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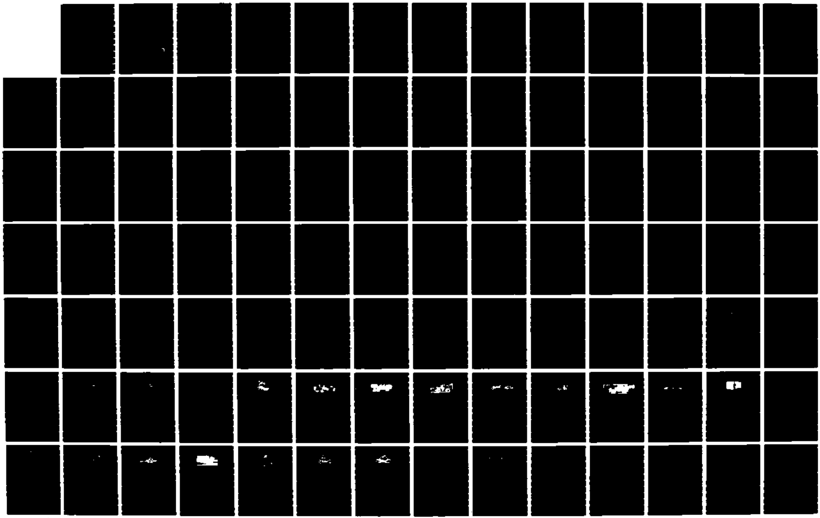

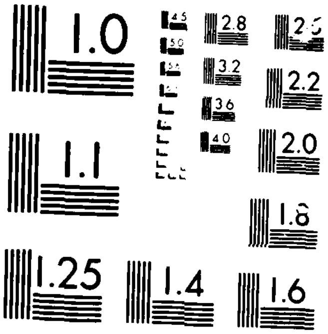

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COUNTEROBSTACLE VEHICLE (COV) UTILITY STUDY

FINAL TECHNICAL REPORT

MRC Report Number 136

McLEAN RESEARCH CENTER, INC.
1483 Chain Bridge Road, Suite 205
McLean, Virginia 22101

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COUNTEROBSTACLE VEHICLE (COV)
UTILITY STUDY

FINAL TECHNICAL REPORT

MRC Report Number 136

May 1986

Prepared for The

U.S. ARMY BELVOIR RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER

By

R. Carpenter, N. Romstedt, et al.

McLean Research Center

1483 Chain Bridge Road, Suite 205

McLean, VA 22101

(703) 734-1410

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The purpose of this study is to identify and evaluate the utility of a single, multipurpose counterobstacle system on the future battlefield.

The study is accomplished by conducting a time-phased analysis of the interrelationship between counterobstacle equipment, missions, and threats over a 30 year period, extending from 20 years ago to 10 years in the future (1965-1995). The analysis involved isolating the counterobstacle mission, by identifying, in priority, the functions performed in accomplishing that mission. A data base was then established listing US Counterobstacle equipment developed and used over the time period, together with the opposing threat capability over the same period. These capabilities were then compared in light of the counterobstacle mission. Wargame analysis was used to show the utility of the counterobstacle system over the timeframe, and to evaluate the utility of a single, multicapable system, called a counterobstacle vehicle (COV) for the future.

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G. Barrett

22b. TELEPHONE *(Include Area Code)*
(703) 664-5470

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The findings of the study include the following:

- The COV is able to reduce the extra losses that accrue to an attacker from a minefield by one-third.

- The COV can improve the chance of successful mission accomplishment of an attacking force by ten percent.

STUDY GIST

TROSCOM

COUNTEROBSTACLE VEHICLE (COV) UTILITY STUDY

1. The Principal Findings

a. The COV is able to reduce the extra losses that accrue to an attacker from a minefield by one-third.

b. The COV can improve the chance of successful mission accomplishment of an attacking force by ten percent.

2. Main Assumptions

a. Utility of the COV can be determined by a historical evaluation and projection of the U.S. Counterobstacle System (COS) and its opposing threat over a 30-year time base.

b. From a human factors standpoint, a similar historical evaluation over the same time base will give insights into crew-equipment interface and effectiveness of human performance during system operation and maintenance. Critical task analysis will contribute to the determination of human performance parameters, system capabilities, and tactical/environmental conditions which will also provide useful insights for COV utility/development.

3. Principal Limitations

a. Current engineer wargame analysis is not sufficiently flexible to allow a timely, sensitive evaluation of COS variations.

b. There is only limited data available for a thorough evaluation of the counterobstacle system performance.

4. Scope of the Study

The study included research for historical data, evaluation by analysis and by wargaming, and comparing results with current and anticipated capability, to include COV experimental prototype performance.

5. Objective

The objective is to gain insights of the utility of a single, multicapable vehicle (COV) to accomplish the counterobstacle mission.

6. Basic Approach

The study developed a data base describing both the U.S. COS and opposing threat, analyzed COS mission performance both unopposed and opposed, and evaluated and compared results.

7. Reason for Performing Study

To provide insights on the utility of the COV.

8. Sponsor

U.S. Army Belvoir Research Development and Engineering Center.

9. Principal Investigator

Robert D. Carpenter, McLean Research Center, Inc. (MRC).

10. Comments and Questions

McLean Research Center, Inc.
1483 Chain Bridge Road, Suite 205
McLean, VA 22101
Telephone: (703) 73401410

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

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The study is accomplished by conducting a time-phased analysis of the interrelationship between counterobstacle equipment, missions, and threats over a 30 year period, extending from 20 years ago to 10 years in the future (1965-1995). The analysis involved isolating the counterobstacle mission by identifying, in priority, the functions performed in accomplishing that mission. A data base was then established listing US Counterobstacle equipment developed and used over the time period, together with the opposing threat capability over the same period. These capabilities were then compared in light of the counterobstacle mission. Wargame analysis was used to show the utility of the counterobstacle system over the timeframe, and to evaluate the utility of a single, multi-capable system, called a counterobstacle vehicle (COV) for the future.

The findings of the study include the following:

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CHAPTER I

INTRODUCTION

A. PURPOSE OF PROJECT

The purpose of this subcontract is to provide documentation and systems integration assessments to be used in program acquisition planning by the U.S. Army Belvoir Research, Development and Engineering Center (BRDEC). BRDEC is responsible for the development and management of engineer materiel used in the counterobstacle and countermine missions. The goal of the effort is to assist BRDEC in its development and acquisition plans for this materiel, and to determine the utility of a Counterobstacle Vehicle (COV), based on the application of management science techniques together with the expected missions, threats, environments, system alternatives, and new technology opportunities.

B. METHOD OF ANALYSIS

The above-stated goal is approached by performing a time-phased analysis portraying the interrelationship between counterobstacle equipment, missions and threats over the period from 1965 to 1995. Figure I-1 describes the process. Using this time frame, the analysis then demonstrates the applicability of U.S. counterobstacle equipment against a representative enemy threat, in appropriate scenarios, using wargame modeling techniques. Appropriate measures of effectiveness (MOE's) are developed to reveal the advantages of system capability improvements, and to compare the performance of competing alternatives. In addition, an analysis of the human factors involved in the counterobstacle systems was conducted, over the same time base and against the same enemy threat spectrum, to provide significant insights into the human dimensions involved. Comparisons of counterobstacle capability over the time frame are developed. From these analyses, documentation of the utility of a Counterobstacle Vehicle (COV) system is developed, which then provides a perspective in support of a COV systems acquisition/hardware integration plan, based on the role and utility of this combat engineer equipment.

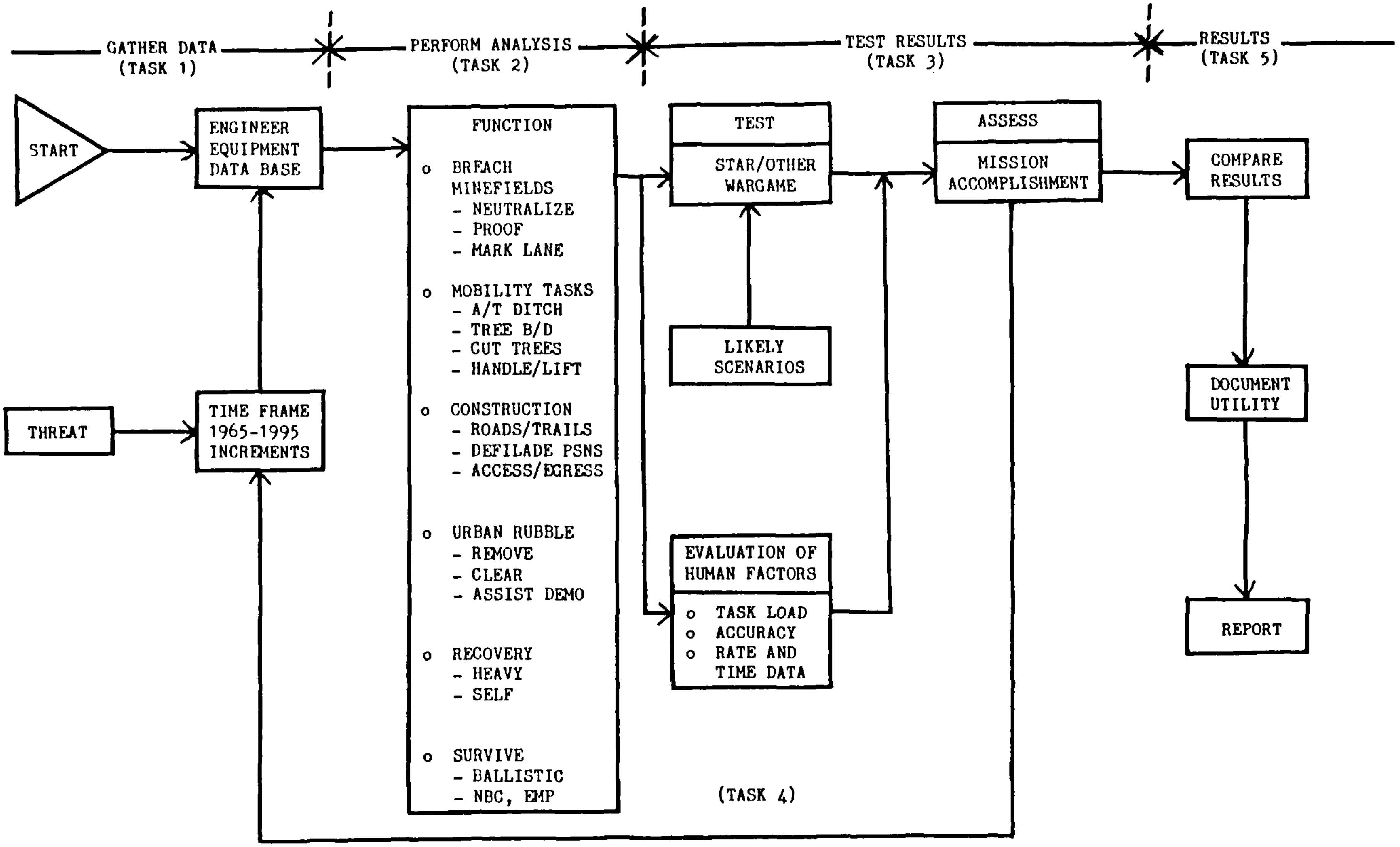


Figure I-1. COV Utility Study Process.

CHAPTER II

INVESTIGATION

A. BACKGROUND

Many of the major functions performed by combat engineers on the battlefield can be described in terms of ease of passage of combat forces through the battlefield. In the defense, it is normally to the defender's advantage to choose to defend in terrain through which is difficult for the attacker to move. Such terrain reduces the attacker's ability to concentrate combat power rapidly, and generally permits the defender to exact losses on the attacker's forces moving against defended positions. In addition to the difficulty normally associated with passage through natural terrain, the defender can erect man-made obstacles to enhance those that occur naturally. This is a major task for his engineers to accomplish. In support of offensive operations, on the other hand, the role of the attacker's engineer is to enhance his side's ability to pass through the terrain rapidly, thereby improving his advantage by reducing exposure to the enemy's weapons, and enhancing his ability to concentrate forces decisively at the critical points, as emphasized in the AirLand Battle and Army 21 concepts. This is the U.S. Army's counterobstacle mission.

For many years the U.S. Army has pursued development of various systems which can help overcome the natural and man-made obstacles erected on the battlefield to reduce an attacker's mobility. Recently the Army has embarked on a program to develop a single system with countermine/counterobstacle capability -- a counterobstacle vehicle (COV) -- to enhance the mobility of the combined arms teams on the battlefield. This COV must be able to counter existing and reinforcing obstacles, and to clear and mark lanes through areas mined by threat forces. The engineer systems that perform these multiple functions now tend to be slow, vulnerable, labor intensive, limited in quantity, and systematically unintegrated.

The COV concept is based upon the integration of counterobstacle technology to produce a single survivable vehicle which is capable of performing multiple mobility functions in mid- and high-intensity conflicts, in all terrain and weather conditions. For counterobstacle tasks, a COV will be equipped with arm(s) for digging, lifting, and grappling. Other functions, such as bulldozing, concrete/pavement breaking and tree cutting, provide combat engineers with a capability to perform combat road and trail construction, to support military operations in urban terrain, and to execute certain countermobility and survivability tasks. For countermine tasks, the COV will be equipped with a Full Width Mine Plow (FWMP) and may tow a projected line charge (MICLIC), and carry a lane marking system (CLAMS).

Since World War II, missions and requirements for combat engineering equipment have placed high emphasis on increasing mobility, survivability, accessibility, and reliability while reducing logistics support and operating costs. This, of course, is a tall order for engineering a system in view of the rapidly advancing threat systems. In order to clarify the role/utility and development guidelines for a counterobstacle/countermine vehicle, comparisons with old, current, and possible new systems are necessary. It is useful to consider these systems as part of a single overall counterobstacle system -- a

COS -- in order to put the role and mission of these parts of the overall concept in perspective. It is also useful to consider changes in the threat and concepts of operation as key factors also affecting the utility of this equipment.

Using a whole system approach in examining the mission of the counterobstacle system (COS) lends important insights to the concept of the engineer role in support of the mobility of Army combat systems. A single, survivable multifunctional vehicle capable of accompanying combat forces to, and assisting their passage through, the battlefield can greatly enhance their survivability and effectiveness in combat. This in turn can give better insights into the true value of such a system to the Army in its most meaningful terms -- those of mission accomplishment. By considering only parts of the full system mission, such as minefield breaching, or combat road and trail construction, and considering separate, relatively disparate pieces of equipment to accomplish these parts, we tend to view the counterobstacle mission piecemeal, and thus find it easier to dismiss, or overlook, its relative importance.

B. U.S. COUNTEROBSTACLE SYSTEMS (COS)

The time frame of relevance to the analysis is that from 1965 to 1995 -- or, viewed from the present, the period from 20 years ago to 10 years from now. Our task is to look at those U.S. and threat systems opposing each other over that time frame -- all within the counterobstacle mission area.

The counterobstacle mission area is outlined in the chart of Figure II-1. In addition to defining the mission area, the figure also sets forth the relative priorities of these missions, as established by the U.S. Army Engineer School (USAES). The area consists of those obstacles, both natural and man-made, that will act as deterrents to an attacker's mobility. It consists of minefield breaching means (1st priority task), of mobility enhancement in natural terrain by constructing combat roads and trails (2nd priority), and overcoming man-made obstacles, such as anti-tank ditches, improving access and egress from gaps, and clearing obstructions such as tree blowdown/abatis, log obstacles, urban rubble, and road craters (3rd and 4th priority). Added as last priority are supplementary missions that the equipment can accomplish when higher priority missions do not demand its use (EOD, Rapid runway repair, and certain earthmoving tasks).

Considering U.S. COS available to accomplish these missions over the time frame of the analysis produced the table at Figure II-2. The time frame quite naturally breaks down into three categories of systems: those existing at the start of the period (past capability -- 1965-70), those presently in the inventory of engineer counterobstacle equipment (current capability), and those planned for addition to the inventory in the near future, but not now available (future capability -- up to 1995). Note that many of the system components (individual items) have been in the inventory over 20 years (CEV, Dozers, AVLB, hand-held chain saws, hand-held mine detectors). Likewise, many are labor-intensive, and offer little or no protection to the operator in a combat situation, such as exposure to direct or indirect fire (hand-held detectors, chain saws, dozer, scoop loader). In many situations, the degree of exposure is unacceptable, but there is nothing else available to accomplish the mission. These individual pieces of engineer counterobstacle equipment are described in more detail in Annex A.

FUNCTION	Priority
MOBILITY:	
COUNTERMINE:	
DETECT	1
NEUTRALIZE	1
PROOF	1
MARK	1
COUNTEROBSTACLE:	
CREATE COMBAT ROADS AND TRAILS	2
CUT TREES	2
NEUTRALIZE ANTI-TANK DITCHES	3
PREPARE WET GAP APPROACHES	3
REMOVE TREE BLOWDOWN/ABATIS	3/4
NEUTRALIZE LOG OBSTACLES (CRIBS/HURDLES)	4
REMOVE URBAN RUBBLE	4
NEUTRALIZE ROAD CRATERS	4
ASSIST EOD TEAMS	5
PERFORM RAPID RUNWAY REPAIR	5
COUNTERMOBILITY:	
CREATE ANTI-TANK DITCHES	5
SURVIVABILITY:	
EXCAVATE FIGHTING POSITIONS/CP'S	5

Figure II-1. Countermine/Counterobstacle Mission Area and Priorities.

FUNCTION	PRIORITY	PAST CAPABILITY (1965)	CURRENT CAPABILITY	FUTURE CAPABILITY (1995)
MOBILITY:				
COUNTERMINE:				
DETECT	1	HAND-HELD DETECTORS PSS-11, PRS-7	HAND-HELD DETECTORS PSS-12, PRS-8	MIRADOR
NEUTRALIZE	1	M-157 LINE CHARGE M-173 PROJECTED CHARGE	M-157 LINE CHARGE MICLIC ROLLER	VEMASID MICLIC/ROBAT MICLIC/COV
PROOF	1		TWMP ROLLER	FWMP/COV ROLLER
MARK	1	ENGR TAPE	HEMMS	CLAMS/COV HEMMS
COUNTEROBSTACLE:				
CREATE COMBAT ROADS AND TRAILS	2	CEV, DOZER, SCOOP LOADER	M-9, CEV, DOZER, SCOOP LOADER	COV, M-9
CUT TREES	2	HAND-HELD CHAIN SAWS, DEMO	HAND-HELD CHAIN SAWS, DEMO	COV, DEMO
NEUTRALIZE ANTI-TANK DITCH	3	CEV, AVLB, DOZER	CEV, M-9, AVLB, DOZER	M-9, AVLB, COV
PREPARE WET GAP APPROACHES	3	DOZER, CEV, LOADER	DOZER, SCOOP LOADER, CEV, M-9	COV W/BUCKETS, M-9
REMOVE TREE BLOWDOWN/ABATIS	3/4	CEV, DOZER W/WINCH, CRANE	CEV, DOZER W/WINCH, CRANE, M-9	COV W/GRAPPLE, BUCKET, WINCH; M-9
NEUTRALIZE LOG OBSTACLES (CRIBS/HURDLES)	4	CEV (W/DEMO GUN), DOZER W/WINCH, CRANE	CEV, M-9, DOZER W/WINCH CRANE	COV W/GRAPPLE, BUCKET; M-9
REMOVE URBAN RUBBLE	4	CEV, DOZER	CEV, DOZER, M-9	COV, M-9
NEUTRALIZE ROAD CRATERS	4	CEV, DOZER	CEV, M-9, DOZER, LOADER	COV, M-9
ASSIST EOD TEAMS	5	CEV	M-9, CEV	COV, M-9
PERFORM RAPID RUNWAY REPAIR	5	CEV, DOZER, SCRAPER, SCOOP LOADER	CEV, M-9, DOZER, LOADER, SCRAPER	M-9, COV, DOZER/SCRAPER
COUNTERMOBILITY:				
CREATE ANTI-TANK DITCHES	5	DOZER, SCRAPER	M-9, DOZER/SCRAPER	M-9, DOZER/SCRAPER TEXS (SEE), COV
SURVIVABILITY:				
EXCAVATE SURVIVABILITY POSITIONS	5	DOZER	M-9, DOZER JD-410	M-9, SEE, COV JD-410

Figure II-2. U.S. Counterobstacle System Over Time.

C. THREAT ENVIRONMENT

The major danger to the functioning of these systems comes either from the obstacles themselves (primarily mines), or from threat weapons (direct or indirect fire). These are described in Annex B, which is deliberately separated from the main paper as Volume II, since it is classified. The weapons systems involved are broken out by the same time frame as the U.S. equipment (past, current, and future capability) to aid in establishing the analytical comparisons accomplished in the next section.

Chapter III

DISCUSSION:
Effectiveness Evaluation

A. OBJECTIVE

The effectiveness evaluation documented in this chapter was performed to determine the capability of the counterobstacle system (COS) of the U.S. Army to perform its mission over the timeframe of evaluation, that is, to establish a baseline performance of the COS, and to evaluate how that performance changes over the period, and to determine what capabilities are meaningful for a counterobstacle vehicle (COV). The COS referred to is the totality of the Army's materiel and doctrine developed to cope with obstacles to tactical maneuver. These obstacles can be both man-made, such as minefields or anti-tank ditches, or they might be natural obstructions, such as rivers or forested areas.

