performance during the war coalesced into the ERI engineer brigade. This JANUS-A computer model, in SWA terrain, given Iraqi

dispositions clearly demonstrated that the best task force level breaching organization was an the engineer company (+) with plows and rollers, plus four breachers.

128 Yates, Lawrence A., "Military Stability and Support Operations: Analogies, Patterns and Recurring Themes," *Military Review*, July-August, 1997, p. 52.

129 Colman, BG Richard E; COL David F. Melcher, COL Robert Shirron, and COL Gilbert L. Van Sickle, "Restructuring the Initiative. A Proposal for Engineer C2 in the Division Fight", 11 July, 1997, from an article accepted for publication by *Military Review*, p. 3.

BIBLIOGRAPHY

Government Publications

U.S. Department of the Army. Field Manual 100-5 *Operations.* Washington D.C.: Government Printing Office, June 1993.

__________. Field Manual 5-71-3 *Brigade Engineer Combat Operations (Armored).* Washington D.C.: Government Printing Office, 3 October 1995.

__________. Field Manual 5-71-100 *Division Engineer Combat Operations.* Washington D.C.: Government Printing Office, April 1993.

__________. Field Manual 5-100 *Engineer Operations.* Washington D.C.: Government Printing Office, June 1995.

__________. Field Manual 7-98 *Operations in a Low-Intensity Conflict.* Washington D.C.: Government Printing Office, 19 October 1992.

__________. Field Manual 20-32 *Mine-Countermine Operations.* Washington D.C.: Government Printing Office, 30 September 1992.

__________. Field Manual 34-130 *Intelligence Preparation of the Battlefield.* Washington D.C.: Government Printing Office, 8 July 1994.

__________. Field Manual 71-100 *Division Operations.* Washington D.C.: Government Printing Office, June 1996.

__________. Field Manual 71-123 *Tactics and Techniques for the Combined Arms Heavy Forces: Armored Brigade, Battalion/Task Force, and Company Team.* Washington D.C.: Government Printing Office, September 1992.

__________. Field Manual 90-3 *Desert Operations,* Washington D.C.: Government Printing Office, August 1993.

__________. Field Manual 90-5 *Jungle Operations.* Washington D.C.: Government Printing Office, August 1982.

__________. Field Manual 90-6 *Mountain Operations.* Washington D.C.: Government Printing Office, June 1980.

__________. Field Manual 90-13 *River Crossing Operations.* Washington D.C.: Government Printing Office, June 1996.

__________. Field Manual 90-13-1 *Combined Arms Breaching Operations.* Washington D.C.: Government Printing Office, May 1993.

U.S. Army Armor School. FKSM 17-3-2 *Armor in Battle.* Fort Knox Kentucky. 1986.

U.S. Army TRADOC Pamphlet 525-5 *Force XXI Operations.* Fort Monroe, Virginia. August, 1994.

Unpublished papers, Thesis', Monographs

Adkins, LTC R. A. *Iron Sappers Lead the Way. 16th Engineer Battalion's Support of 1st Armored Division in Southwest Asia.* US Army War College Monograph, Carlisle Barracks, PA. 30 March 1993.

Brinkerhoff, John R. *United States Army Reserve in Operation Desert Storm, Engineer Support at Echelons Above Corps: The 416th Engineer Command.* Washington D.C. 18 May 1992.

Chappell, MAJ Harold L. *Evolution or Revolution: Mobility for the Airland Battle Future Concept.* School of Advanced Military Studies Monograph, Fort Leavenworth KS, 20 February 1991.

Craft, COL Douglas W., *An Operational Analysis of the Gulf War.* U.S. Army War College, Carlisle, PA. August 31, 1992.

Davis, MAJ Mark A. *Armor Attacks In Restrictive Terrain: Is Current Doctrine Adequate?* School of Advanced Military Studies Monograph, Fort Leavenworth KS, 14 December 1995

DeLony, MAJ James W. *Tactical Mobility And The Instride Obstacle Breach: Impossible, Probable, Futuristic?* School of Advanced Military Studies Monograph, Fort Leavenworth 29 November 1988.

Hildenbrand, MAJ Mark. *The Heavy Division Engineer Regiment A Key To Tactical Freedom Of Action.* School of Advanced Military Studies Monograph, Fort Leavenworth KS, 20 December 1991

Jemiola, LTC R. W. *9th Engineer Battalion in Operation Desert Storm.* US Army War College Monograph, Carlisle Barracks, PA, 30 March 1993.