B. ROLE OF OBSTACLES ON THE BATTLEFIELD

1. Attacker's Perspective

In every case, when confronted with an obstacle, an Army unit has three options. First, it could employ resources to breach through the obstacle and continue on to the objective. Obstacle breaching is typically very expensive in terms of casualties and materiel losses because the enemy has purposefully positioned both the obstacles and its own forces to exact the greatest advantage in combat. Second, the Army unit could attempt to bypass the obstacle in order to reach the objective along a different route. However, natural bypasses are not always available, particularly within a narrow sector of operations, so the unit is forced to construct a bypass or to request permission to go out of its defined sector. Bypassing an obstacle results in lost time and resources, and often leaves the enemy force occupying some piece of defensible terrain which may have to be fought over again (although perhaps at a more convenient time). The third option is to be halted by the obstacle. The Army unit might be halted by a large river or significant compound obstacle for which no bypass or crossing means is available. In this case, the unit momentum is stopped and the schedule for taking objectives on the other side of the obstacle must be reconsidered. The enemy is given a chance to reorganize and improve his defense, thus making the obstacle even more formidable.

In general, and depending in large measure on the situation, terrain, and forces involved, the Army preferred approach to coping with obstacles is to bypass if at all possible, but breach if necessary to achieve the unit objective. The counterobstacle system is vital to the Army force by rapidly constructing bypass routes, and by directly penetrating obstacles in a fashion that reduces the obstacle's effectiveness. Without an available and effective counterobstacle system, the unit is halted by the obstacle and the objectives are not achieved.

2. Defender's Perspective

From the defender's point of view, obstacles accomplish three very specific purposes. First, they greatly reduce the attacker's ability to maneuver. Obstacles restrict his mobility and force the attacker to focus his resources on looking for a bypass or creating a breach. In either case, the attacking force cannot continue to advance across the entire section but must confine his mobility to specific regions within that sector. The most effective obstacles will completely halt the attacker. By denying maneuver, the defender gains time to reconstitute forces, to improve defenses, and to assemble resources at the points where the attacker remains mobile.

The second purpose of obstacles is to delay the attacking force so that it can be more effectively handled by defensive weapon systems. While the attacker is looking for ways around or through the obstacle, his forces remain vulnerable to the defender's direct and indirect fire weapons. This vulnerability to direct fire is particularly severe when surprised by an obstacle in open terrain. The force attrition achieved during this phase can significantly enhance the defender's advantage (for example, reducing the attacker's local force ratio from 5:1 to 4:1), thus making the remainder of the defense easier. Even when obstacles are breached or bypassed, the maneuver constriction causes the attacker's forces to be channeled and slowed as they traverse the relatively narrow gap (in a cleared lane through a minefield, for example). For the defender, this translates to a significantly reduced target presentation rate. His weapons can focus on vehicles both in the gap and on the concentrations at either end of the gap, making it very difficult for the attacker to move enough force across the obstacle to continue onward.

The third purpose of some obstacles, particularly mined obstacles, is to cause direct attrition on the attacking force. The attacker will suffer losses from the mines themselves upon encountering the mined area and upon breaching and traversing through it. In the absence of effective mine clearing resources, the losses due to mines could be substantial, depending on the mine potency and density. Mines achieve their lethality by attacking the relatively lightly armored underside of the attacking vehicle which is not normally exposed to defensive weapons. Other obstacles, such as anti-tank ditches, may also briefly expose the vulnerable vehicle underside but they rely on direct fire weapons to achieve a vehicle kill.

With these specific advantages provided by obstacles, the defender will employ them whenever the time is available to prepare them. The more time he has, the better the obstacles will be.

3. Generic Assessment of Obstacles

For those situations where an obstacle must be confronted and breached, the battle dynamics can be illustrated in a highly simplified generic sense. Figures III-1 and III-2 provide stylized graphs of the attacker's losses in a hypothetical attack situation as a function of distance to the objective and duration of the attack. These charts depict the general nature of results to be derived from combat models when those results are averaged over sufficient replications to reduce the statistical variations between any two samples. In both charts, the loss curves are shown first for a battle without the presence of obstacles. For the purpose of illustration, the attacker reaches the

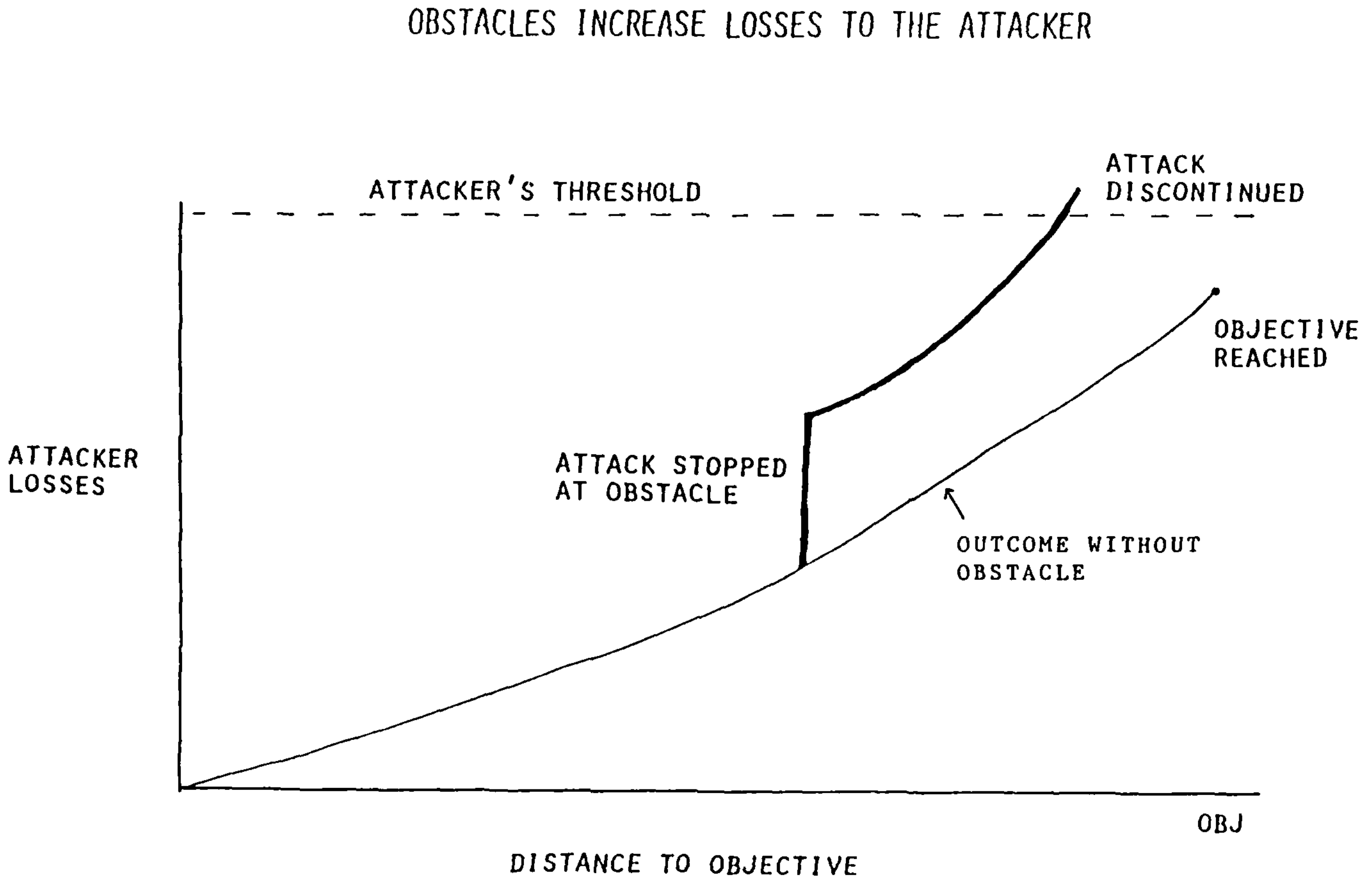

OBSTACLES INCREASE LOSSES TO THE ATTACKER

Figure III-1 Attacker's Losses Versus Distance to Objective **(Hypothetical)**.

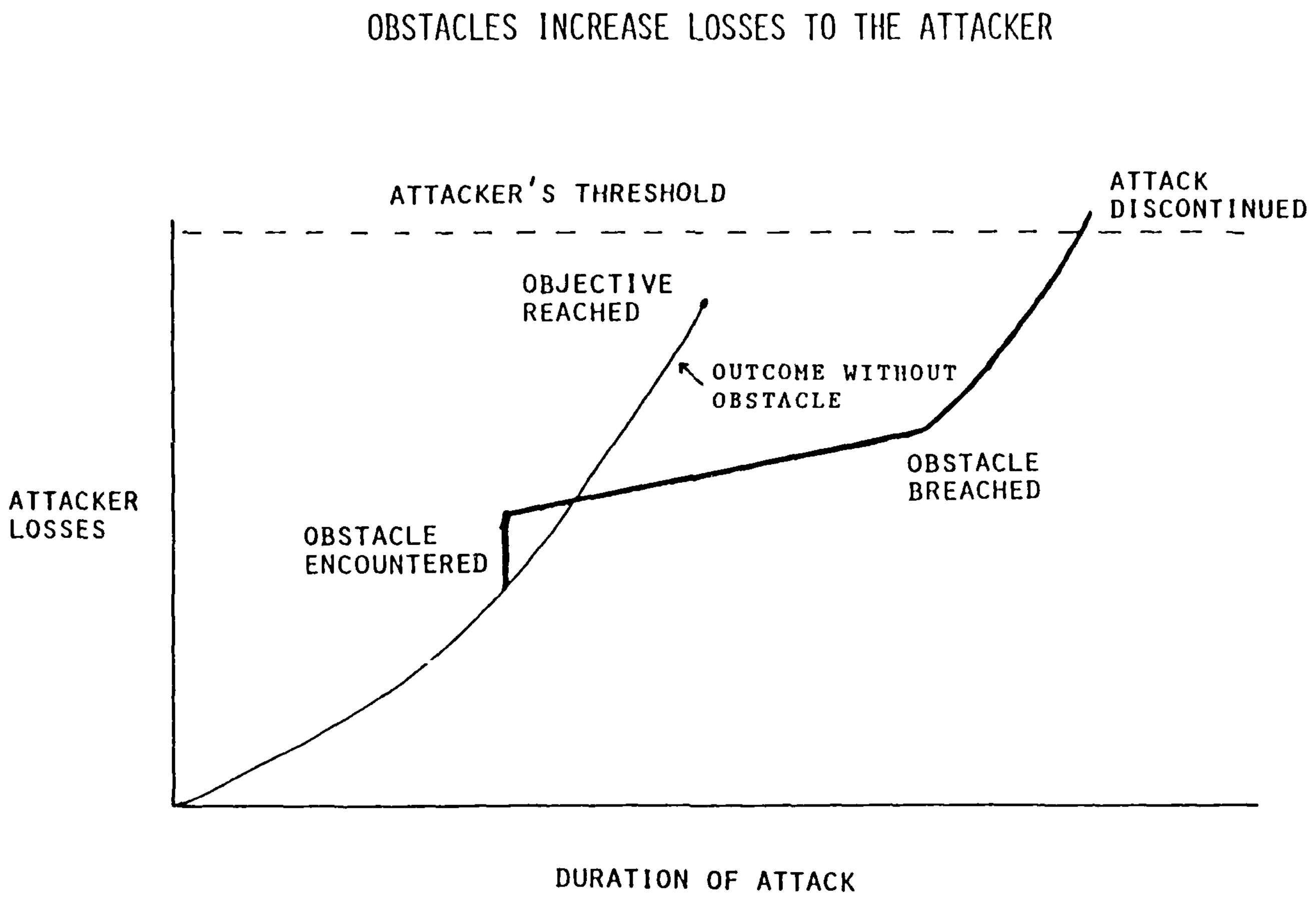


Figure III-2 Attacker's Losses Versus Duration of Attack **(Hypothetical)**.

objective at some point sustaining losses below his physical or psychological threshold. In a battle with obstacles, the attacker's losses increase as shown by the heavier curves. In terms of distance, the attack is stopped at the obstacle and losses are sustained until such time as the attack can be continued. The time-based graph illustrates the two components of those obstacle-related losses. First the losses are related to the unanticipated encounter with a lethal obstacle such as a minefield. At that point, the forces assume a much more protected position as the breaching resources are sent forward. Still, losses due to direct and indirect fire are sustained as the assault and overwatching forces must provide suppressive fire on the defense. This is the second component of the obstacle-related losses. After the obstacle is breached, the attack continues more slowly and losses accumulate more rapidly (as the force is funneled through the breach, and the force ratios have narrowed).

What the defender hopes to achieve is to increase the attacker's losses above the physical and psychological threshold so that he will discontinue the attack before the objective is reached. In this process he hopes to influence the psychological threshold downward by inflicting substantial casualties and high loss rates from multiple sources. The attacker, on the other hand, hopes to reach the objective with sufficient remaining forces to secure it, while forestalling the psychological pressure through a continuous advance toward the objective. Therefore, it is important to him psychologically to maintain some forward progress (momentum).

C. COS PERFORMANCE -- UNOPPOSED

1. General

In order to evaluate the capability of the COS to perform its mission over the time frame in question, we need to examine the battlefield performance of the various items of equipment that make up the system in the face of threat forces. First, however, it will be necessary to examine the unopposed performance capability of the system over the time frame. This can be determined by looking at representative missions, in priority, and by equipment capability. Figure III-3 lists, by mission and priority, the performance comparisons examined over the time frame. This evaluation does not look at all the possible counterobstacle missions listed in Figure III-2, but these missions are representative of those occurring in each priority, over the time frame of interest. The equipment listed is that available in the period, and the best available for the mission.

MISSION	PRIORITY	EQUIPMENT		
		PAST (1965)	CURRENT	FUTURE (1995)
MINEFIELD BREACHING	1	M173	MICLIC ROLLER	MICLIC COV
COMBAT ROADS & TRAILS CONSTRUCTION	2	CEV	M-9 ACE	COV
NEUTRALIZE ANTI-TANK DITCH	3	CEV	M-9 ACE	COV
NEUTRALIZE LOG CRIB OBSTACLE	4	CEV	CEV	COV
MISCELLANEOUS - DIG HULL DEFILADE POSITION FOR TANK	5	D-7 DOZER	M-9 ACE	COV

Figure III-3. Representative Mission/Equipment Scenarios Over Time (1965-1995)

2. Hasty Minefield Breach, (Priority 1)

a. Past capability (1965-1970): Neutralization of the minefield was undertaken by the M173 projected charge demolition kit in the mid-60's. When deployed, it cleared a path 4.6 meters wide by 83 meters long, somewhat less than the desired 100 meters. The skid-mounted device was towed into position by a prime mover (tank, CEV, etc), after a 45 - minute preparation period. After disconnecting and relocating to establish a standoff, the device was then set up by remotely removing the cover, positioning the rocket propelling motor, then firing it to extend the line charge into the minefield. The extended charge was then detonated to create the path described above, by actuating the pressure fuzes of the mines laid there. The total time required to employ the M173 is 60 minutes -- 45 minutes to prepare (at a remote location), 10 minutes to bring to the employment site, and 5 minutes to set up and fire (1). For comparison purposes, the best employment time for the M173 is 15 minutes.

b. Current capability: In the current time period, this breaching technique is still planned for and used (2). However, the M173 is being replaced with the Mine Clearing Line Charge (MICLIC), which is an improved rocket-deployed line charge. This trailer-mounted device clears a lane 8 meters wide and 100 meters long. It can be employed in (an estimated) 30 seconds (3), which represents a major increase in capability, since it does away with the lengthy set up and firing time of the M173. Current employment doctrine calls for proofing the MICLIC - cleared lane with roller or plow, an action requiring 1.2 minutes only for 100 meters at the accepted planning rate of 5 kph for roller employment (4). However, time to bring the roller or plow into position needs to be included -- leading to a reasonable planning estimate of 5 minutes additional. This yields a total breaching time of 7 minutes for the MICLIC and roller.

c. Future capability: For the future, the COV is envisioned as capable of towing the MICLIC itself. This would permit employment of the MICLIC followed by the immediate proofing of the cleared lane by the FWMP of the COV. Current performance data of the experimental prototype yields a plowing rate of 2 to 3 kmph, yielding a plowing time of 3 minutes to proof the 100-meter lane of the MICLIC. The total breaching time therefore becomes 4 minutes, using these planning figures.

d. Summary: Employment times over the period, for the breaching systems involved, are therefore:

Past Capability - 15 minutes
Current Capability - 7 minutes
Future Capability - 4 minutes

3. Construction of Combat Roads and Trails (Priority 2)

a. Past Capability: In 1965, the CEV was newly available for this kind of rough work, which was an appropriate task for it in the forward area. The CEV was well-equipped to handle the earthmoving requirement with engineer squad support, using chain saws to remove trees involved. Planning factors range from 75 minutes per 100 meters of trail for wooded areas, to 20 minutes per 100 meters for non-wooded areas (5).

b. Current Capability: In the current period, the M-9 ACE replaces the CEV, at a 20% increase in production rate. Tree clearing still requires dismounted engineers with chain saws, which in wooded terrain is still the pacing activity. Planning factors range from for 60 minutes per 100 meters of trail (wooded), to 15 minutes per 100 meters of trail (non-wooded) (6).

c. Future Capability: Employment of COV for construction of combat roads and trails offers primarily increased protection in a hostile environment. With a bulldozer capability equivalent to a heavy dozer (D-8) and possibility of use of a tree cutting device on the end of the telescopic arm, it is possible for the first time to construct a road or trail in a protected environment (from NBC or indirect fire). Production rate can be estimated to range from roughly equivalent to current capability, to significantly improved (7).

d. Summary: Counterobstacle system construction rate for the combat roads and trails mission are, therefore:

Past Capability : 20 to 75 minutes per 100 meters
Current Capability: 15 to 60 minutes per 100 meters
Future Capability : 15 to 60 minutes per 100 meters

4. Neutralize Standard Threat Anti-Tank Ditch (Priority 3)

a. Past capability: The CEV with its armored protection and earthmoving capability, provided a viable means of crossing an anti-tank ditch under fire. The CEV can cross a standard threat anti-tank ditch in 0.145 hours, approximately 9 minutes (8). See Annex B for a more detailed description of the anti-tank ditch.

b. Current Capability: The M-9 provides a protected earthmoving capability that can cross a standard threat anti-tank ditch under fire. The current planning factor for M-9 accomplishment of this task is 7 minutes (9).

c. Future Capability: The COV prototype has completed testing, and is capable of crossing a standard threat anti-tank ditch in 2.5 minutes if configured as a bulldozer, or in 4.5 minutes if configured as a mine plow. This permits a conservative estimate of 4.0 minutes.

d. Summary: The counterobstacle system capability to cross a standard threat anti-tank ditch, over the period in question is, therefore:

Past Capability :	9 minutes
Current Capability:	7 minutes
Future Capability :	4 minutes

5. Neutralize Log Crib Obstacle (Priority 4)

a. Past and Current Capability: The best method of attack on this obstacle is using the CEV's demolition gun. This 165mm gun fires a round containing 34 lbs of high explosive which detonates upon impact with the target. Current employment doctrine is the same now as it was in the 60's, hence the method of attack is the same for both periods (past and current capability). Applicable production data can be readily calculated for use of this round. FM5-101, Mobility, gives attack doctrine for a log crib (10), stating the round should be aimed low at the center of mass on the target. Dimensions of the crib are also given in FM 5-101 (11), showing the thickness of the log and earth structure as 2.3 meters (7.5 ft). FM 5-25, Explosives and Demolitions, gives a table of breaching charges for reinforced concrete, and conversion factors for other materials (12). It lists the amount of explosive required for untamped breaching as 410 lbs of TNT. The adjustment factor for earth and timber vice concrete is 0.5, giving the necessary charge at 205 lbs of TNT. Since a round carries only 34 lbs, it would appear that six rounds would be required to breach the crib. However, after the first round strikes, it is likely that the second may bury itself somewhat before detonating, thereby obtaining a tamping factor, making the charge more effective. However, it is also likely that the crib needs to be breached in more than one place. Therefore the crib needs to receive a minimum of 3 to 5 rounds in order to destroy enough of it that the CEV can clear through the rest with its dozer blade. It is estimated that four rounds would require at least as many minutes to load, aim and fire, plus another 5 minutes would be required to close with the remains of the crib and to doze through enough of it to create a passage for follow-on vehicles.

b. Future Capability: The COV prototype has developed test results stating that it can satisfactorily clear through a log crib obstacle in 8.9 minutes.

c. Summary: From this analysis, we see that the counterobstacle system ability to neutralize a log crib obstacle, over time is substantially the same. This is significant, since it says that the COV can breach this type of obstacle without a demolition gun in the same time as it could be done with a demolition gun before:

Past and Current Capability: 9 minutes
Future Capability : 8.9 minutes

6. Dig Hull Defilade Position for Tank (Priority 5)

a. Past Capability: Creation of a primary tank fighting position required a D-7 dozer to efficiently prepare the position. Planning factors allotted 0.45 hour = 27 minutes for this task (13).

b. Current Capability: The M-9 ACE will be available to perform survivability tasks of this nature. Current production factors call for the same performance for the M-9 (27 minutes) (14). However, protection of the operator from hostile fire while preparing positions is available with the M-9, as opposed to the dozer.

c. Future Capability: The production data for the COV prototype places construction of a hull defilade position for the M-1 at 32 minutes.

d. Summary: Construction of hull defilade fighting positions by the counterobstacle system, over time, has remained substantially the same:

Past and Current Capability: 27 minutes
Future Capability : 32 minutes.

D. COS PERFORMANCE -- OPPOSED

1. Methodology

a. Analysis Concepts: In order to evaluate the capability of the counterobstacle system to perform its mission over the time frame chosen, we need to examine the battlefield performance of the counterobstacle system in the face of threat forces. This is accomplished in this section by using combat modeling techniques. In the unopposed performance section just preceeding this, the known performance results of the experimental prototype COV were used to demonstrate an achievable level of performance. In the analysis described in this section, the COV was treated as a generic component of the counterobstacle system, without evaluating the performance of the existing COV prototype developed by BMY Corporation for the Army. Thus, the focus was placed on a parametric treatment of key performance measures for a COV so that engineering design and cost trade-offs could be made.

b. Measure of Effectiveness: Although there are many measures of effectiveness (MOEs) that could be utilized in a counterobstacle systems analysis, most pertain to specific engineer-related considerations which are of little intrinsic appeal to the non-engineer Army community. Particularly for the COV, which is capable of advancing with modern tank forces, the performance emphasis has to be placed on its contribution to winning battles in which obstacles are employed. Figure III-4 summarizes the critical MOE for counterobstacle equipment of all types. It is tied directly to the losses sustained by the attacking force. By reducing losses, counterobstacle equipment allows a greater fraction of the attacking force to reach the

MOE FOR COUNTEROBSTACLE EQUIPMENT

TO THE EXTENT THAT IT IS EFFECTIVE, COUNTEROBSTACLE EQUIPMENT BUYS A REDUCTION IN THE NUMBER OF ATTACKER'S LOSSES IN A COMBAT ASSAULT

- BY REDUCING EXPOSURE TIME (BATTLE DURATION)
- BY REDUCING DIRECT LETHAL EFFECTS OF OBSTACLE
- BY REDUCING ADDITIONAL EXPOSURE OF EQUIPMENT VULNERABILITIES

Figure III-4 MOE for Counterobstacle Equipment objective and hence to pursue future missions. It improves the attacker's psychological threshold by continuing the momentum of attack and reducing the loss rates and diversity of the defensive threat.

c. <u>Performance Limits:</u> In stating that counterobstacle equipment reduces losses, it must be noted that the equipment cannot be expected to reduce losses to a point below those sustained when obstacles are not employed. Indeed, the <u>ideal</u> performance of counterobstacle systems would be achieved when the battle progresses as if there were <u>no</u> obstacles present.

At the other limit, the performance of specialized counterobstacle materiel rests on a foundation of accumulated doctrine, common sense and general purpose equipment which are used to support obstacle crossings, or even to cross obstacles in the absence of dedicated equipment. For example, minefields can be cleared by hand. This is an expensive course of action in terms of human losses, but it has been done in past battles and will almost certainly be done in future ones. As an expedient, a damaged tank hull can be pushed through the minefield ahead of an operational tank to clear mines. No matter what materiel is used in the assault it will be supported by suppressive direct and indirect fires, smoke, and the use of all possible means to cover, conceal and deceive. These actions do not need specialized counterobstacle equipment but do represent some floor of counterobstacle capability. Therefore, the specialized equipment operates in the gap between the floor and the ideal capabilities of the counterobstacle system.

Existing materiel already spans some of that gap. To the extent that it can be made available in the counterobstacle assault, this equipment will contribute to the success of the battle. New materiel should reduce that gap even further, by demonstrating superior performance or through increased availability of specialized equipment. Thus, the performance limits and MOE are tied together as follows:

```
                         LOSSES TO ATTACKER
+-----------------+---------+---------+--------+---------------+
0                 A         D         C        B            100%
               (Ideal)    (New)  (Existing) (Floor)
```

The difference C-A represents the additional losses sustained in a combat assault when facing obstacles and using some set of existing counterobstacle equipment. The difference C-D represents the losses recovered by introducing some new capability in addition to or as a replacement for some existing materiel. The ratio (C-D)/(C-A)*100 is the percent reduction in additional losses gained as a result of the new equipment. A 100% reduction indicates an ideal new counterobstacle system, while a 0% reduction indicates an ineffective new system.

d. <u>Combat Modeling:</u> These analyses have to be based on detailed combat modeling to establish the loss rates and signficance of performance data in any particular scenario. We know of only two existing models that have sufficient detail of both direct fire combat and engineering activity to support these analyses. The STAR model is a derivative of CARMONETTE and is available at the Engineer School Directorate of Combat Developments. It is a large simulation, written in Simscript 2.0, with about 500,000 individual input data items. A single run requires a run definition file of about 10,000 lines and requires about one hour of computer time per battle replication modeled.

Run results are presented as event histories of each replication, with typically twenty (20) replications being performed for each combat situation. Not surprisingly, establishing the correct run definition file, operating the computer, and printing and interpreting the results is an extremely lengthy and manpower intensive process.

The second available model is COUNTERCOM, which is a combat simulation developed by BRDEC to look at the interaction between combat forces and countermine/counterobstacle equipment. COUNTERCOM is written in FORTRAN for the BRDEC CDC computer and requires about five minutes of computer time for complete simulation and results analysis of twenty (20) replications of a battle situation. The run definition file for COUNTERCOM is usually less than 1000 lines with an additional 10,000 data items maintained in a generic data base.

For these analyses, MRC attempted to extract data from scheduled Engineer School STAR runs. However, due to difficulties encountered in running the model and in interpreting the run results, the data was not made available to MRC in sufficient time to meet the analytical requirements. Instead, previously documented COUNTERCOM runs were used to establish the appropriate loss rates (15). The choice of models is significant only in the computation of actual expected losses. Every model has its inherent biases and none can be expected to recreate precisely the complexity, randomness, and diversity of combat. All that can be hoped is that the model represent performance trends correctly so that differences in average combat outcomes can be attributed to capability differences reflected in the input data.

e. Specific Situation and Results:

(1). Combat Situation Without Obstacles

The specific situation modeled in the COUNTERCOM runs was a U.S. Battalion (+) Task Force consisting of M113 armored personnel carriers mounted with TOW wire guided missiles and M60A3 main battle tanks attacking a Soviet Motorized Rifle Company armed with SAGGER anti-tank guided missiles mounted on BMP armored personnel carriers. In this attack the US force began with a 5 to 1 advantage (53 to 10 vehicles). The attack was conducted across relatively open European terrain with company teams advancing on two axes to the objective with the third company team in overwatch.

It is recognized that the specific COUNTERCOM runs compare weapons technology associated with the period identified as "Past capability" in this study, and that the U.S. force should consist of M-1 Abrams tanks armed with 105 mm guns and M-2 Bradly IFV's with TOW missiles. Likewise, threat forces should be armed with SPANDRELL anti-tank missiles to reflect current battle capabilities. However this analysis contends that the relative improvements in both sides' capabilities from the past to current period tend to be offsetting, and while the specific numbers would vary, the relative outcome would not. Therefore, this model correctly reflects that relative outcome and can be used to correctly predict the performance capabilities of present and future systems in force-on-force simulations. This contention should be confirmed by comparison with the outcomes of the STAR or other analyses, when available (16).

On the average, without obstacles, the battle duration was 760 seconds and the attacker lost 17.2 vehicles (32.5% of his force). An analysis of these runs indicate in general the following losses to the attacker from all causes (specifically excluding obstacles since they were not played). Note that loss rates for attacking vehicles drop dramatically in the final 500 meters which is due in part to the reduced effectiveness of defending anti-tank guided missiles at close range.

DISTANCE TO OBJ (M)	BATTLE DURATION (SEC)	# ATTACKERS	# LOST	LOST/SEC	FRACTION LOST/SEC
ATTACKING TANKS					
2500-1500	0-300	10.00	1.19	0.0040	0.00040
1500- 500	300-600	8.81	0.90	0.0030	0.00030
500- 0	600-760	7.91	0.30	0.0019	0.00019
ATTACKING APCS					
2500-1500	0-300	24.00	1.04	0.0035	0.00015
1500- 500	300-600	22.96	4.16	0.0139	0.00058
500- 0	600-760	18.80	1.04	0.0065	0.00027
OVERWATCHING VEHICLES					
2500-1500	0-300	19.00	1.88	0.0063	0.00033
1500- 500	300-600	17.12	3.78	0.0126	0.00066
500- 0	600-760	13.34	2.95	0.0184	0.00097

(2) Addition of Obstacles

When obstacles were positioned in the battlefield region from 500 to 1500 meters from the objective, the attacker's losses to non-mine kills on the average increased linearly with the extra time spent breaching and traversing the obstacle. Losses were not confined to the assault vehicles, but to the overwatching forces as well who continued to provide suppressive fires. On the average, the loss rate was 0.0003 of the total force lost per second during that period. Comparable values in similar situations modeled in COUNTERCOM ranged from 0.0005 to 0.0002 of the total force lost per second, providing confidence that the loss rate obtained for this situation is within the nominal range.

(3) Derivative Methodology

The data presented above suggests that a simple relationship can be used to represent attacker's average losses in a counterobstacle situation:

Expected Losses = Battle Losses without Obstacles
+ (Expected Extra Time Spent Breaching and Traversing Obstacle) * (Average Loss Rate While Breaching and Traversing Obstacle) * Original Force Size
+ (Expected Remaining Mine Density in Breach Lane) * (Average Lane Width Swept by Following Vehicles)
+ Expected Losses to Counterobstacle Equipment

The key then lies in computing the expected extra time spent in breaching the obstacle, the expected remaining mine density (if any) in the breach lane, and the expected losses to counterobstacle equipment. Naturally, these numbers will vary with the numbers of items available at the start of the battle, and at key points during the battle. A decision tree approach is used to enumerate the possibilities and assign outcome probabilities at each branch of the tree. Suppose that a roller tank and a plow tank are available at the outset of the battle. Suppose also that the roller and plow are equally likely at 80% to survive up to the obstacle (a minefield in this example), that is, Psr = Psp = 0.8, and that both survive 90% in the obstacle breach (Psmr = Psmp = 0.9) while each being 90% effective (EFF) in neutralizing mines in the lane, taking 300 seconds (te) to perform the breach. Then the expected results are computed as follows:

OUTSET	START OF MINEFIELD	END OF MINEFIELD	EVENT PROBA-BILITY (Pe)	CO LOSSES	EXTRA TIME (te)	REMAINING MINE DENSITY
ROLLER + PLOW (1.0)	ROLLER + PLOW(.64)a	ROLLER,PLOW(.81)b	.5184f	0	300	.01g
		ROLLER (.09)c	.0576	1	300	.06h
		PLOW (.09)d	.0576	1	300	.06
		NEITHER(.01)e	.0064	2	225	.28
	ROLLER (.16)	ROLLER (.90)	.1440	1	300	.10
		NEITHER (.10)	.0160	2	150	.55
	PLOW (.16)	PLOW (.90)	.1440	1	300	.10
		NEITHER (.10)	.0160	2	150	.55
	NEITHER (.04)	NEITHER(1.00)	.0400	2	0	1.00
EXPECTED RESULTS				0.56i	282.72j	0.10

NOTE: Decision tree probabilities calculated thus:

a) Psr * Psp = (0.8) * (0.8)
b) Psmr * Psmp = (0.9) * (0.9)
c) Psmr * (1-Psmp)
d) Psmp * (1-Psmr)
e) (1-Psmp) * (1-Psmr)

f) Pe = a) * b)
g) (1-EFF) * (1-EFF)
h) see next section
i) E[CO Losses] = Pe * CO Losses
j) E[Time] = (Pe * te)

Using this data in the derivative methodology, then

$$\begin{aligned}\text{Expected Losses} &= 17.2 + (282.72)(0.0003)(53) \\ &\quad + (0.10)(5.0) \\ &\quad + 0.56 \\ &= 22.76 \text{ vehicles lost}\end{aligned}$$

This represents a 32.3 percent increase in losses over the ideal case where no obstacle was present.

2. Parametric Performance Against Minefield

a. Obstacle Definition

In this instance, the obstacle to be breached is a nominal protective minefield with the following characteristics:

Density -- 1.0 mine per meter
Depth -- 100 meters
Location -- 500 - 1000 meters from objective

Because the countermine vehicle does not know exactly where the minefield is located, the countermine action is taken for 250 meters. The cleared lane is 4.5 to 5 meters wide, while the countermine vehicle's presented frontal area is 3 meters. It is assumed in this analysis that the countermine vehicle's survivability due to direct fire is approximated by that of a tank. The objective of this analysis is to determine the speed and mine clearing effectiveness required of the countermine system.

b. Formulation For Expected Mine Density

The formulation for the expected mine density remaining after a successful breach is a linear function of the time taken to cross the minefield since the probability of being killed from direct fire while in the minefield is approximately uniform over time and since the probability of reducing the mine density is linear over the distance traversed. Figure III-5 depicts the general probability distribution of mine densities for the case when there is one countermine vehicle. Figure III-6 depicts the probability distribution of mine densities for the case when there are two countermine vehicles. Derivation of the formulas, and the consideration producing these curves is contained in Annex C of this report.

c. Application of Mine Clearing Line Charge (MICLIC)

The application to the above minefield obstacle of the mine clearing line charge as a countermine device represents the capability to rapidly achieve a reduced expected mine density at the expense of some additional time penalty and resulting direct fire losses. By doctrine, the line charge will be employed in advance of any plowing or rolling activity, and if necessary will be the only countermine action if the other countermine resources are lost.

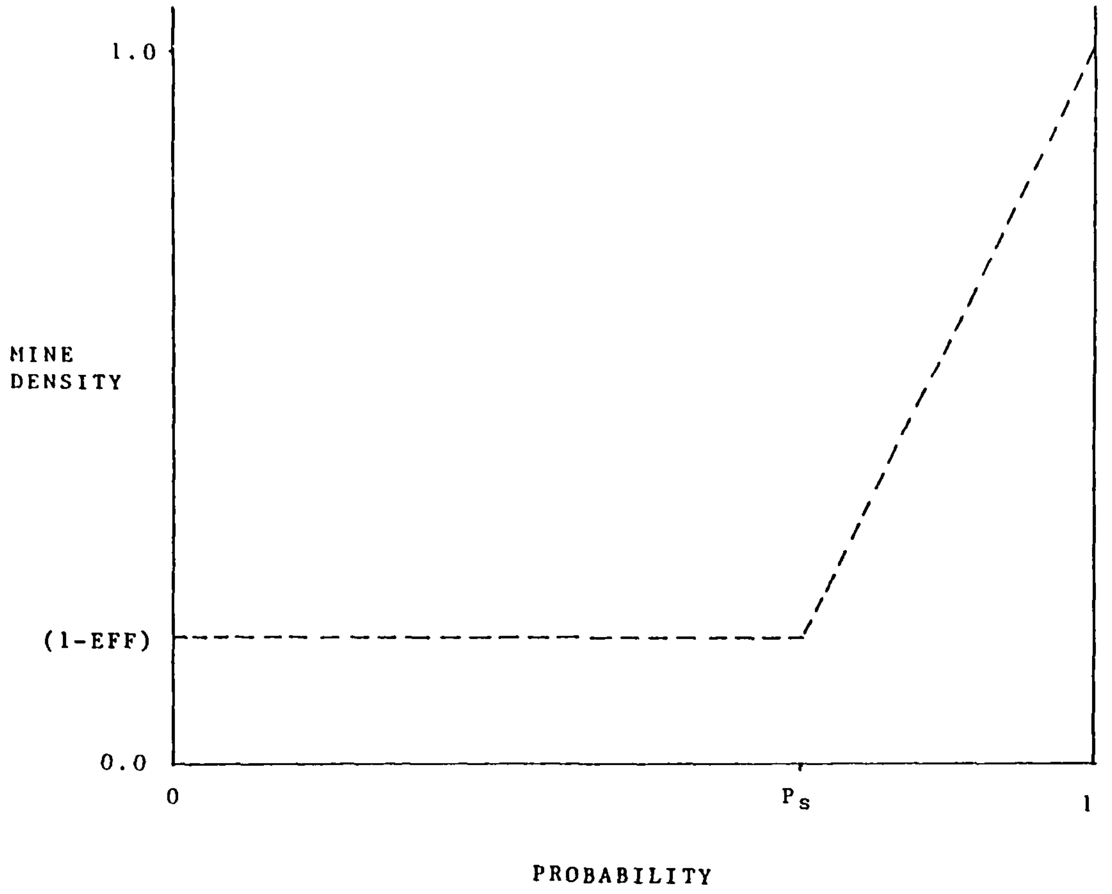


Figure III-5 Probability Distribution of Mine Densities for a Single Countermine System

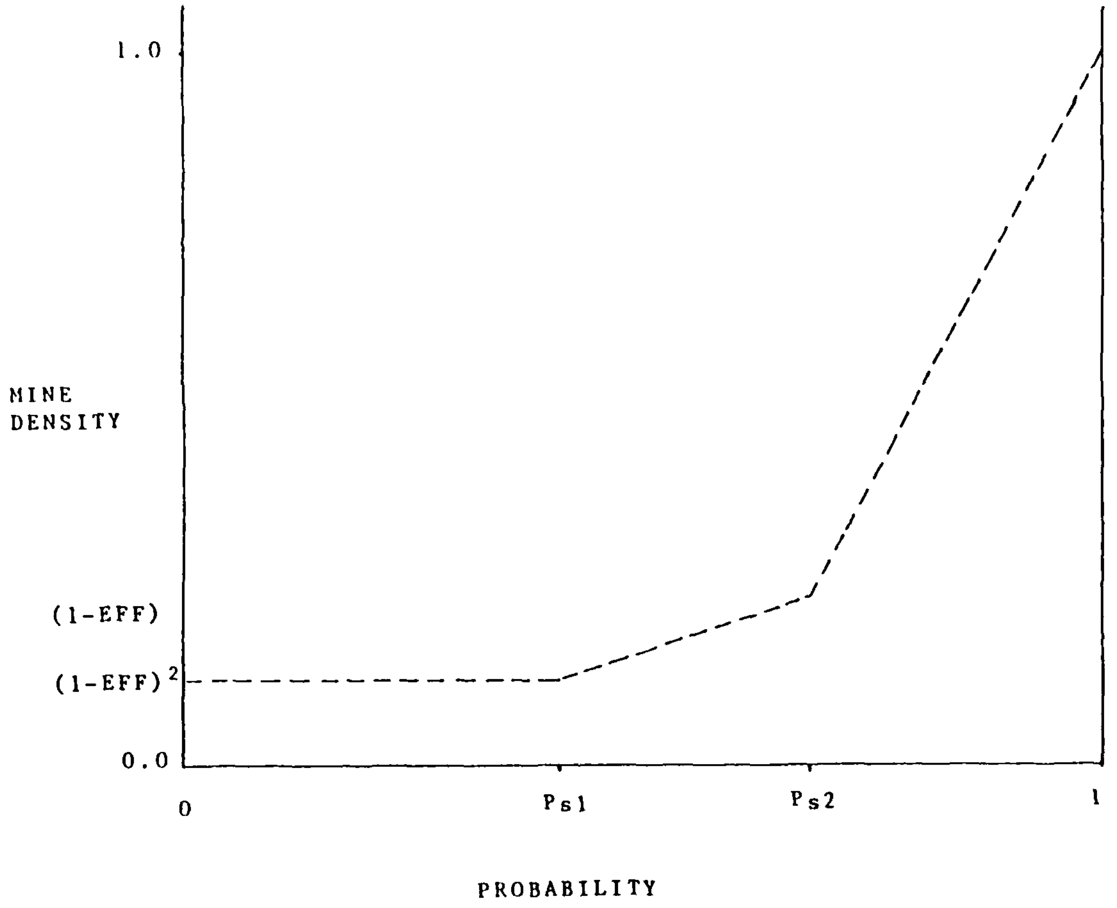


Figure III-6 Probability Distribution of Mine Densities for Two Countermine Systems

The major limitation of the line charge is its operable length of approximately 100 meters. This either demands precise and fortuitous application on the 100 meter deep minefield, or the use of two line charges in succession. Since joining two line charge lanes is difficult to achieve in practice, it is unlikely that the tactical commander would attempt this action. Thus, the lane can expect only one line charge application, followed by subsequent proofing actions of rollers and/or plows.

The critical issue in evaluating the impact of a line charge is the set up and firing time in an exposed position. During this period, the entire force is sustaining casualties. It is essential that this time be minimized. The MICLIC represents a significantly improved line charge over the M173 in this respect. As seen below, the time spent in exposed positions can be crucial to the attacker:

	M173	MICLIC
Additional Time (minutes) in Exposed Position	5.0	0.5
Additional Losses to Attacking Forces (percent)	9.00	0.90

The time invested might be considered well spent since the line charges are effective at clearing mines (90-95%) and they make a wide lane (8 meters). This compares to 1.2 minutes to operate a roller through the same 100 meters, producing a much narrower lane. Disregarding the lane width difference, the MICLIC could be considered equivalent to a roller or plow operating at 12.0 kmph over that 100 meters. The lane width advantage of the line charge is reduced by its relatively short and defined length which may not have completely spanned the minefield.

d. Results

There are two major concerns in the design of the countermine capability for the counterobstacle system. First is the speed at which the mined area is cleared, and second is the effectiveness with which mines are neutralized. The initial analysis evaluated the Percent of Attacking Forces Lost as a function of the speed of the countermine system given that the mine clearing effectiveness = 0.90. Figure III-7 shows these results when one and then two countermine systems per lane are employed. Naturally, having two countermine vehicles per lane improves the resulting force survival likelihood since the probability of achieving a completely cleared lane is enhanced. The improvement is somewhat overshadowed by the scale of the graph and the impact of speed on the performance of the countermine system. The reader is reminded that in the obstacle-free case 32.5 percent of attacking force is lost.