Niedringhaus, CPT David A. *US ARMY Armor In Limited War: Armor Employment Techniques In Korea And Vietnam.* Masters Thesis, Ohio State University, Columbus Ohio. 29 May 1987.

Schrodel, MAJ Joseph. *Tactical Mobility: Organizing For An All Arms Problem.* School of Advanced Military Studies Monograph, Fort Leavenworth KS, 30 November 1987

Sinkler, MAJ Robert A. *Modularity-the Next Step in the Evolution of the Armored Engineer Battalion.* School of Advanced Military Studies Monograph, Fort Leavenworth 6 December 1996.

Wimmer, MAJ Kevin S. *Armored Warfare in the Jungle Environment.* MMAS Thesis Fort Leavenworth KS, 1991

Books

Atkinson, Rick. *Crusade.* New York: Houghton Mifflin Company 1993.

Beck, Alfred M.; Abe Bortz, Charles W. Lynch, and Ralph F. Weld. *The Corps of Engineers: The War Against Germany; U.S. Army in World War II.* Washington D.C.: Government Printing Office, 1985.

Coll, Blanche D.; Jean E Keith, and Herbert H Rosenthal. *The Corps of Engineers: Troops and Equipment; U.S. Army in World War II.* Washington D.C.: Government Printing Office, 1958.

Fowle, Barry W. *Builders and Fighters: U.S. Army Engineers in World War II.* Fort Belvior, Virginia: U.S. Army Corps of Engineers, 1992.

Friedman, Norman, *Desert Victory The War for Kuwait*, Annapolis Maryland: Naval Institute Press, 1991.

Pirnie, Bruce R. and Simons, William E. *Soldiers for Peace Critical Operational Issues.* Santa Monica, CA. RAND, 1996.

Polger, Robert R. *U.S. Army Engineer 1965-1970.* Washington D.C.: Government Printing Office, 1974.

Scales, BG Robert H. *Certain Victory: The U.S. Army in the Gulf War.* Washington D.C. U.S. Army CGSC Press, 1993.

Starry, MG Donn A. *Mounted Combat in Vietnam.* Washington D.C.: Government Printing Office, 1978.

Periodicals and Articles

Aikman, LTC Bill, "Seven Days in Sarajevo," *Military Engineer*, May 1994.

The Associated Press, "Intensive campaign urged to clear out mines from Bosnia," *The Kansas City Star*, October 6, 1997.

Brown, MAJ David R., "Bosnia: Engineer Planning for Operations Other than War," *Engineer*, November 1993.

Colman, BG Richard E; COL David F. Melcher, COL Robert Shirron, and COL Gilbert L. Van Sickle. "Restructuring the Initiative. A Proposal for Engineer C2 in the Division Fight," *Military Review,* 11 July 1997. From an article accepted for publication by *Military Review*.

Edgar, 1LT Ernie, "249th Engineers Storm the Desert," *Military Engineer*, November 1991.

Goetz, MAJ Andrew, "Photo-Essay from Operation Joint Endeavor," *Engineer*. August 1996.

Goetz, MAJ Andrew, "Photo-Essay from Operation Joint Endeavor - Part II," *Engineer*. December 1996.

Houck, MAJ Boyd D., "Engineer Support to Peacekeeping," *Engineer*. August 1993.

Kirsch, LTC Robert S and CPT Thomas H. Magness, "Iron Sappers," *Military Engineer*, November 1991.

Scicchitano, J. Paul, "Eye of the Tiger," *Army Times,* June 10, 1991.

Tice, Jim, "Coming Through, The Big Red raid," *Army Times*, August 26, 1991.

Treleaven, MAJ David L., "Engineers in Bosnia: An Overview," *Engineer*, March 1996.

Watts, LCDR Bruce and LT Robert Fahey, "Engineering in Bosnia," *Military Engineer*, May 1994.

Yates, Lawrence A., "Military Stability and Support Operations: Analogies, Patterns and Recurring Themes," *Military Review,* July-August 1997.

Reports

11th ACR, *Operational Report: Lessons Learned. 1 November 1966, thru 31 January 1967*, 19 June 1967.