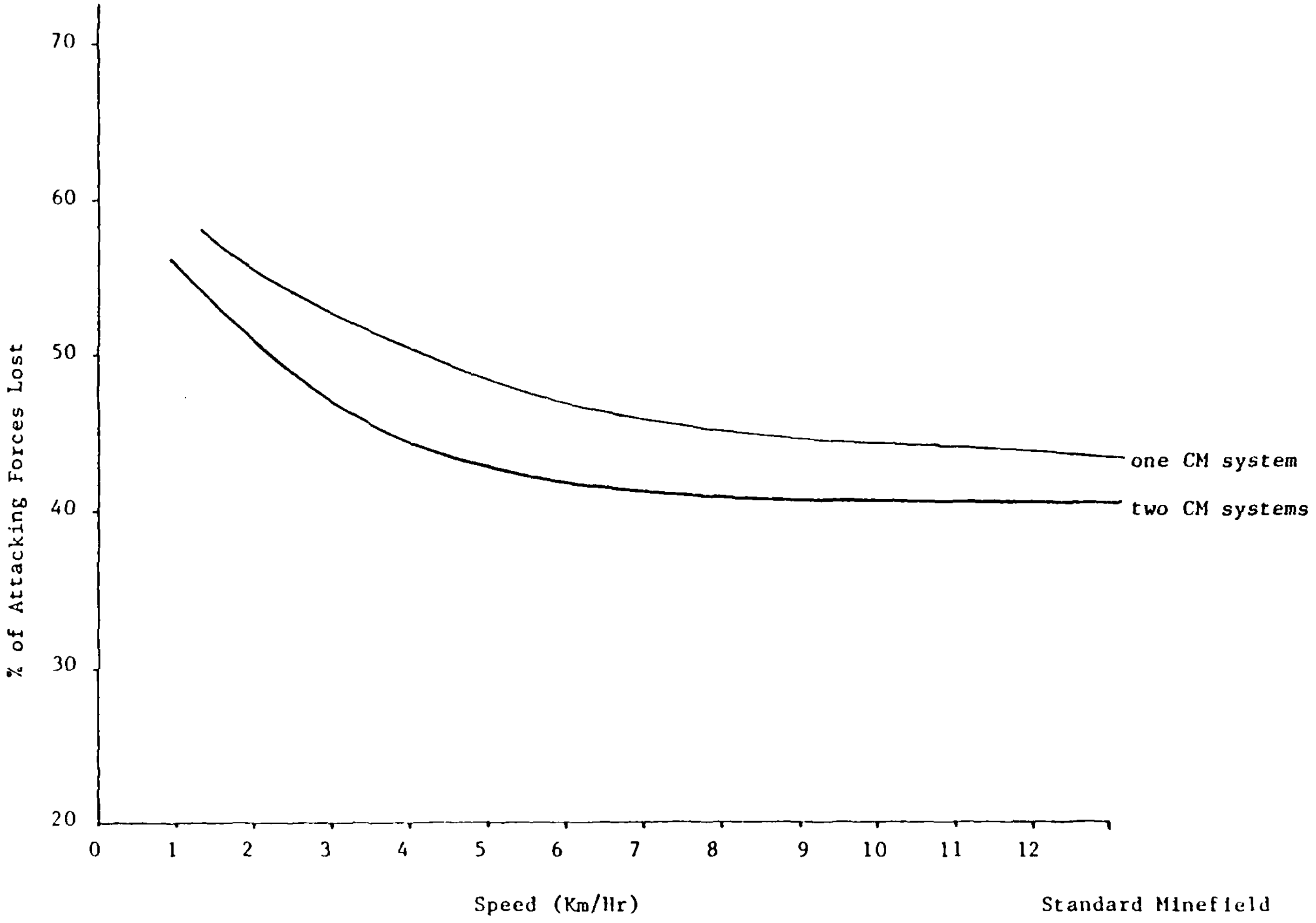


Figure III-7 *Percent of Attacking Forces Lost Versus Speed for* Both One and Two Countermine Systems

3. Parametric Performance Against Compound Obstacle

a. Obstacle Definition

Against a compound obstacle, the performance of the countermine system is more taxed and has greater implications on the success of the combat situation. For this analysis the compound obstacle is made up of a minefield, an anti-tank ditch, and another minefield. The characteristics of each minefield are the same as the minefield only situation used earlier. Each minefield is 100 meters in depth with a density of 1 mine per meter of front. The anti-tank ditch is positioned between the two minefields and is of standard trapezoidal construction (see Annex B for description). The compound obstacle is positioned in the range from 500 to 1000 meters from the objective and is without bypass. Again, countermine action will preceed (for 250 meters) the ditch crossing activity, after which is a second countermine phase (for 250 meters).

In this compound obstacle, the anti-tank ditch becomes the critical factor in determining if the obstacle is successfully breached. This is due to the fact that if there is no vehicle equipped to reduce the ditch, then the attack cannot proceed. The attacker is forced to withdraw to covered positions and then advance dismounted infantry with explosive charges to reduce the ditch walls. This is such a time and resource consuming step that the attacking commander might well seek to bypass the objective outside of his maneuver sector.

The vehicles represented in this analysis included a generic COV, a CEV, a tank mounted plow and a roller in various combinations. The COV and the CEV are capable of breaching the ditch; the roller and plow are not. Therefore, if after breaching the first minefield only the roller or the plow survives, there is no remaining equipment capability to get through the ditch and so the attack is stopped.

b. Measures of Effectiveness

The relevant measures of effectiveness used to describe the breach are:

(1). Probability of Mission Success: This measures the probability of successfully breaching the obstacle. This includes those cases in which no counterobstacle vehicles survived the final minefield, but the attacking forces made it through the anti-tank ditch. In these cases, the attack proceeds through the unbreached minefield and naturally will sustain heavier losses in the uncleared portion. This is a critical measure of effectiveness, far outweighing the combat losses, since it measures the mission related performance of the attacking force.

(2). Expected Extra Time: This is the amount of extra time spent clearing the obstacle as compared to an obstacle-free situation. Since the casualties sustained are a function of time, it is important that the extra time be held to a minimum. The times are accumulated only in those instances when there is a successful breach of the compound obstacle.

(3). Expected Mine Density: This is a measure of the remaining mine density in the breach lane from both of the minefields, given that there was a successful breach of the compound obstacle. Each minefield begins with a density of one, so the range for this measure is 0.0 - 2.0.

(4). <u>Expected Number of Surviving Counterobstacle Resources</u>: This represents the number of resources that survived given a successful breach of the compound obstacle.

c. Specific System Results

Initially, four combinations of counterobstacle resources were explicitly evaluated. These represented a CEV or a COV, along with a single tank mounted mine roller, or along with a mine roller and tank mounted track width mine plow (TWMP). All counterobstacle systems were given equal survivability to direct fire weapons. For this analysis, the following performance parameters were assumed:

Minefield Breaching Speed -- 5 Km/Hr
Minefield Breaching Effectiveness -- 0.90
AT Ditch Crossing Time COV -- 5 minutes
CEV -- 10 minutes

The four measures of effectiveness are summarized in the following table for each combination of resources:

	ROLLER & CEV	COV ONLY	ROLLER & COV	ROLLER,TWMP & CEV	ROLLER,TWMP & COV
P(survival)	.40	.63	.62	.47	.62
Extra Time	908 sec	651	656	932	658
E(MD)	.673	.291	.138	.445	.063
E(# surviving resources)	1.199 (2)	0.563 (1)	1.394 (2)	1.756 (3)	2.026 (3)

The conclusion to be drawn from these results is that the addition of a TWMP to the COV made only a small difference in the outcome measures - and almost exclusively in the expected mine density. In contrast, the impact of the addition of a TWMP to the CEV cases is also significant to the probability of mission success. This is because the CEV is not a mine clearing resource and thus is more likely to suffer a mine casualty than the COV. The addition of the TWMP significantly reduces the mine exposure for the CEV while having little net utility to the COV. The major difference of 300 seconds between the expected extra times for the COV and CEV cases directly reflects the ditch crossing times assumed for the two systems, and this additional exposure is the major factor in the mission success differences between the two.

d. Generic COV System Results

This portion of the analysis extends from the Specific Systems results for the COV with a single additional tank mounted roller. Here, the COV is not treated as a defined system, but instead is represented parametrically. Each of the parameters of interest, anti-tank ditch crossing time, minefield breaching speed and mine clearing effectiveness, are varied and the measures of effectiveness values computed. Results are plotted to illustrate the significance of the performance parameters and allow engineering and cost tradeoffs against mission outcomes to be made. The results are based on the derived methodology described earlier in this chapter, based on COUNTERCOM runs.

(1). Anti-Tank Ditch Crossing Time: Figures III-8 and III-9 illustrate the parametric performance of a generic COV system as its anti-tank ditch crossing time is varied. The first figure presents the probability of mission success while the second presents the percent of attacking forces lost. As the ditch crossing time increases, the mission success probability decreases approximately linearly (over this range) and the losses increase linearly. This reflects the desireability of rapid ditch crossing capability. Not only does the likelihood of actually crossing the ditch increase when the crossing is rapid, but also the attackers total losses go down.

(2). Minefield Plowing Speed: A similar sequence was performed for minefield plowing speed. The results are plotted in Figures III-10 and III-11. The curves illustrate the desireability of a rapid advance through the minefield. Incremental speed increases in the 2 to 4 kmph range are more significant then in the 4 to 6 kmph range, but the improvements are still noticeable. For example, increasing the plowing speed from 4 to 6 kmph reduces losses by about 4 percent and increases the likelihood of a successful mission by about 2 percent. The significance of these payoffs cannot be measured in the isolation of a single battle, but must be weighed in the larger context of the campaign.

(3). Mine Clearing Effectiveness:

(a). Tradeoff Analysis: The parametric analyses described above show that there is a major engineering tradeoff to be considered in COV development, between speed of the mine clearing vehicle and effectiveness of clearing the minefield obstacle.

The second analysis focused on the engineering tradeoff between the speed of the vehicle and its mine clearing effectiveness. In this analysis, both speed and effectiveness were varied and the expected results computed. Figure III-12 presents the expected remaining mine density as a function of speed for various levels of mine clearing effectiveness. Figure III-13 presents the expected number of countermine resources lost for the same speed range. As expected, the slower the system crosses the minefield, the greater its losses and the mine density it will be unable to clear. These results translate into the Percent of Attacking Forces Lost at different levels of effectiveness for a single countermine system as shown in Figure III-14.

(b). Compound Obstacle Tradeoff: The wargame analysis clearly shows that the time lost in plowing the minefield results in significant losses to the attacking force. Increased speed is necessary but a major tradeoff must be considered in order to increase the speed at which the COV plows through a minefield. Either the vehicle must be made heavier and more powerful, or the mine plow must operate at a reduced depth. Given that the COV prototype already uses most of its weight budget, the more likely tradeoff is the latter. At a reduced depth, the plow is less effective in clearing buried mines. At some point, the benefits of increased speed will be matched by the additional losses caused by the increased remaining mine density.

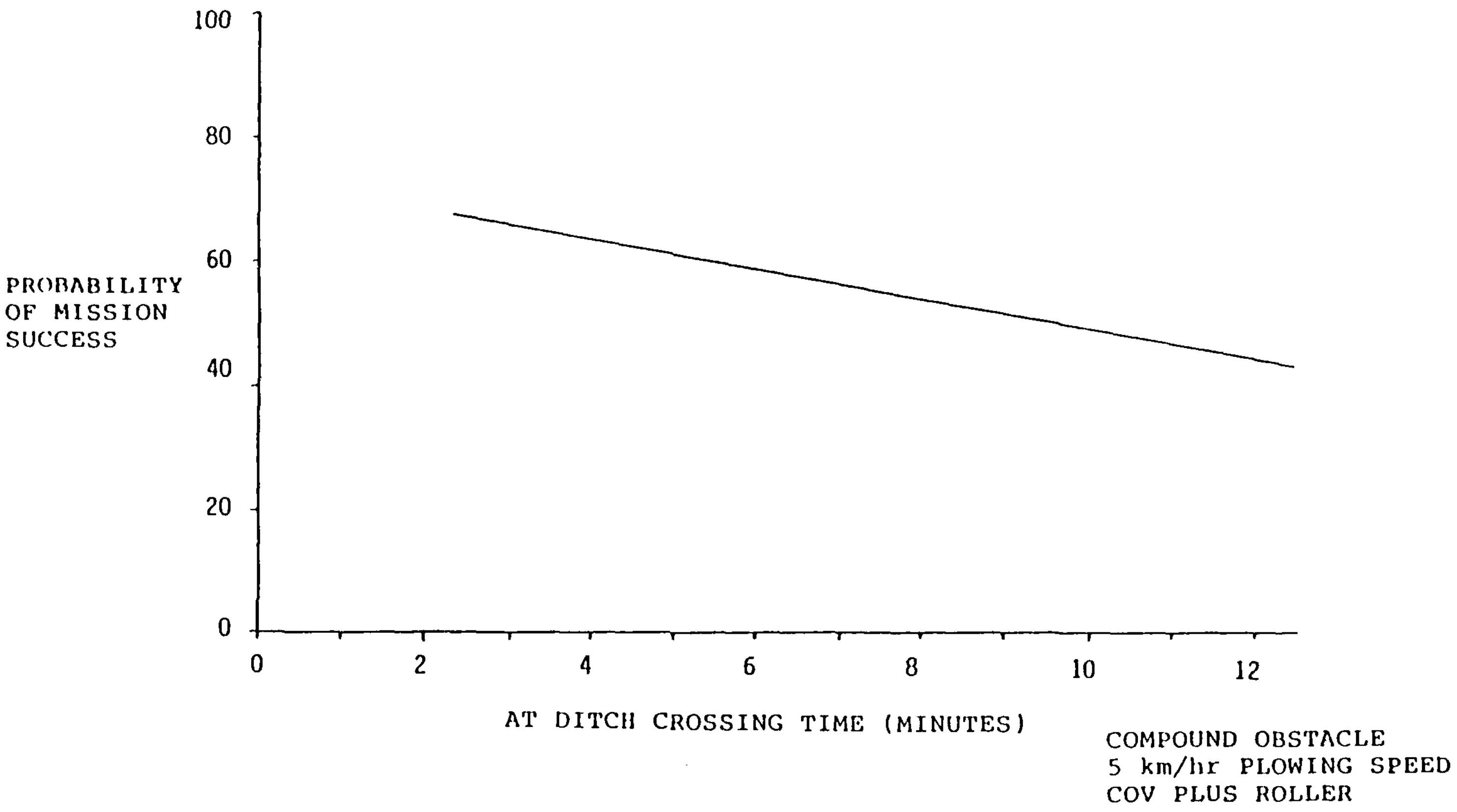


Figure III-8 Probability of Mission Success Versus AT Ditch Crossing Time for COV

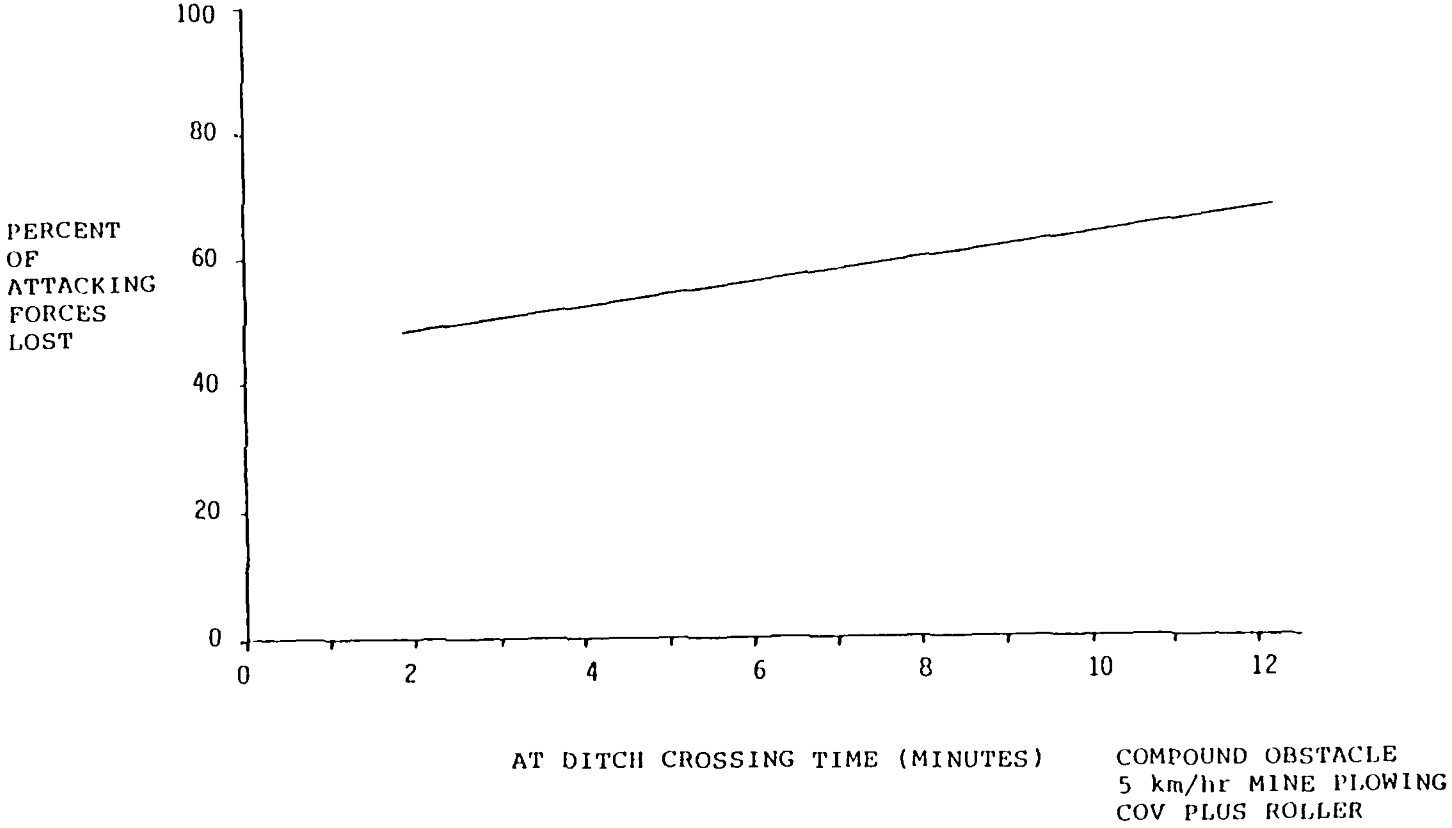


Figure III-9 Percent of Attacking Forces Lost Versus AT Ditch Crossing Time for COV Given a Successful Mission

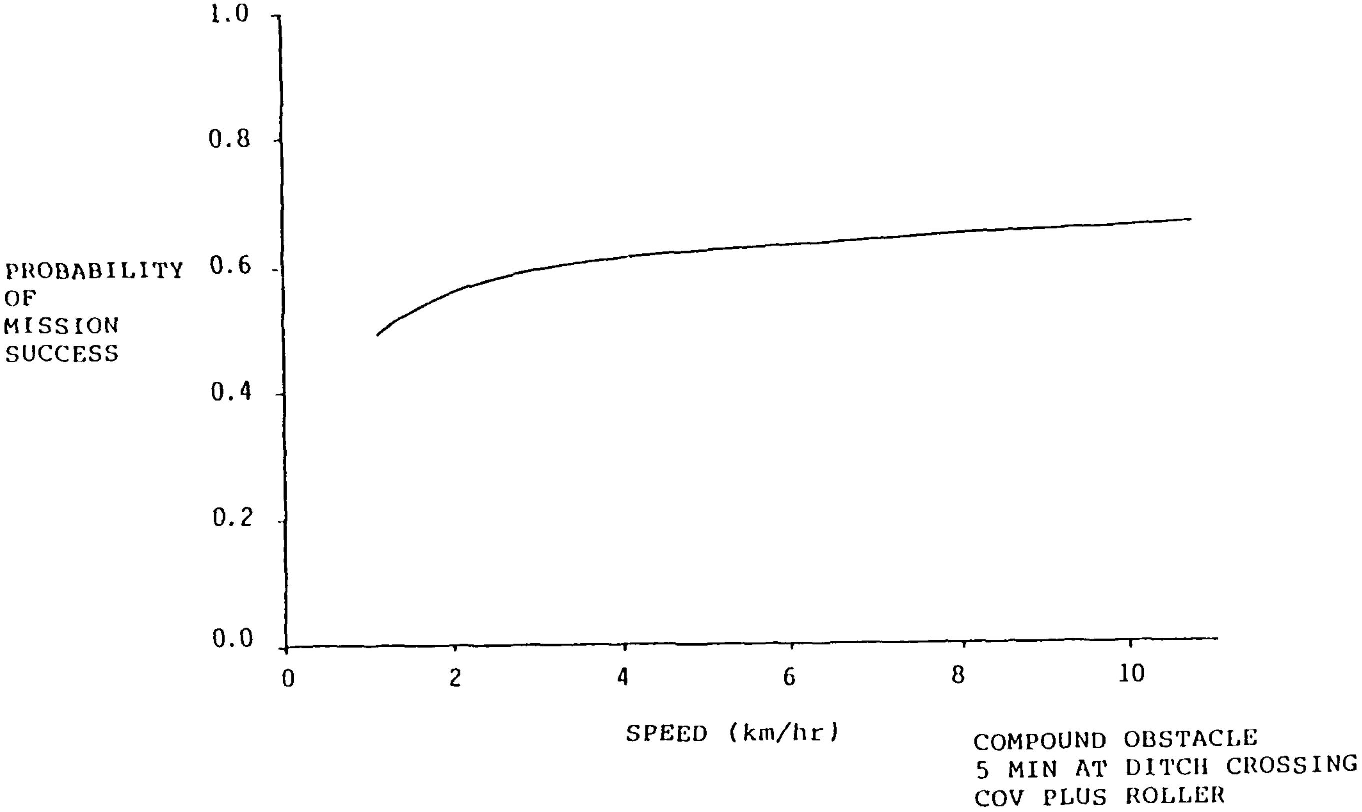


Figure III-10 Probability of Mission Success Versus Minefield Plowing Speed for COV

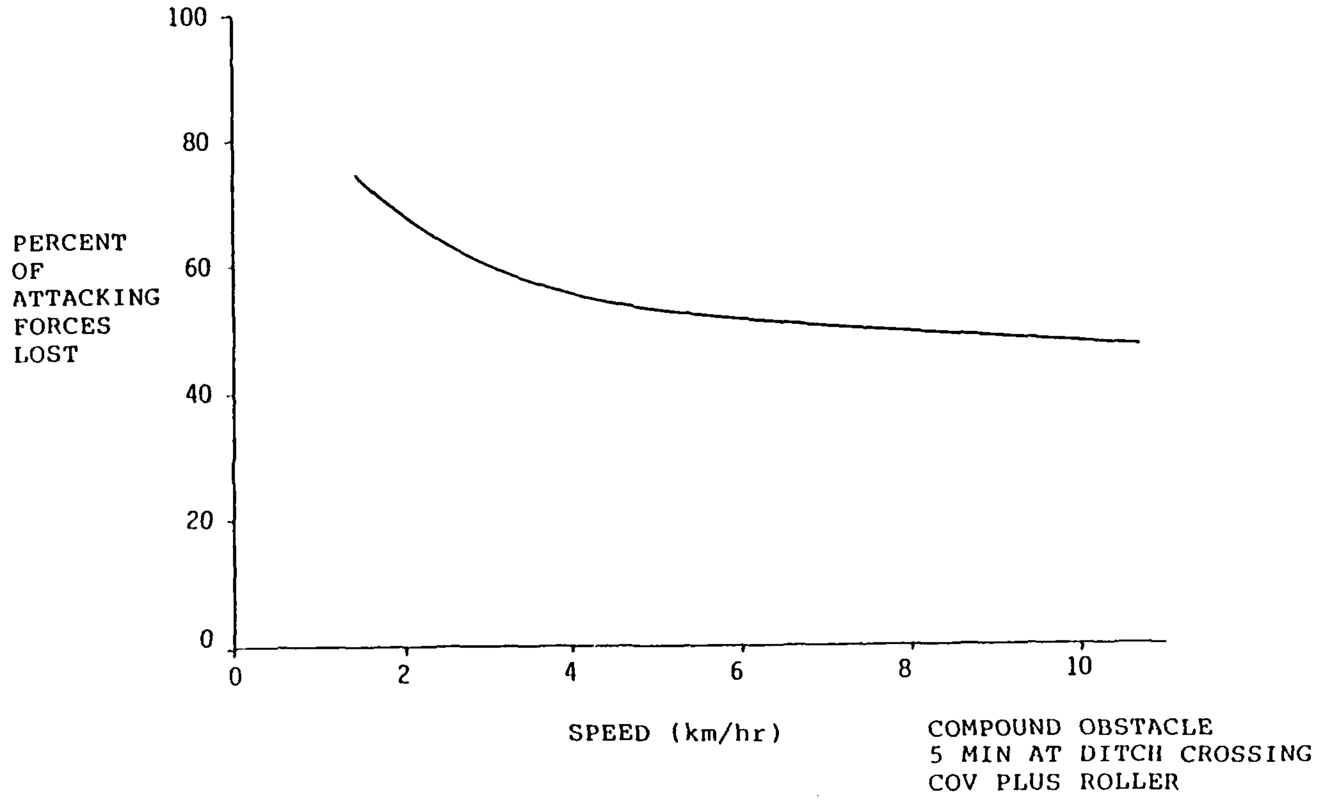


Figure III-11 Percent of Attacking Forces Lost Versus Minefield Plowing Speed for COV Given a Successful Breach

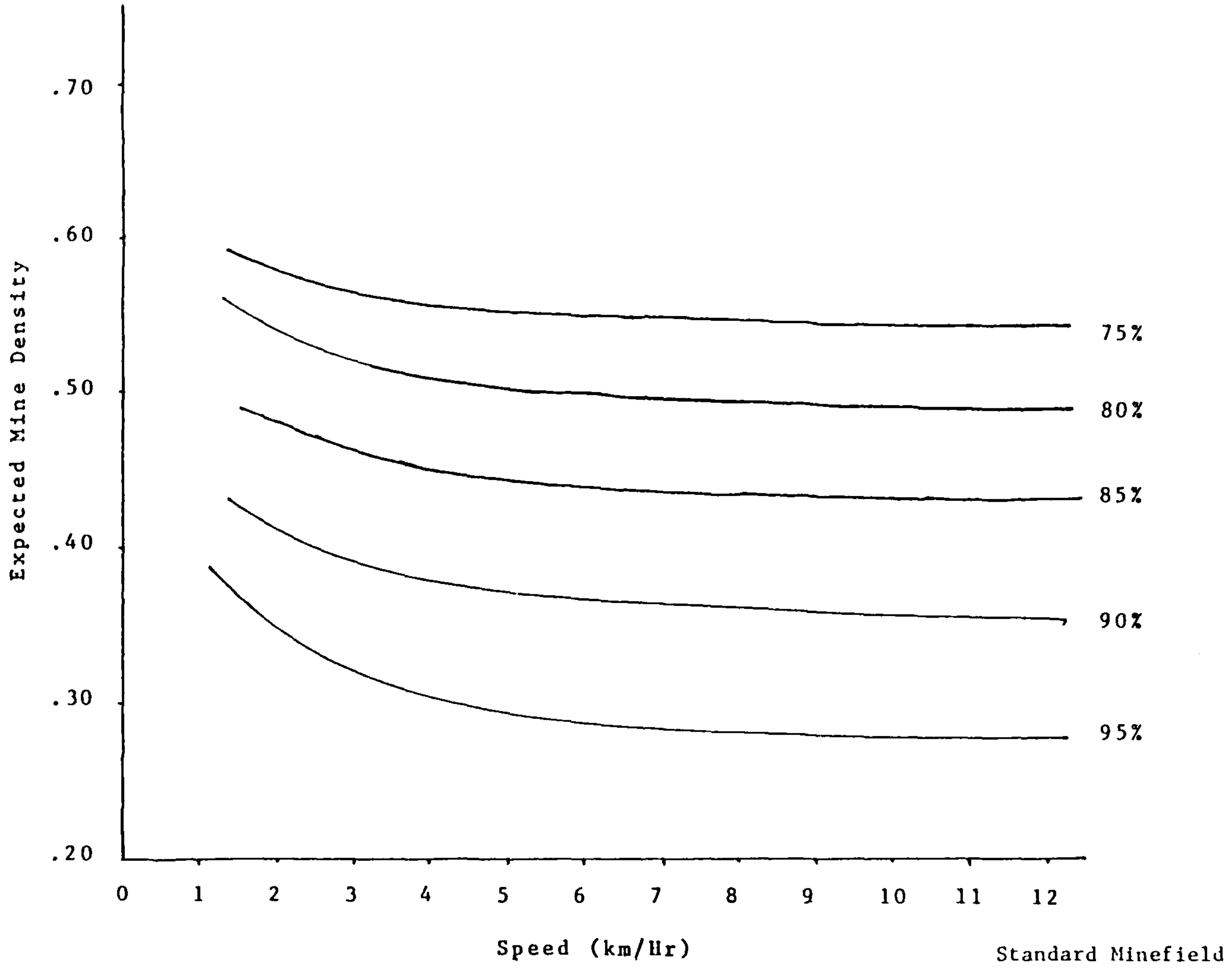


Figure III-12 Expected Remaining Mine Density Versus Speed for a Single Mine Clearing System

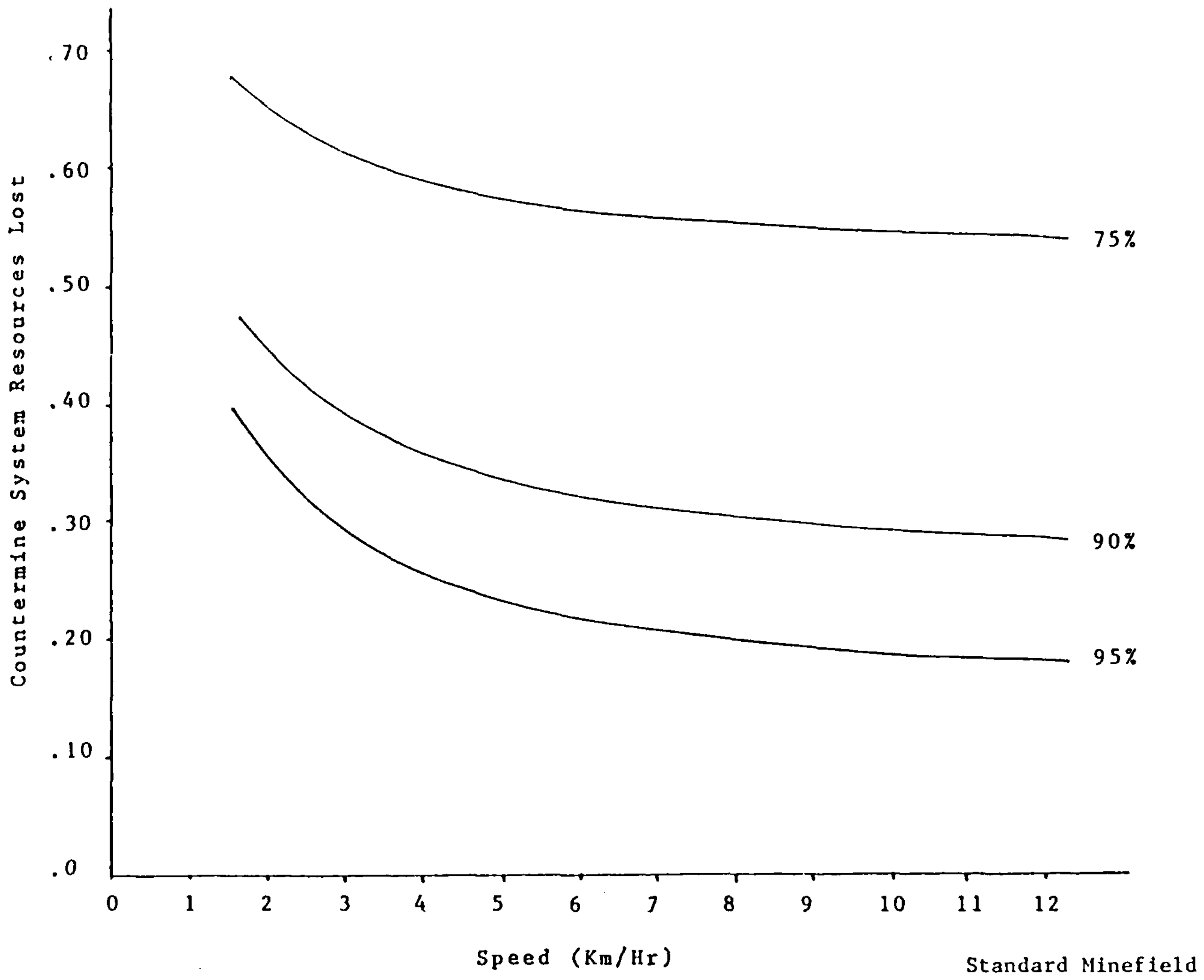
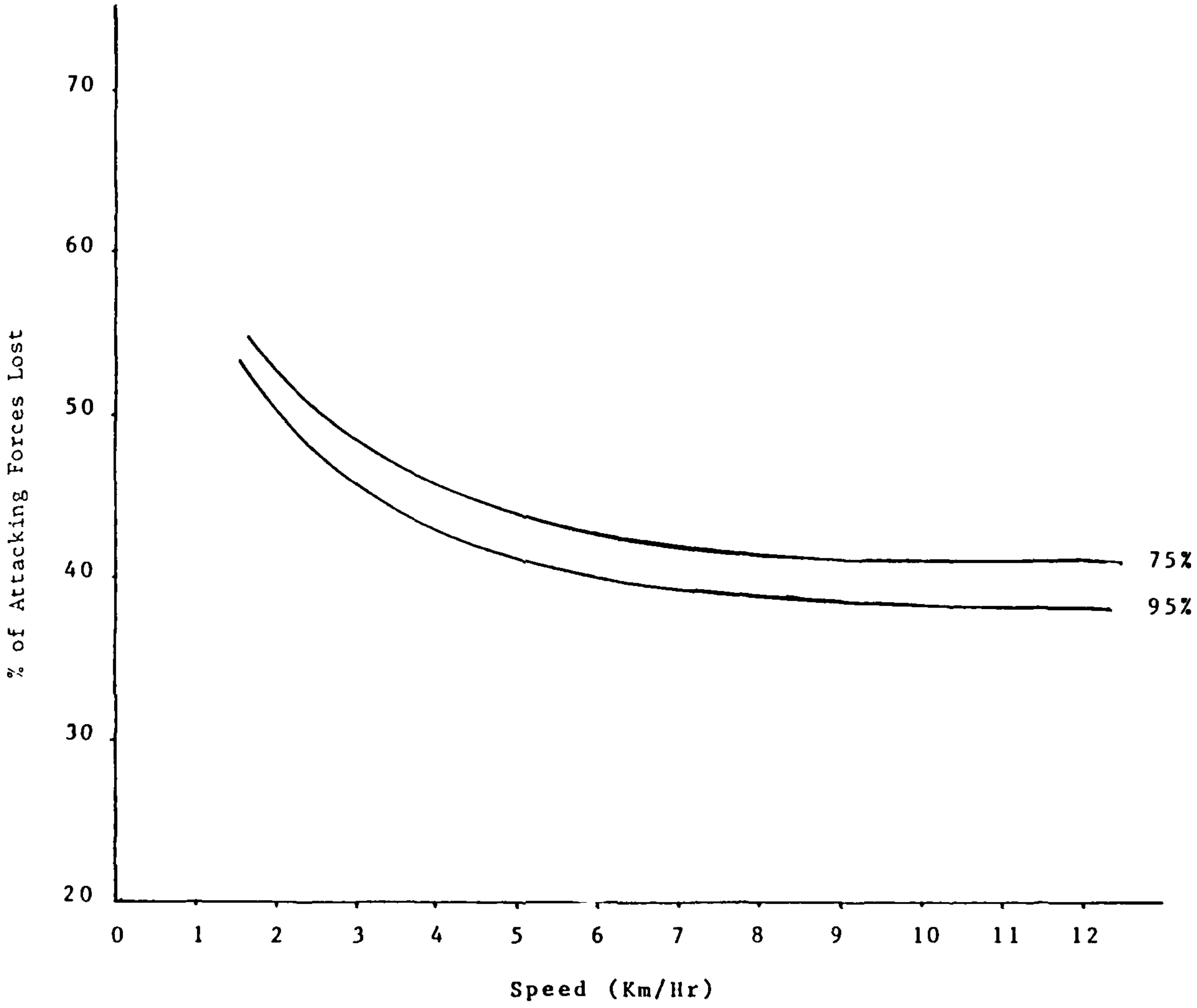


Figure III-13 Expected Number of Countermine Resources Lost Versus Speed for a Single Countermine System



Standard Minefield

Figure III-14 Percent of Attacking Forces Lost Versus Speed for a Single Countermine System

Figure III-15 summarizes the results of a series of analyses performed by varying the mine clearing effectiveness of the COV plow. The expected remaining mine density varies with the plowing effectiveness (shown for 75%-95%), and it also varies as a result of the plowing speed (since the COV is exposed longer at slower speeds). Note that the density shown is based upon an initial density of 2 mines per meter of front and the COV is accompanied by a roller which proofs the lane. If a 0.15 remaining mine density were the design goal, then it could be achieved by a 95% effective COV plow operating at 2.5 kmph or by an 85% effective COV plow operating at 6.5 kmph.

However, the linkage back to the total force losses must be considered, as shown in Figure III-16. When kills from all sources are considered, the significance of the mine clearing performance itself is not as evident. A 95% effective plow at 2.5 kmph results in 63 percent losses while a 75% effective plow at 6.5 kmph results in only 53 percent losses. The conclusion to be drawn from the results is that speed of plowing is a more important factor than effectiveness over the range of values discussed.

e. Analysis of Results

The objective of this paragraph is to translate the parametric results presented in the preceeding paragraphs into specific quantitative conclusions regarding the utility of the COV. The utility of the COV will be stated in terms of the percent reduction in additional attacker losses sustained due to the obstacle. In computing this percent reduction, the COV will be compared to existing fielded systems. Note that these results are only as good as the assumptions concerning relative performance of the COV and existing systems.

(1). Countermine Performance

	PAST	CURRENT	FUTURE
Equipment	M173	MICLIC & ROLLER	MICLIC & COV
% Losses to Attacker	58%	48%	43%

In the direct countermine mission, the COV-MICLIC combination achieves a 32 percent reduction in the additional losses to the attacker caused by the obstacle below those achieved with the MICLIC-Roller combination.

(2). Compound Obstacle Performance

	PAST	CURRENT	FUTURE
Equipment	CEV, M173	M-9, MICLIC, Roller	COV, MICLIC, Roller
Probability of Mission Success	.40	.56	.62
% Losses to Attacker	62%	60%	54%

Against a significant compound obstacle the future capability with a COV produces a 6 percent greater likelihood of mission success while achieving a 22 percent reduction in the additional losses to the attacker caused by the obstacle, below the current systems.

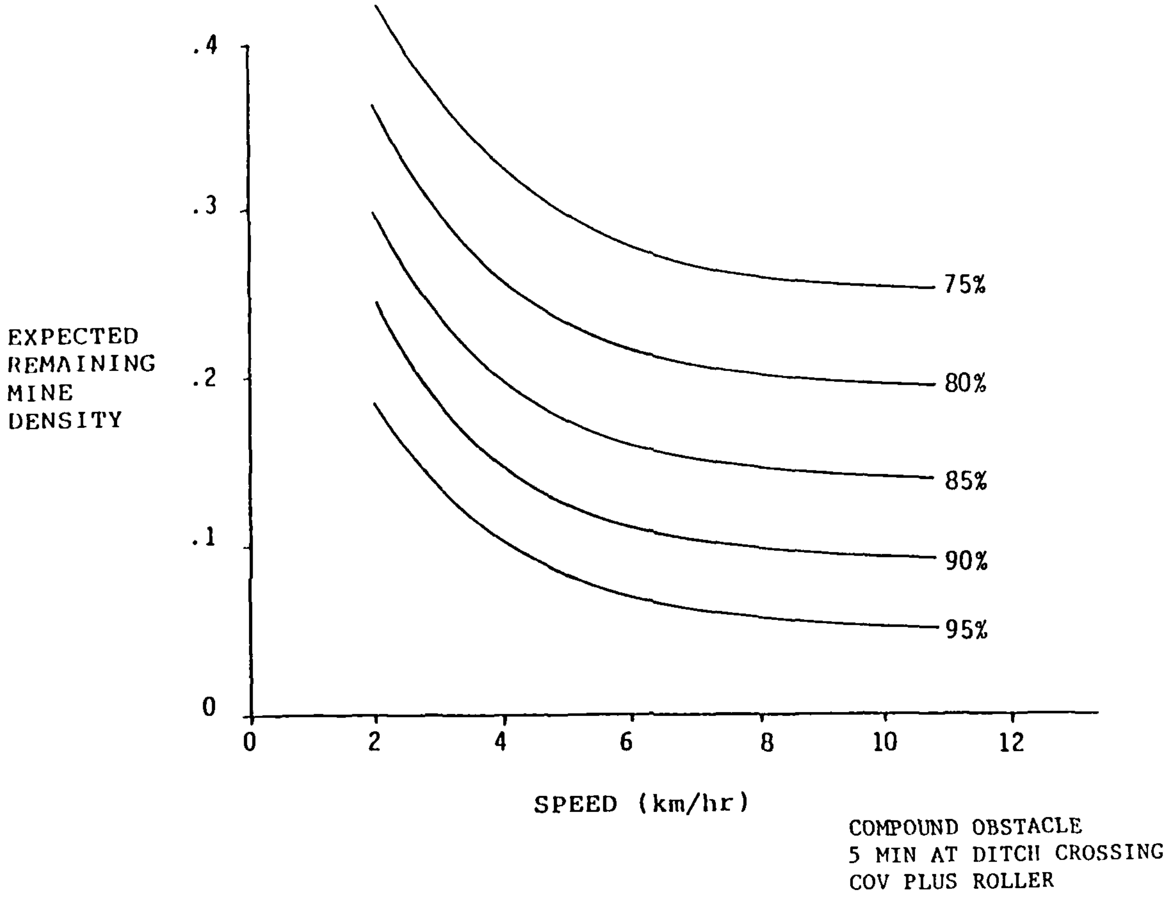


Figure III-15 Expected Remaining Mine Density Versus COV Minefield Plowing Speed for Various Mine Plowing Effectiveness of the COV

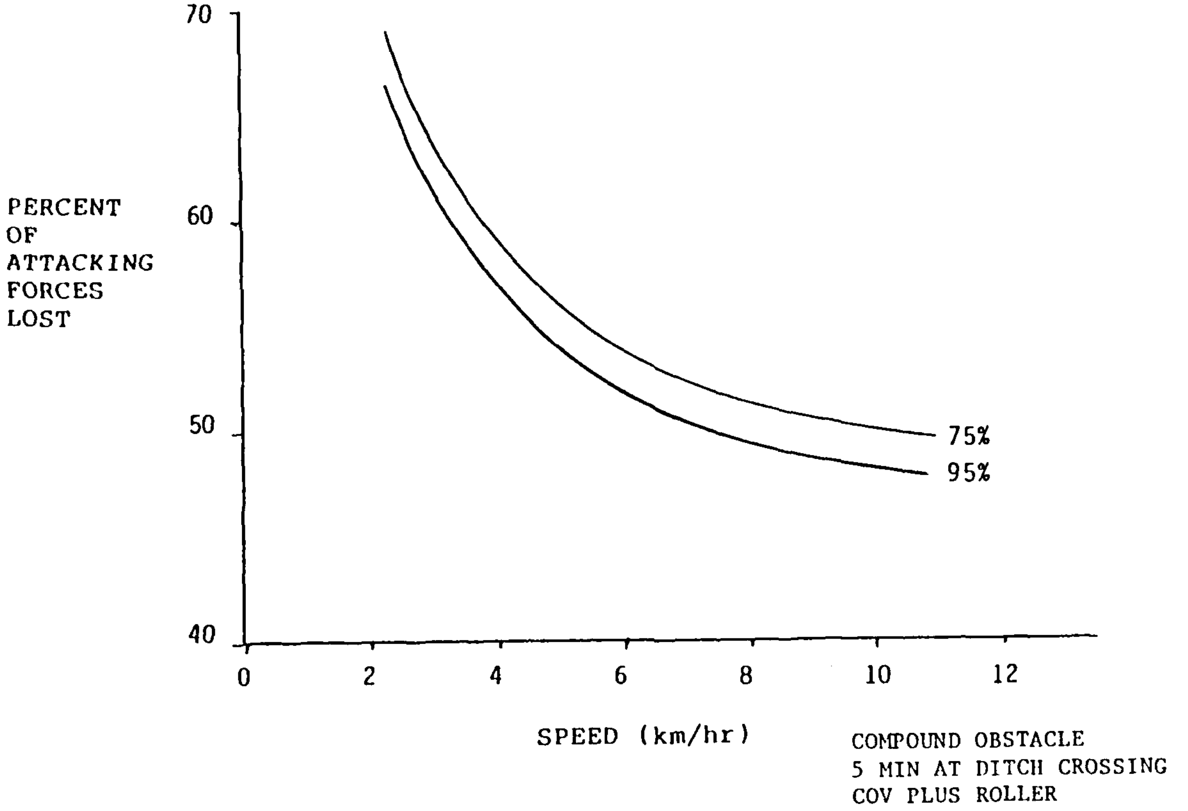


Figure III-16 Percent of Attacking Forces Lost Versus COV Minefield Breaching Speed for Various Mine Plowing Effectiveness of the COV

E. HUMAN FACTORS EVALUATION OF COV AND ALTERNATIVES

1. Background

As the Army modernizes with high-technology hardware, it must ensure that it can man new equipment. In the past, system performance requirements presented in requirements documents have not always been met by all soldiers operating, maintaining, and repairing the system in the field. The Army believes that previously developed materiel systems have not performed in the field as desired because these systems were not designed with adequate consideration of the performance capabilities and limitations of the soldiers assigned to them. Further, Required Operational Capability statements (ROCs) should focus on total system development and should require performance, not hardware.