11th ACR, *Operational Report: Lessons Learned. 1 May 1967, thru 31 July 1967*, 14 February 1968.

11th ACR, *Operational Report: Lessons Learned. 1 August 1967, thru 31 October 1967*, 19 December 1967.

French Army Supreme Command, Far East, *Lessons from the Indo-China War Volume II*, 31 May 1955.

French Army Supreme Command, Far East, *Lessons from the Indo-China War Volume III*, 31 May 1955.

Ninth U.S. Army, *Ninth Army Engineer Operations in Rhine River Crossing*, June 30 1945.

XIX Corps Engineer, *Unit History of Combat Operations in the ETO*, August 1945

VII Corps Engineer, *Engineer Operations By the VII Corps in the European Theatre Vol. 1-7*, 23 March 1949

2-34 Armor, *Operational Report: Lessons Learned*, 19 May 1967.

U.S. Army Armor School, *Operation of Armored Engineer Battalions in ETO*, May 1950.

U.S. Army Concept Team, Vietnam, *Armor Organization for Counterinsurgency Operations in Vietnam*, 15 March 1966.

U.S. Army Concept Team, Vietnam, *Optimum Mix of Armored Vehicle for use in Stability Operations*, March 1971.

U.S. Army Corps of Engineers, *Final Report of the Chief Engineer European Theater of Operations 1942-1945*, Washington D.C. 1946 .

U.S. Army Engineer School Technical Report No. 1, *Quick Reaction Analysis Combined Arms Deliberate Breach of a Complex Obstacle*, Fort Leonard Wood, Missouri. 29 December 1990.

U.S. Army Military Assistance Command Vietnam, *Combat Experiences*, 7 September 1969.

U.S. Army Training and Doctrine Command, *Initial Impressions Report, Operation Joint Endeavor*, Fort Leavenworth, Kansas, May 1996.

U.S. Army Training and Doctrine Command Technical Report TRAC-TR-0396, *Force XXI Division Design Analysis: Phase I Final Report*, Fort Monroe, Virginia. March 1996.

U.S. Army Vietnam, *Evaluation of U.S. Army Mechanized and Armored Combat Operations in Vietnam. Volume One: Basic Report,* 28 March 1967.

U.S. Army Vietnam, *Evaluation of U.S. Army Mechanized and Armored Combat Operations in Vietnam. Volume Three: Combat Capabilities,* 28 March 1967.

U.S. Army Vietnam, *Evaluation of U.S. Army Mechanized and Armored Combat Operations in Vietnam. Volume Seven: Essential Elements of Analysis,* 28 March 1967.

U.S. Army Vietnam, *Mechanized and Armor Combat Operations in Vietnam,* 28 March 1967.

U.S. Army Vietnam, *Senior Officer Debriefing Report - Colonel Donn A. Starry,* 1 August 1970.

U.S. Department of Defense, *Conduct of the Persian Gulf War: Final Report to Congress*, Volume 3, Appendix T. Washington D.C. April 1992.

INTERNET

Center for Engineer Lessons Learned. (http:\\www.wood.army.mil) COL(P) Hans Van Winkle, Deputy Chief of Staff, Engineer (DCSENG); U.S. Army Europe (USAEUR) briefing. Operation Joint Endeavor. Engineer Commander's Conference. April 1996. Accessed 9 October 1997.

Center for Engineer Lessons Learned. (http:\\www.wood.army.mil) COL Steve Hawkins Commander, 1st Armored Division Engineer Brigade briefing. Engineer Commander's Conference. April 1996. Accessed 9 October 1997.

Headquarters USAEUR, DCSENG, Operation Joint Endeavor, *Fixed Bridging Overview* (http:\\ www.dcsengr.hqusareur.army.mil). Accessed 19 October 1997.

Headquarters USAEUR, DCSENG, Operation Joint Endeavor, *Float Bridging Overview* (http:\\ www.dcsengr.hqusareur.army.mil). Accessed 19 October 1997.

Headquarters USAEUR, DCSENG, Operation Joint Endeavor, *Commanders Critical Information Requirements (CCIR) for DCSENGR 1 JAN 96 (C+30)* (http:\\ www.dcsengr.hqusareur.army.mil), accessed 9 October 1997.

Interviews

Hawkins. COL Steve. Commander 1st Armored Division Engineer Brigade Commander, Operation Joint Endeavor, interviewed by the author April, 1996.