In September 1984, the Systems Research Laboratory of the Army Research Institute issued a draft document entitled "Human Factors, Manpower, Personnel, and Training ROC Enhancement." This document is included as Annex D to this report. The document outlines suggested changes to the Required Operational Capability (ROC) format. Although it has no official status, the document is an excellent guide for those preparing a ROC to ensure proper consideration for human factors.

2. Methodology

a. Human Factor Involvement. The contents of this section evaluate crew-equipment interface and effectiveness of human performance during counterobstacle system operation/maintenance from a human engineering standpoint, over the 30-year time base of interest (1965-1995).

The U.S. COS equipment available to accomplish the counterobstacle mission over the time period of interest is repeated from Chapter II at Figure III-17. It is desirable to capture the historical perspective of the impact of human factors on performing this mission with this equipment. As discussed in Section II above, it is useful to consider the counterobstacle mission as a whole, rather than its individual parts, such as countermine actions, or creation of combat roads and trails, and the COS as a whole, rather than the individual parts that make it up, such as the CEV, or the M-9 ACE, etc. The same technique is useful in the human factors analysis portion of this evaluation.

The human factors analysis was conducted according to the following sequence:

(1) Establish factors to be analyzed,

(2) Determine functional classes to be evaluated,

(3) Establish time base of evaluation,
(4) Determine human performance capability in terms of load, accuracy rate, and time for each function, over the time base,

FUNCTION	PRIORITY	PAST CAPABILITY (1965)	CURRENT CAPABILITY	FUTURE CAPABILITY (1995)
MOBILITY:				
COUNTERMINE:				
DETECT	1	HAND-HELD DETECTORS PSS-11, PRS-7	HAND-HELD DETECTORS PSS-12, PRS-8	MIRADOR
NEUTRALIZE	1	M-157 LINE CHARGE M-173 PROJECTED CHARGE	M-157 LINE CHARGE MICLIC ROLLER	VEMASID MICLIC/ROBAT MICLIC/COV
PROOF	1		TWMP ROLLER	FWMP/COV ROLLER
MARK	1	ENGR TAPE	HEMMS	CLAMS/COV HEMMS
COUNTEROBSTACLE:				
CREATE COMBAT ROADS AND TRAILS	2	CEV, DOZER, SCOOP LOADER	M-9, CEV, DOZER, SCOOP LOADER	COV, M-9
CUT TREES	2	HAND-HELD CHAIN SAWS, DEMO	HAND-HELD CHAIN SAWS, DEMO	COV, DEMO
NEUTRALIZE ANTI-TANK DITCH	3	CEV, AVLB, DOZER	CEV, M-9, AVLB, DOZER	M-9, AVLB, COV
PREPARE WET GAP APPROACHES	3	DOZER, CEV, LOADER	DOZER, SCOOP LOADER, CEV, M-9	COV W/BUCKETS, M-9
REMOVE TREE BLOWDOWN/ABATIS	3/4	CEV, DOZER W/WINCH, CRANE	CEV, DOZER W/WINCH, CRANE, M-9	COV W/GRAPPLE, BUCKET, WINCH; M-9
NEUTRALIZE LOG OBSTACLES (CRIBS/HURDLES)	4	CEV (W/DEMO GUN), DOZER W/WINCH, CRANE	CEV, M-9, DOZER W/WINCH CRANE	COV W/GRAPPLE, BUCKET; M-9
REMOVE URBAN RUBBLE	4	CEV, DOZER	CEV, DOZER, M-9	COV, M-9
NEUTRALIZE ROAD CRATERS	4	CEV, DOZER	CEV, M-9, DOZER, LOADER	COV, M-9
ASSIST EOD TEAMS	5	CEV	M-9, CEV	COV, M-9
PERFORM RAPID RUNWAY REPAIR	5	CEV, DOZER, SCRAPER, SCOOP LOADER	CEV, M-9, DOZER, LOADER, SCRAPER	M-9, COV, DOZER/SCRAPER
COUNTERMOBILITY:				
CREATE ANTI-TANK DITCHES	5	DOZER, SCRAPER	M-9, DOZER/SCRAPER	M-9, DOZER/SCRAPER TEXS (SEE), COV
SURVIVABILITY:				
EXCAVATE SURVIVABILITY POSITIONS	5	DOZER	M-9, DOZER JD-410	M-9, SEE, COV JD-410

Figure III-17. U.S. Counterobstacle System Over Time.

(5) Analyze critical tasks within these functional classes, identifying actions taken, workspace available, number of personnel required (level of effort), operator interaction when more than one crew member is involved, special hazards involved, and effects of operational environments (battlefield conditions, light/darkness, climate, etc.),

(6) Array the data developed in a form amenable to evaluation, and

(7) Determine significance and trends indicated by the data. Develop relevant conclusions from this analysis.

b. Human Factors Considered. While many human factors could be considered, both the scope of the problem and the lack of a complete definition of the COV force the analyst to limit which factors can be treated in realistic and significant detail. Human factors which are herein considered include:

(1) Training Difficulties -- Some people may not be able to acquire sufficient skill levels required to perform a task, thus limiting the available personnel resource pool, or the necessary skill level may require exceptional training and refresher courses.

(2) Level of Effort -- Considers tasks to be performed in terms of labor intensity. This factor includes both the number of personnel required and the degree of effort required from each person.

(3) Environmental Control -- Protecting the individual from harsh ambient environments through environmental control systems in vehicles will improve the ability to perform tasks without distraction due to personal discomfort.

(4) Repair and Maintenance -- This may be required in many threat environments for emergency repair or decontamination. Factors 1, 2, and 3 also impact this human factor.

(5) Stress in Mission -- Missions produce stress when the threat of injury or death is high, when the individual is exposed to harsh environments such as temperature extremes, or is required to perform heavy labor tasks.

c. Function Classes. Following the system concept described above, it is helpful to group the functions shown in Figure III-17 into the limited number of function classes shown in Table III-1.

To treat each of the functions in Figure III-17 individually would be a much more complicated task and, with only a poorly defined COV at present, it is unlikely that meaningful differentiations between functions within these function classes could be justified. Thus, it would be difficult to define significant differences in the COV ability to perform the various earthmoving functions in Function Class III, or the R&M or taining required to repair and maintain the equipment necessary to perform these functions, without a much more precise definition of the COV and its ancillary equipment.

Table III-1. Function Class Definition.

Function Class	Functions Covered
I	Detect, neutralize, proof, mark mines.
II	Cut trees, remove tree blowdown/abatis, neutralize log obstacles.
III	Neutralize A-T ditch, prepare wet gap approach, create combat roads and trails, remove urban rubble, neutralize road crater, create A-T ditch, excavate positions.
IV	Assist EOD teams, perform rapid runway repair.

Data on the present and past systems is probably sufficient to perform a detailed analysis of each function. However, such an intensive effort can hardly be justified, since it would result in an unbalanced (in the sense of level of detail) historic perspective when compared to the expected future conditions, since at present the COV is poorly defined, i.e., little more than a concept (the current experimental prototype COV very likely bears little resemblance to the final vehicle). Too much detail would complicate the later comparison of future systems with the past and present.

Function Class I is related to mine clearing and requires some explicit functions not needed in the other classes (e.g., CLAMS, depth sensing plow). Function Class II involves cutting, plowing aside, grappling or grabbing and moving logs, and possibly demolition. Function Class III involves dozing, backblading, and other earth moving. Function Class IV involves both earth moving and possibly grabbing and moving (either live EOD or delay-fuzed area denial munitions in runway repair). Further factors which distinguish the members of this function class are that they are of the lowest priority in Figure III-17 and that they will normally be performed only when there is little likelihood of enemy direct or indirect fire (excepting possibly strafing aircraft), although a chemical environment is always considered possible.

d. <u>Time Base of Task Analysis</u>: This is the same period as that used for the analysis above: past, present, and future.

e. <u>Human Performance Capability and Critical Task Analysis</u>: Using the functional classes of mission tasks described above in Table III-1, human performance capability is evaluated for each period in the time base in terms of load, accuracy, rate, and time. These results are tabulated in Table III-2. Also tabulated there are workspace available, number of personnel required (level of effort), and operator interaction when more than one crew member is involved. Note that each entry is a quantitative, although subjective, rating on a scale of 1 to 5, relating to the degree to which this particular area is or is not a problem.

Table III-2. Human Factors Evaluation Data for Function Classes.

Function Class	Human Performance Capability				Work Space Available	Time Base	Number of Pers. Required Level of Effort	Operator Interaction (when >1 Crew Member Involved)
	Load	Accuracy	Rate	Time				
I	3	2	5	5	5	Past	4	3
II	2	2	4.5	4.5	4	Past	4	3
III	2	2	2	2	4	Past	2	2
IV	1	1	3	1	4	Past	3	3
I	2	2	5	5	5	Current	4	3.5
II	2	2	4.5	4.5	4	Current	4	3
III	2	2	2	2	4	Current	2	2
IV	1	1	3	1	4	Current	3	2.5
I	1.5	1.5	1	2	2	Future	1	2
II	1	2	2	2	2	Future	1	3
III	1	1	1	1	1	Future	2	3
IV	1	1	2	1	1	Future	1	3.5

1 = No significant problem
2 = Minor problem
3 = Moderate problem
4 = Serious problem
5 = No solution or no mitigation of the problem.

In the extremes; a value of 1 implies that no obvious improvement is or was available, not that the problem is, or was, trivial; conversely, a value of 5 does not imply that a task cannot be performed but rather that no meaningful action was, or is being, taken to mitigate the problem.

f. <u>Array of Developed Data</u>: We are now in a position to array the data developed in the human factors analysis. Table III-3 does this, in matrix form, over the time base described above. Human performance capability, in terms of load, accuracy, rate, and time, have been transformed into the ratings provided under the environmental constraints described under mission performance, columns A through E. The five human factors which are listed

Table III-3. Human Factors -- Historical Perspective.

	TIME BASE																								
	1965								CURRENT								1995								
	BENIGN	NBC	IND. FIRE	DIR. FIRE	NBC&IF	TRAINING	LEVEL OF EFFORT	ENV. CONTROL	BENIGN	NBC	IND. FIRE	DIR. FIRE	NBC&IF	TRAINING	LEVEL OF EFFORT	ENV. CONTROL	BENIGN	NBC	IND. FIRE	DIR. FIRE	NBC&IF	TRAINING	LEVEL OF EFFORT	ENV. CONTROL	ROW
	A	B	C	D	E	F	G	H	A	B	C	D	E	F	G	H	A	B	C	D	E	F	G	H	
MINEFIELD BREACHING																									
I PERFORM MISSION	2.5	4	5	5	5	3	4	5	2	2	5	5	5	3.5	4	5	1.5	1.5	1	4	1.5	2	1	1	1
R&M	2	4	5	5	5	2	1	5	2.5	3	5	5	5	2.5	1	5	3	3	5	5	5	3	2.5	1.5	2
STRESS IN MISSION	4	4.5	5	5	5	2	-	2	4	4	5	5	5	2	-	2	2	2	2	4	2	2	-	1	3
TREES/LOGS/ABATIS																									
II PERFORM MISSION	2	4	4.5	4.5	4.5	3	4	4	2	3	4.5	4.5	4.5	3	4	4	1.5	2	2	4	2	3	1	1.5	4
R&M	3	4	5	5	5	4	4	4	3	3.5	5	5	5	4	4	4	3.5	3.5	5	5	5	3.5	3.5	2	5
STRESS IN MISSION	2	4	5	5	5	1	-	2	2	2.5	5	5	5	1	-	2	1	1	1	4	1	1	-	1	6
EARTH/RUBBLE MOVING																									
III PERFORM MISSION	2	4	2	4.5	4	2	2	4	2	2	2	4.5	2	2	2	4	1	1	1	4	1	3	1	1	7
R&M	2.5	4	5	5	5	3	3	4	2.5	3.5	5	5	5	3	3	4	3	3	5	5	5	3	3	2	8
STRESS IN MISSION	2	4	1	4	4	1	-	2	2	2.5	1	4	2.5	1	-	2	1	1	1	4	1	1	-	1	9
MISC. SUPPORT																									
IV* PERFORM MISSION	1	4	-	-	-	3	3	4	1	2	-	-	-	3	3	4	1	1	-	-	-	3.5	1	1	10
R&M	2.5	4	-	-	-	3	3	4	2.5	3.5	-	-	-	3	3	4	3.5	3.5	-	-	-	3.5	3.5	2	11
STRESS IN MISSION	3.5	4	-	-	-	2.5	-	2	3.5	3.5	-	-	-	2.5	-	2	3	3	-	-	-	2.5	-	1	12
COLUMN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	

* CLASS IV MISSIONS ARE NOT SUBJECT TO ENEMY FIRE.

1 = NO SIGNIFICANT PROBLEM
2 = MINOR PROBLEM
3 = MODERATE PROBLEM
4 = SERIOUS PROBLEM
5 = NO SOLUTION OR NO MITIGATION OF PROBLEM

above are evaluated as discrete items in Table III-3. Five battlefield environments are considered: A) a benign environment where no enemy action is occurring; B) an NBC environment where radioactivity (no blast, thermal, EMP, or prompt nuclear radiation), biological, or chemical agents are present; C) an environment where indirect enemy fire is present; D) an environment where direct enemy fire is present; and E) an environment where both NBC and indirect enemy fire are present. Other combinations of direct fire plus NBC, direct plus indirect fire, etc., were initially considered but, as will be seen subsequently, the direct fire threat was so severe that adding other threats to that environment would not significantly change the results.

Three other columns, F, G, and H, are employed in Table III-3. F) Training Difficulties, relates to the training required to learn the mission skills and to maintain and repair the mission-oriented equipment or the stress associated with training (e.g., training to do mine clearing or EOD may not be dangerous in itself, but would probably create anxiety and stress when an individual contemplated the danger associated with actual performance of such a mission). Training difficulties may result from complexity of the task or from the fact that only a limited percentage of the average population possesses the required physical strength, manual dexterity, sensory acuity, etc., to perform the task. G) Level of Effort, carried from Table III-2, relates to both the number of people required to perform the task and the physical effort required per individual. No entries relate stress and level of effort as this would be somewhat confusing (i.e., stress relates more to an environment, level of effort relates to a task). H) Environmental Control, relates to the ability to control the ambient environment by heating, cooling, filtering dust, and protecti from the elements. Control of the environment can improve mission performance capability, ease physical exertion during R&M, and reduce stress. Entries in Table III-3 indicate the degree to which the environment could be controlled during mission performance or R&M, not what effect that control might have on mission performance or R&M. The entries in column H in the stress in mission rows indicate the level of the problem posed by the state of environmental control available to the system during performance of the mission.

g. Explanation of Ratings/Evaluation. Table III-3 may be viewed as a matrix for the purpose of describing its elements. The matrix thus has 12 rows (four function classes times three capability criteria) and 24 columns (three time bases times eight environments and human factors). The detailed rationale for each entry is at Annex E.

3. Results

An analysis of Table III-3 will provide meaningful insights from the human factors standpoint for the future of a COV.

a. Mission Performance (obtained by sum of Columns A through E):

	1965	PRESENT	1995
I	21.5	19.0	9.5
II	19.5	18.5	11.5
III	16.5	12.5	8.0
IV	5.0	3.0	2.0
TOTAL	62.5	53.0	31.0

Since a decrease in totals implies a reduction in mission performance problems, these totals reflect a steady improvement in those human factor areas associated with mission accomplishment, that is, performance capability (load, accuracy, rate, and time) in various battlefield environments, over the 30-year period.

b. Repair and Maintenance (sum of Columns A through E):

	1965	PRESENT	1995
I	21.0	20.5	21.0
II	22.0	21.5	22.0
III	21.5	21.0	21.0
IV	6.5	6.0	7.0
TOTAL	71.0	69.0	71.0

These results appear to be intuitively satisfying in that, while the counterobstacle equipment is becoming more complex, improvements in repair and maintenance procedures and techniques are allowing the Army to hold its own. However, the lack of significant improvement points out a human factor area for added emphasis in the requirements document. The possibility of a significant incentive deserves consideration.*

c. Stress In Mission (sum of Columns A through E):

	1965	PRESENT	1995
I	23.5	23.0	12.0
II	21.0	19.5	8.0
III	15.0	12.0	8.0
IV	7.5	7.0	6.0
TOTAL	67.0	61.5	34.0

One of the most significant of human factors considerations is this item of stress. It shows the same dramatic improvement evidenced in mission performance. Clearly, the COS development is supported by this human factor consideration. A component of this relates to the SCALP program which is a consideration of the COS.

d. Training (sum of Column F):

1965	PRESENT	1995
29.5	30.5	31.0

---

* The Army strongly supports keeping equipment simple and placing emphasis on ease of repair and maintenance (e.g., throw-away components) but in practice, seems to continue to develop more complicated systems. A possible approach to reverse this trend could be an incentive clause that would provide a monetary reward for a simple, easy to operate, easy to repair and maintain system/subsystem. Such a system/subsystem would also contribute to ease of training. Criteria would be needed to measure results.

Rationale for these results are the same as for Repair and Maintenance. The Army is able to hold its own, but not reduce training requirements, a reasonable outcome.

e. <u>Level of Effort</u> (sum of Column G):

1965	PRESENT	1995
21.0	24.0	16.5

The ability of the COV to perform the required missions with reduced labor intensity is clearly demonstrated with this element. A definite plus for the COV.

f. <u>Environmental Control</u> (sum of Column H):

1965	PRESENT	1995
42.0	42.0	16.0

The ability to control the environment with the COV is significant. The impact on the battlefield of the future would be expected to result in an improvement, especially in continuous operations in an NBC environment where heat stress would produce deleterious effects without this feature.

CHAPTER IV

CONCLUSIONS

A. GENERAL

The evaluations from the previous chapter provide us an opportunity to comment on the various capabilities of the counterobstacle system (COS) in accomplishing its mission in relative isolation, first, according to its efficiency to accomplish the work in an unopposed environment, and then in the context of the battle. From this, we can see what progress has been made in the COS over the past 20 years, and what improvement is to be expected in the next 10 years and thus, where the COV has utility.

B. INSIGHTS ON THE COS OVER TIME

Figure IV-1 summarizes the results of the analyses in the previous three chapters. Detailed comments on each follow.

1. Minefield Breaching:

The ability of the system in the past is reflected in the 15-miute employment time for the M173 line charge. This represents a best case employment and contains no detection time or reaction time. In the past period, no viable detection means for locating the minefield existed other than by visual detection, if the mines were surface laid, or by hand-held detectors (not viable for use in an opposed situation). The most likely detection means was by activating one of the mines in the minefield by running over it. Hence, the improvement from the past to the present capability (where the MICLIC and roller replaced the M173) should be measured not only in terms of losses reduced by shortened exposure time (which is reduced by 53%), but also by those losses occurring in the initial discovery of the minefield (since, doctrinally, the minefield is detected by the roller), by the improved value of expected remaining mine density in the cleared lane, and by the longer cleared lane created by the explosive line charges. There are still likely to be losses associated with the marking phase of the breaching process, however, since the marking system is placed by exposed, dismounted engineers.

For the future period, the COV offers still further improvements. The COV offers a 40% further reduction in time to breach over the MICLIC-roller combination which translates to a one-third reduction in those extra losses the attacker must suffer while breaching the obstacle. The COV also provides, in addition to the savings in losses described above, a further saving in losses resulting from the marking phase of the minefield breach since the CLAMS is emplaced as the COV proofs the lane, and the dismounted engineers are not required.

2. Combat Roads and Trails Construction

This task is one that is generally performed away from the heat of a direct force-on-force confrontation. It was not wargamed for that reason. However, if this activity is observed, it is quite likely that the enemy will cal for indirect fire on it. An engineer squad with chain saws is highly vulnerable to indirect fire, and this represents a disadvantage in both the

		TIME PERIOD			
TASK	MISSION PRIORITY	PAST 1965	CURRENT	FUTURE 1995	COV UTILITY
Minefield Breaching	1	15 min	7 min (53% Improvement)	4 min (42% Improvement)	Excellent - COV removes exposure of dismounted marking crew.
Extra Losses Caused by Obstacles		25.5% of force	15.5% of force	10.5% of force	COV reduces extra obstacle losses by one third.
Combat Roads and Trails Construction	2	20-75 mins per 100 meters	15-60 mins per 100 meters	15-60 mins per 100 meters (or better)	Good - COV replaces exposed engineer squad w/chain saws, has capacity to construct faster than M-9.
Neutralize Antitank Ditch	3	9 min	7 min (22% improvement)	4 min (42% improvement)	Excellent - 42% improvement on time to cross.
Compound Obstacle		40% probability of mission success	56% probability of mission success	62% probability of mission success	COV offers 10% increase in mission success.
		30% extra losses due to obstacles	28% extra losses due to obstacles	22% extra losses due to obstacles	COV reduces extra losses by 21%.
Neutralize Log Crib Obstacle	4	CEV w/gun 9 min	CEV w/gun 9 min	COV w/o gun 8.9 min	Good - COV w/o gun can reduce log crib in same time as CEV w/gun.
Excavate Tank Difilade Position	5	D-7 27 min	M-9 27 min	COV 32 min (for M-1)	Fair - COV is comparable to M-9 in position construction.

Figure IV-1. Summary of Results of COS Evaluation and COV Utility.

past and current peiods. The improvement in time and efficiency brought on by the use of improved equipment for the mission is significant from the standpoint of the amount of road and trail construction that must be done in support of the combat forces. But the main improvement in the COS for this task results from the introduction of the COV. The ability to perform the task from within a protected workspace is a major advantage offered by the COV for the future period. Also, the savings in manpower expenditure (level of effort) is important since the COV offers a substitute for the engineer squad with chain saws. Both of these results are strongly supported by the human factors analysis and represent a significant utility to the COV that was not previously available in the COS, either in the past or at the present time.

3. Neutralization of Antitank Ditch

This mission is one that must be considered in conjunction with the battle since this type of obstacle will definitely be covered by enemy direct fxire weapons and exposure time is crucial. Clearly, a 22% reduction in time to cross the ditch between the past and the current period, and a further 42% reduction between current and future periods show the extreme utility of the COV in this role. When considered in conjunction with two minefields (the compound obstacle configuration tested in the combat model evaluation), the obstacle series brings out the utility of the COV as a single, multi-purpose system. Here, multiple capabilities are called for, none of which are available on any single past or current system. Having these on a single system inherently allows a greater reduction in exposure time, resulting in a 22% savings in obstacle losses and a 10% increase in probability of the entire force succeeding in accomplishing its mission.

4. Neutralize Log Crib Obstacle

This task shows the utility of the COV by demonstrating that the COV can overcome a log crib using its onboard capability in the same time as the CEV did in the past and current time frames using its demolition gun and dozer blade. This permits the demolition gun to be phased out of the system with no loss in capability. Its benefit is measured primarily in release from reliance on the supply system for ammunition resupply for a low use, low density item (the demolition gun). This is another example of the multi-purpose capability of the COV.

5. Excavation of Tank Defilade Position

This task is one illustrative of the supplementary capabilities of the COS -- that of earth moving. Like the situation discussed in 2 above, this task is not likely to be accomplished under direct fire. If enemy fire does occur, it is likely to be indirect. The improvement from bulldozer to M-9 ACE permitted operation in an indirect fire environment. The same is true for the COV, so the same capability is present for the future period as well as the current period.

CHAPTER V

RECOMMENDATIONS

The following are positive aspects of a single, multi-capable, counter-obstacle vehicle:

(1) The COV can breach minefields for an attacking force while saving approximately one-third of the losses the presence of the minefield will cause the attacker to suffer.

(2) The COV offers the ability to construct combat roads and trails more rapidly and with fewer workers and less danger to the construction crew.

(3) The COV can overcome a serious, compound obstacle that could defeat the attack of a friendly force with a 10% increase in assurance of mission accomplishment of the entire force.

(4) The COV can accomplish missions lusing strictly its mechanical strength that previously required a demolition gun to achieve in the same time.

Recommend that these data be used in various justification documentation to support development of a Counterobstacle Vehicle for the U.S. Army.

REFERENCES

1. EFOSS, Appendix N, p. N-III-jj-5.

2. FC 17-16-1, May 1984, p. 3-83

3. MICLIC ROC, p. 3, states the requirement to be able to fire the MICLIC within 30 seconds of reaching the firing point. "Robotic Minefield Breaching Analysis," Feb 84 (ROBAT STUDY), uses 20 seconds as a typical firing time for MICLIC.

4. MAA

5. MAA, p. 5-B-22

6. _ibid_.

7. Current performance data on the COV prototype shows firebreak construction of 114,000 ft2 in 7.7 hours. This is within the capability of the M-9, but nearly a 30% improvement from its average performance. However, this is insufficient data to ascibe a higher capability to the COV based on this performance, but it does contain an indication of improved capability.

8. MAA, 5-B-21, and EFOSS

9. MAA, 5-B-21, citing Engineer Modeling Study

10. Dept. of Army Field Manual 5-101, Mobility, January 1985, p. 5-9

11. Dept. of Army Field Manual 5-101, Mobility, January 1985, p. A-23

12. Dept. of Army Field Manual 5-25, February 1971, p. 3-19

13. EFOSS, p. N-III - q-1 through N-III - q-6

14. _Ibid_.

15. "Combat Engagement Analysis of Current and Developmental Countermine Systems," 30 September 1981, BDM Corporation

16. Some effort should be considered to develop and use a valid combat simulation model that will correctly reflect force-on-force encounters with current and anticipated future capabilities on both sides, and also reflect the presence or absence of physical obstacles erected on the battlefield. This model needs to be made easy to employ, with results rapidly produced, so that combat modelers may test and evaluate various capabilities for their impact on the battle outcome.

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ANNEX A

ENGINEER EQUIPMENT DESCRIPTIONS

This Annex A contains descriptions of engineer equipment items which have been considered in this study either as supplements or as alternatives to the Counterobstacle Vehicle (COV). The item descriptions are grouped as follows:

- Counterobstacle and Combat Engineer Vehicles

  COMBAT ENGINEER VEHICLE (CEV, M728)
  M9 ARMORED COMBAT EXCAVATOR (ACE)

- Gap Crossing/Bridging Equipment

  ARMORED VEHICLE LAUNCHED BRIDGE (AVLB)

- Earthmoving/Construction Equipment

  D7F, TRACTOR, FULL TRACKED, MEDIUM
  D8K, TRACTOR, FULL TRACKED, HEAVY
  UTILITY TRACTOR (JD 410)
  SMALL EMPLACEMENT EXCAVATOR (SEE)
  SCOOP LOADER, 2.5 CU YD, CASE MODEL MW24B
  SCOOP LOADER, 5 CU YD, CASE MODEL MW24B
  SCRAPER, TOWED, 18 CU YD
  SCRAPER, SELF-PROPELLED, 14-18 CU YD
  CRANE, 20 TON, WHEEL MOUNTED
  FAMILY OF CRANES, WHEEL MOUNTED

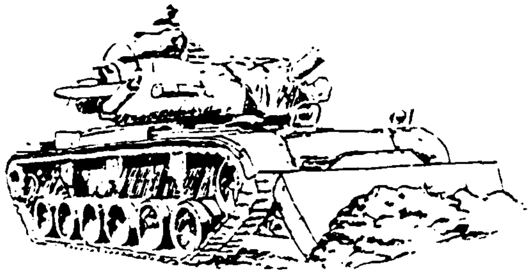
- Mine detecting/Clearing/Marking Equipment

  MINE DETECTING SET, METALLIC AND NONMETALLIC, PORTABLE (AN/PRS-7 AND AN/PRS-8)
  MINE DETECTING SET, METALLIC, PORTABLE (AN/PSS-11)
  MINE DETECTOR SYSTEM (MIRADOR)
  M157 MINE CLEARING PROJECTED CHARGE
  M173 MINE CLEARING PROJECTED CHARGE
  MINE CLEARING LINE CHARGE M58A1 (MICLIC)
  VEHICLE MAGNETIC SIGNATURE DUPLICATOR (VEMASID)
  ROBOTIC OBSTACLE BREACHING ASSAULT TANK (ROBAT)
  MINE CLEARING ROLLER, TRACK WIDTH, TANK MOUNTED
  TRACK WIDTH MINE PLOW
  FULL WIDTH MINE PLOW
  HAND EMPLACED MINEFIELD MARKING SET (M133)
  CLEAR LANE MARKING SYSTEM (CLAMS)

- Tactical Explosive

  TACTICAL EXPLOSIVE SYSTEM (TEXS)

COMBAT ENGINEER VEHICLE (CEV, M728)



PHYSICAL CHARACTERISTICS: WEIGHT: 64+ TONS

LENGTH: 352.8 IN WIDTH: 146.3 IN HEIGHT: 127.8 IN

ENGINE: 750 BHP DIESEL

TRACTION SYSTEM: FULL TRACK

ARMOR: HULL AND TURRET

MAJOR COMPONENTS/ATTACHMENTS:

M60 TANK CHASSIS, TURRET WITH 165MM GUN, DOZER BLADE, A-FRAME WITH WINCH

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: 5 MIN

DEMOLITION GUN: 165 MM WITH M123A1 HEP AMMUNITION USED AGAINST HARD TARGETS UP TO 1000 M RANGE AND TO NEUTRALIZE MINEFIELDS AT RANGES OF 1000-3000 M

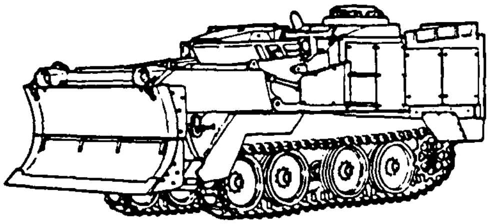
CREW SIZE: 4 MEN

DISTRIBUTION: 2 PER CMBT ENGR CO OF ARMORED DIV, MECH DIV, ARMORED BDE, MECH BDE

1 PER CMBT ENGR CO OF INF DIV

STATUS: TYPE CLASSIFIED - STANDARD

M9 ARMORED COMBAT EXCAVATOR (ACE)



PHYSICAL CHARACTERISTICS: WEIGHT: 16.25 TONS

LENGTH: 246 IN WIDTH: 126 IN W/ DOZER WGS HEIGHT: 90 IN

ENGINE: 295 HP DIESEL

TRACTION SYSTEM: FULL TRACKED

ARMOR: ALUMINUM

MAJOR COMPONENTS/ATTACHMENTS:

HULL, DOZER BLADE, SCRAPER BOWL, WINCH

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: 30 MIN

SPEED: 30 MPH

CREW SIZE: 1 MAN

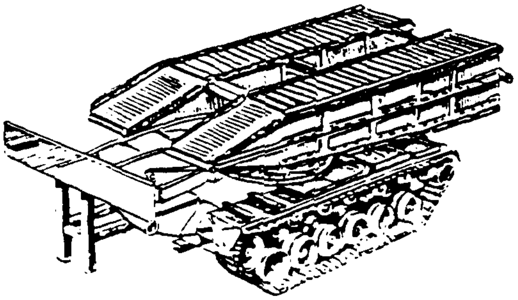
DISTRIBUTION: 2 PER CMBT ENGR PLATOON IN DIVISIONS AND SEPARATE BRIGADES

1 PER OTHER CMBT ENGR PLATOON

1 PER CMBT ENGR CO IN ABN DIV

STATUS: TYPE CLASSIFIED - STANDARD

ARMORED VEHICLE LAUNCHED BRIDGE (AVLB)



PHYSICAL CHARACTERISTICS: WEIGHT: 46 TONS

LENGTH: 340.5 IN WIDTH: 144 IN HEIGHT: 124.5 IN
200 IN W/BRIDGE

ENGINE: M60

TRACTION SYSTEM: FULL TRACKED

ARMOR: M60 TANK CHASSIS AND HULL

MAJOR COMPONENTS/ATTACHMENTS:

M60 TANK CHASIS AND HULL, BRIDGE SEAT, OVERHEAD CYLINDER, TONGUE ASSEMBLY, OUTRIGGER, AND BOOM ASSEMBLY, PLUS 60 FT SCISSOR BRIDGE

PERFORMANCE CHARACTERISTICS:

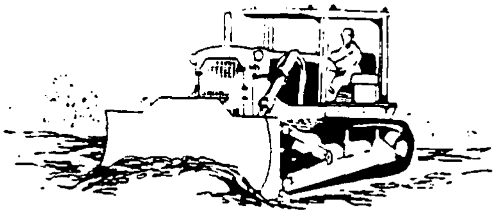
EMPLACEMENT TIME: 2-5 MIN TO LAUNCH SCISSOR BRIDGE

CREW SIZE: 2 MEN

DISTRIBUTION:
11 PER ARMORED CAV REGT
16 PER ARMORED ENGINEER BATTALION
3 PER SEPARATE ARMORED BRIGADE

STATUS: STANDARD

D7F,TRACTOR, FULL TRACKED, MEDIUM



PHYSICAL CHARACTERISTICS: WEIGHT: 25 TONS

LENGTH: 232 IN WIDTH: 133 IN HEIGHT: 124 IN

ENGINE: 200 HP DIESEL

TRACTION SYSTEM: FULL TRACKED

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

TRACTOR, HYDRAULICALLY OPERATED DOZER BLADE, AND WINCH OR RIPPER

PERFORMANCE CHARACTERISTICS:

EARTH MOVING CAPACITY: 447 BCY PER HOUR

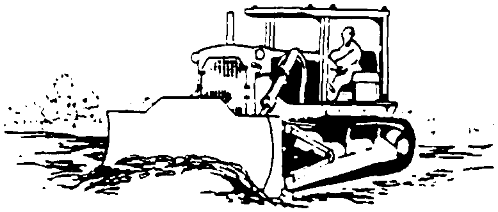
CREW SIZE: 1 MAN

DISTRIBUTION:

ISSUED TO ENGR CONSTR SPT CO, ENGR CMBT SPT EQUIP CO, ENGR CMBT ENGR BN (HVY), AND EQUIP OPERATING TEAMS

STATUS: STANDARD

D8K, TRACTOR, FULL TRACKED, HEAVY



PHYSICAL CHARACTERISTICS: WEIGHT: 37.7 TONS

LENGTH: 264.6 IN   WIDTH: 119 IN   HEIGHT: 135 IN

ENGINE: 300 HP DIESEL

TRACTION SYSTEM: FULL TRACKED

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

TRACTOR, HYDRAULICALLY OPERATED DOZER BLADE, AND REAR MOUNTED WINCH OR RIPPER

PERFORMANCE CHARACTERISTICS: NOT AVAILABLE

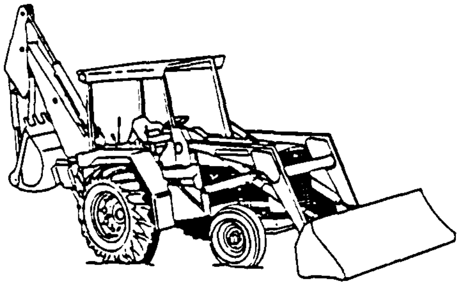
CREW SIZE: 1 MAN

DISTRIBUTION:

ISSUED TO ENGR CONSTR SPT CO, ENGR CMBT SPT EQUIP CO, ENGR CMBT ENGR BN (HVY), ENGR EQUIP MAINT CO, AND EQUIP OPERATING TEAMS

STATUS: STANDARD

UTILITY TRACTOR (JD 410)



PHYSICAL CHARACTERISTICS: WEIGHT: 7.5 TONS

LENGTH: 286 IN WIDTH: 97 IN HEIGHT: 102 IN

ENGINE: DIESEL

TRACTION SYSTEM: 4 RUBBER-TIRED WHEELS

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

WHEELED TRACTOR, SCOOPBUCKET, BACKHOE, CONCRETE BREAKER, AND TAMPER

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: 30 MIN

BACKHOE CAPACITY: 30 CUBIC YARDS PER HOUR

CREW SIZE: 1 MAN

DISTRIBUTION:

ISSUED TO ENGINEER COMPANIES IN DIVISION, CORPS, AND HEAVY ENGINEER BATTALIONS

STATUS: STANDARD

SMALL EMPLACEMENT EXCAVATOR (SEE)

PHYSICAL CHARACTERISTICS: WEIGHT: 1.89 TONS

LENGTH: 242 IN WIDTH: 93.5 IN HEIGHT: 139.5 IN

ENGINE: 94 HP DIESEL

TRACTION SYSTEM: WHEELS

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

4 WHEELED VEHICLE, BACKHOE, DOZER BLADE

PERFORMANCE CHARACTERISTICS:

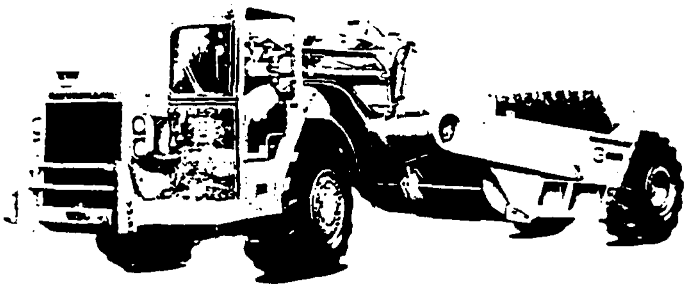
SET-UP TIME: MINIMAL

CREW SIZE: 1 MAN

DISTRIBUTION: AIRBORNE, AIRMOBILE, AND RAPID DEPLOYMENT UNITS

STATUS: MACI, NOT TYPE CLASSIFIED

SCRAPER, SELF-PROPELLED,14-18 CU YD



PHYSICAL CHARACTERISTICS: WEIGHT: 32.5 TONS

LENGTH: 499 IN WIDTH: 125 IN HEIGHT: 143 IN

ENGINE: 330 HP DIESEL

TRACTION SYSTEM: RUBBER TIRED WHEELS

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

HEAVY DUTY SCRAPER, HYDRAULIC SYSTEM, ENGINE, AND OPERATOR'S CAB

PERFORMANCE CHARACTERISTICS:

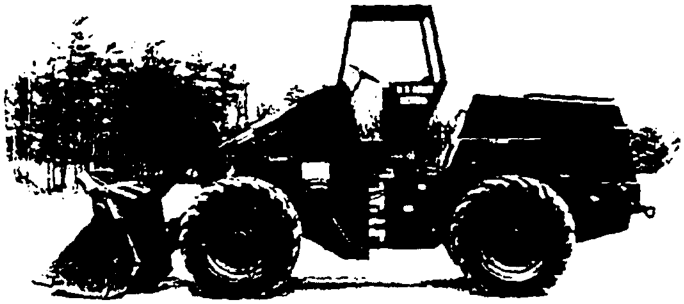
SET-UP TIME: NOT AVAILABLE

CREW SIZE: 1 MAN

DISTRIBUTION:
TO REPLACE TOWED SCRAPER IN LIGHT ENGR EQUIPMENT CO,ENGR COMBAT SPT EQUIPMENT CO, AND ENGR CO OF HEAVY ENGR COMBAT BNS

STATUS: MACI ITEM - NOT TYPE CLASSIFIED

SCOOP LOADER, 2.5 CU YD, CASE MODEL MW24B



PHYSICAL CHARACTERISTICS: WEIGHT: 12.5 TONS

LENGTH: 291 IN WIDTH: 102 IN HEIGHT: 128 IN

ENGINE: DIESEL

TRACTION SYSTEM: FOUR RUBBER TIRED WHEELS

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

FOUR WHEELED MACHINE, 2.5 CUBIC YARD MULTIPURPOSE BUCKET

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: MINIMAL

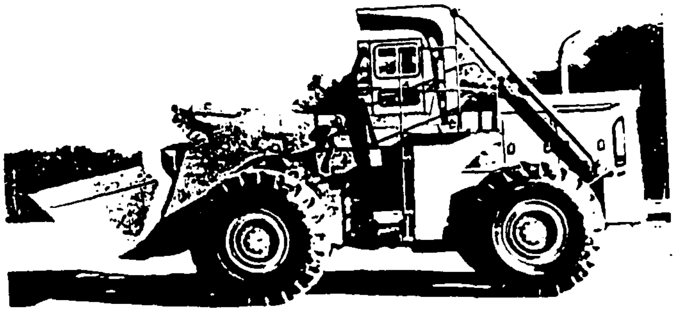
CREW SIZE: 1 MAN

DISTRIBUTION:

ENGR UNITS OF VARIOUS TYPES AT ALL ECHELONS

STATUS: STANDARD

SCOOP LOADER, 5 CU YD, CLARK MODEL 175B



PHYSICAL CHARACTERISTICS: WEIGHT: NOT AVAILABLE

LENGTH: 315.96 IN WIDTH: 114.96 IN HEIGHT: 159.96 IN

ENGINE: 304 HP DIESEL

TRACTION SYSTEM: WHEELED

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

FOUR WHEELED MACHINE, 5 CUBIC YARD FRONT SCOOP LOADER BUCKET, AND OPTIONAL MULTIPURPOSE BUCKET

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: MINIMAL

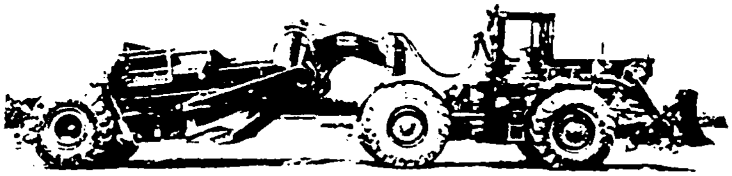
CREW SIZE: 1 MAN

DISTRIBUTION:

ENGR COMBAT SPT EQUIPMENT CO, ENGR CONSTRUCTION SPT CO, ENGR EQUIP OPR TEAMS

STATUS: STANDARD

SCRAPER, TOWED, 18 CU YD, WABCO MODEL CT4



PHYSICAL CHARACTERISTICS: WEIGHT: 15.5 TONS

LENGTH: 368 IN WIDTH: 124 IN HEIGHT: 130-142 IN

ENGINE: NONE - TOWED BY TRACTOR PRIME MOVER

TRACTION SYSTEM: RUBBEER TIRED WHEELS

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

HEAVY DUTY, LARGE CAPACITY SCRAPER INCLUDING HYDRAULIC OPERATING SYSTEM

PERFORMANCE CHARACTERISTICS:

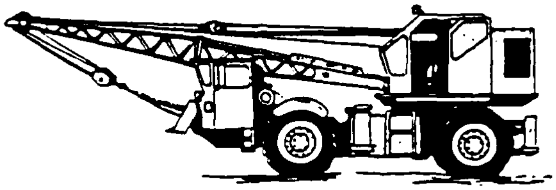
SET-UP TIME: NOT AVAILABLE

CREW SIZE: 1 MAN

DISTRIBUTION: LIGHT EQUIPMENT ENGR CO, ENGR CMBT SPT EQUIPMENT CO, ENGR CO OF HEAVY ENGR COMBAT BNS

STATUS: STANDARD

CRANE, WHEEL MOUNTED, 20 TON



PHYSICAL CHARACTERISTICS: WEIGHT: 33.4 TONS

LENGTH: 537 IN WIDTH: 150 IN HEIGHT: 132 IN

ENGINE: 8 CYLINDER CUMMINS DIESEL FOR CARRIER
4 CYLINDER DETROIT DIESEL FOR CRANE

TRACTION SYSTEM: FOUR RUBBER TIRED WHEELS

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

FOUR WHEELED CARRIES WITH OPERATOR CAB AND FRONT MOUNTED UTILITY BLADE, CRANE COMPARTMENT WITH OPERATOR CAB, CRANE ENGINE, 30 FT BOOM, 20 TON BLOCK AND TACKLE, AND FOUR HYDRAULICALLY OPERATED OUTRIGGERS

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: NOT AVAILABLE

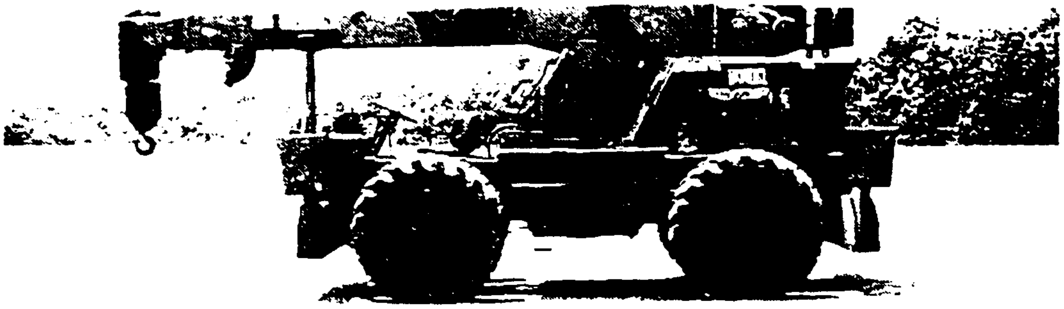
CREW SIZE: 2 MEN

DISTRIBUTION:

ENGE CONSTR, ENGR CMBT, ENGR BRDG, ORD AMMO, PETRL SUPPLY, MAINT, S&S, SUPPLY, AND TRANS UNITS

STATUS: STANDARD

FAMILY OF CRANES, WHEEL MOUNTED, HYDRAULIC, LIGHT



PHYSICAL CHARACTERISTICS:

WEIGHT, LENGTH, WIDTH, AND HEIGHT: NOT AVAILABLE

ENGINE: NOT AVAILABLE

TRACTION SYSTEM: FOUR RUBBER TIRED WHEELS

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

SELF-PROPELLED 7.5-10 TON CRANE WITH FOUR OUTRIGGERS (COMMERCIAL CANDIDATES ARE GALION MODEL 80 AND LINK BELT MODEL YC18)

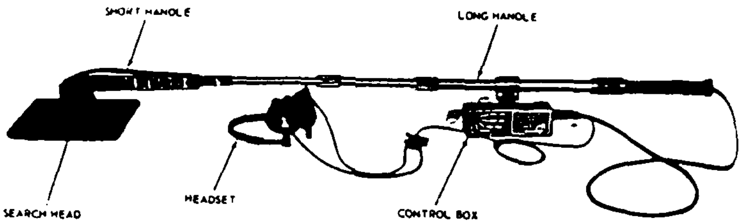
PERFORMANCE CHARACTERISTICS: NOT AVAILABLE

CREW SIZE: 1 MAN

DISTRIBUTION: NOT DETERMINED

STATUS: MACI ITEM - NOT TYPE CLASSIFIED

MINE DETECTING SET, METALLIC AND NONMETALLIC, PORTABLE (AN/PRS-7 AND AN/PRS-8)



PHYSICAL CHARACTERISTICS: WEIGHT: 24 LBS

LENGTH: 24 IN WIDTH: 16 IN HEIGHT: 7.5 IN

ENGINE: NONE

TRACTION SYSTEM: MAN PORTABLE

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

SEARCH HEAD, SHORT HANDLE, LONG HANDLE, CONTROL BOX AND HEADSET, RECEIVER, TRANSMITTER ASSEMBLY WITH CASE, AND BATTERY

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: 15 MIN

MINE DETECTION: METALLIC AND NON-METALLIC BURRIED MINES

CREW SIZE: 1 MAN

DISTRIBUTION: ENGINEER, COMBAT, COMBAT SUPPORT, AND COMBAT SERVICE SUPPORT UNITS

STATUS: STANDARD

MINE DETECTING SET, METALLIC, PORTABLE (AN/PSS-11)

PHYSICAL CHARACTERISTICS: WEIGHT: 36 LBS

LENGTH: 24.25 IN WIDTH: 16 IN HEIGHT: 7.5 IN

ENGINE: NONE

TRACTION SYSTEM: MAN PORTABLE

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

SEARCH HEAD, EXTENSION HANDLE, CONTROL BOX, HEADSET, RECEIVER, TRANSMITTER ASSEMBLY WITH CARRYING CASE, AND BATTERY

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: 15 MIN

MINE DETECTION: METALLIC MINES BURRIED OR HIDDEN FROM SIGHT

CREW SIZE: 1 MAN

DISTRIBUTION: ENGINEER, COMBAT, COMBAT SUPPORT, AND COMBAT SERVICE SUPPORT UNITS

STATUS: STANDARD

MINE DETECTOR SYSTEM (MIRADOR)

(ILLUSTRATION NOT AVAILABLE)

PHYSICAL CHARACTERISTICS:

WEIGHT, LENGTH, WIDTH,HEIGHT: **NOT AVAILABLE - SYSTEM NOT YET DEFINED**

ENGINE: NOT AVAILABLE

TRACTION SYSTEM: NOT AVAILABLE

ARMOR: NOT AVAILABLE

MAJOR COMPONENTS/ATTACHMENTS:

EXPECTED TO INCLUDE CONTROL AND MONITOR SYSTEM, REMOTE CONTROL SYSTEM, MINE DETECTOR SYSTEM

PERFORMANCE CHARACTERISTICS:

MINE DETECTION: ON ROAD AND OFF ROAD, METALLIC AND NON-METALLIC, BURRIED AND SURFACE LAID

CREW SIZE: NOT AVAILABLE

DISTRIBUTION: NOT AVAILABLE

STATUS: DEVELOPMENTAL

M157 MINE CLEARING PROJECTED CHARGE

PHYSICAL CHARACTERISTICS: WEIGHT: 5.5 TONS

LENGTH: 401 FT WIDTH: 12 IN HEIGHT: 7 IN

ENGINE: NONE

TRACTION SYSTEM: PUSHED INTO MINEFIELD BY TANK

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

DEMOLITION KIT CONSISTING OF 62 CENTER LOADING SECTIONS, 13 BODY SECTIONS, 2 IMPACT FUZE SECTIONS, 1 TAIL SECTION, AND M603 FUZE

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: 6-8 MANHOURS TO ASSEMBLE

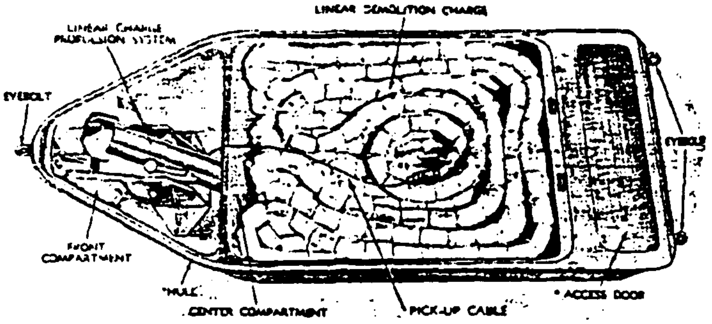
CLEARED LANE: 4 M X 90 M

CREW SIZE: NO DEDICATED CREW

DISTRIBUTION: CLASS V ITEM DRAWN BY ENGINEER UNIT AS REQUIRED

STATUS: STANDARD

M173 MINE CLEARING PROJECTED CHARGE



PHYSICAL CHARACTERISTICS: WEIGHT: 1.55 TONS

LENGTH: 145 IN WIDTH: 56.5 IN HEIGHT: 24 IN

ENGINE: NONE

TRACTION SYSTEM: TOWED INTO FIRING POSITION BY TANK OR OTHER VEHICLE

LINE CHARGE PROJECTED INTO MINEFIELD BY ROCKET

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

WATERPROOF SKID M3, LINEAR DEMOLITION CHARGE, ROCKET PROPULSION SYSTEM, ACCESSORIES FOR TOWING AND FIRING

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: 0.5 MANHOURS

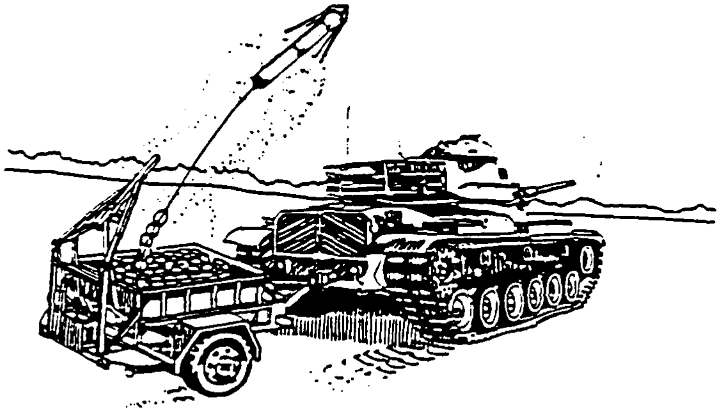
CLEARED LANE: 4.6 M X 83 M

CREW SIZE: NO DEDICATED CREW

DISTRIBUTION CLASS V ITEM DRAWN BY ENGINEER UNIT AS REQUIRED

STATUS: STANDARD

MINE CLEARING LINE CHARGE M58A1 (MICLIC)



PHYSICAL CHARACTERISTICS: WEIGHT: 1.6 TONS

LENGTH: 93 IN WIDTH: 53 IN HEIGHT: 28 IN

ENGINE: NONE - TOWED INTO POSITION

TRACTION SYSTEM: MOUNTED ON TWO WHEELED TRAILER

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

TWO WHEELED TRAILER, ROCKET LAUNCHER RAIL, 1700 LB EXPLOSIVE LINE CHARGE (71 CM X 134 CM X 236 CM), ROCKET (TO DEPLOY LINE CHARGE), REMOTE FIRING/DETONATION SYSTEM

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: 20 MIN

CLEARED LANE: 8 M X 100 M

TYPE MINES AFFECTED: PRESSURE FUZED MINES

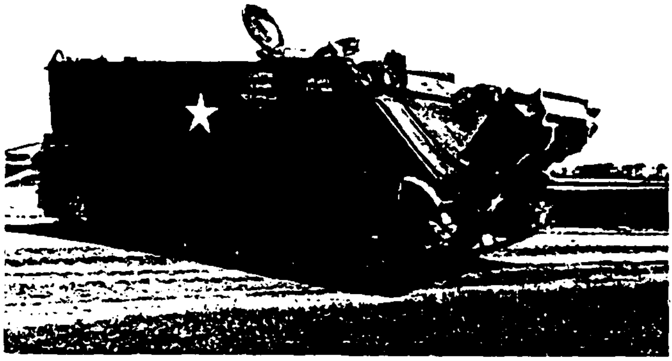
CREW SIZE: NONE - OPERATED BY CREW OF TOWING VEHICLE

DISTRIBUTION:

2 TRAILERS PER ENGINEER COMPANY IN DIVISIONS, SEPARATE BRIGADES, ARMORED CAVALRY REGIMENTS, AND CORPS

STATUS: DEVELOPMENTAL - IN SERVICE IN MARINE CORPS - BEING ADAPTED TO ARMY USE

VEHICLE MAGNETIC SIGNATURE DUPLICATOR (VEMASID)



PHYSICAL CHARACTERISTICS: (THREE SIZES PROPOSED)

CIRCUMFERENCE:	17 FT	32 FT	59 FT
WEIGHT: (COIL)	85 LBS	135 LBS	350LBS
(ELECTRONICS)	85LBS	85 LBS	85LBS

ENGINE: NONE

TRACTION SYSTEM: MOUNTED ON TANK OR OTHER VEHICLE

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

ELECTROMAGNETIC COIL DESIGNED TO SPECIFIC VEHICLE, ELECTRONICS PACKAGE

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: APPROXIMATELY 15 MIN

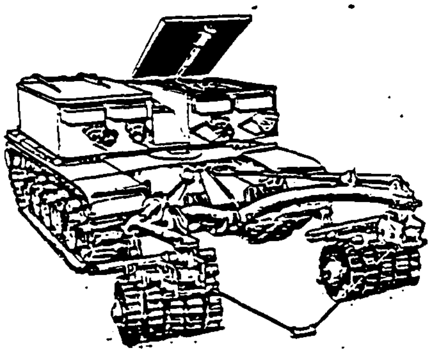
MINE CLEARING: NEUTRALIZES/ACTIVATES MAGNETIC FUZED MINES IN VEHICLE PATH BY PROJECTING MAGNETIC SIGNATURE OF VEHICLE

CREW SIZE: NO DEDICATED CREW

DISTRIBUTION: 1 PER ARMOR, ARMORED CAVALRY, ENGINEER, AND MECHANIZED INFANTRY PLATOON

STATUS: DEVELOPMENTAL

ROBOTIC OBSTACLE BREACHING ASSAULT TANK (ROBAT)



PHYSICAL CHARACTERISTICS: WEIGHT: NOT AVAILABLE

LENGTH: WIDTH: HEIGHT:

ENGINE:

TRACTION SYSTEM:

ARMOR:

MAJOR COMPONENTS/ATTACHMENTS:

M60 TANK HULL, REMOTE CONTROL, COMPUTER, MINE CLEARANCE KIT (MICLIC TYPE), CLAMS, AND ROLLER OR PLOW

PERFORMANCE CHARACTERISTICS:

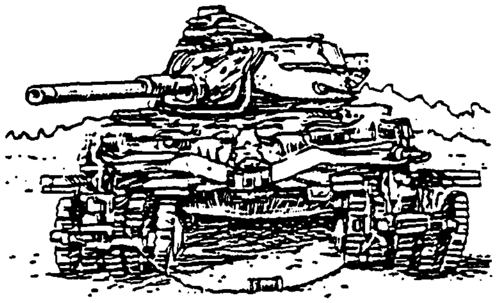
SET-UP TIME:

CREW SIZE: NONE

DISTRIBUTION: NOT AVAILABLE

STATUS: DEVELOPMENTAL

MINE CLEARING ROLLER, TRACK WIDTH, TANK MOUNTED



PHYSICAL CHARACTERISTICS: WEIGHT: 10 TONS

LENGTH, WIDTH, HEIGHT: NOT AVAILABLE

ENGINE: NONE

TRACTION SYSTEM: NONE - ATTACHED TO TANK OR ROBAT

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

TWO ROLLER BANKS OF FIVE ROLLER WHEELS EACH, "DOG-BONE" CHAIN BETWEEN ROLLER BANKS, MOUNTING KIT, TWO HAND OPERATED WINCHES FOR MOUNTING, AND HYDRAULIC ASSEMBLY FOR DISCONNECTING.

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: 15 MIN TO MOUNT (AFTER MOUNTING KIT IS INSTALLED ON TANK; ALSO AFTER ROLLERS REMOVED FROM TRANSPORT TRAILER.)

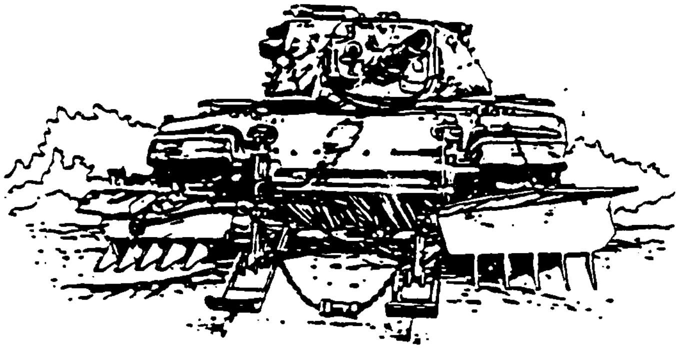
MINE CLEARING: CLEARS/NEUTRALIZES PRESSURE FUZED MINES IN TWO TRACK-WIDTH PATHS AND TILT ROD FUZED MINES BETWEEN TRACKS

CREW SIZE: NONE - TANK CREW OPERATES ROLLER

DISTRIBUTION: 1 PER TANK COMPANY

STATUS: IN PRODUCTION

TRACK WIDTH MINE PLOW



PHYSICAL CHARACTERISTICS: WEIGHT: NOT AVAILABLE

LENGTH: WIDTH: HEIGHT:

ENGINE: NONE

TRACTION SYSTEM: MOUNTED ON A TANK

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

PUSH BEAM,SKID SHOE, MOLDBOARD WITH PROTRUDING TINES, CHAIN SUSPENDED BETWEEN PUSH BEAMS, AND HYDRAULIC SYSTEM

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: 25 MIN

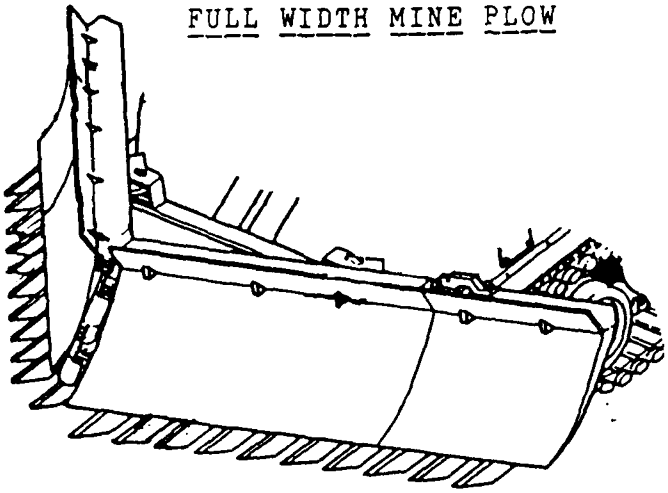
MINE CLEARING: TWO TRACK WIDTH PATHS

CREW SIZE: NO DEDICATED CREW

DISTRIBUTION: NOT AVAILABLE

STATUS: DEVELOPMENTAL

FULL WIDTH MINE PLOW



PHYSICAL CHARACTERISTICS: LENGTH, WIDTH, HEIGHT ARE NOT AVAILABLE

ENGINE: NONE

TRACTION SYSTEM: MOUNTED ON TANK OR OTHER VEHICLE

ARMOR: NOT AVAILABLE

MAJOR COMPONENTS/ATTACHMENTS:

MINE PLOW EXTENDING ACROSS FULL WIDTH OF TANK OR OTHER ARMORED VEHICLE, HYDRAULIC LIFT SYSTEM, MOUNTING KIT, CONTROL SYSTEM

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: NOT KNOWN

CLEARED LANE: FULL WIDTH OF TANK

CREW SIZE: NONE

DISTRIBUTION: NOT DETERMINED

STATUS: DEVELOPMENTAL

HAND EMPLACED MINEFIELD MARKING SET (M133)

PHYSICAL CHARACTERISTICS: WEIGHT: TRANSPORTABLE BY 4 MEN

LENGTH, WIDTH, & HEIGHT: PACKED IN MODULES THAT 1 MAN CAN CARRY

ENGINE: NONE

TRACTION SYSTEM: NONE

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

70 POLES, 70 MINE WARNING SIGNS, 2 SPOOLS OF FLOURESCENT TAPE, POLE DRIVER, SET OF FLASHING LIGHTS, AND OTHER ACCESSORIES

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: VARIES

LANE MARKING: PERIMETER OF CLEARED LANE 2300 - 3000 FEET

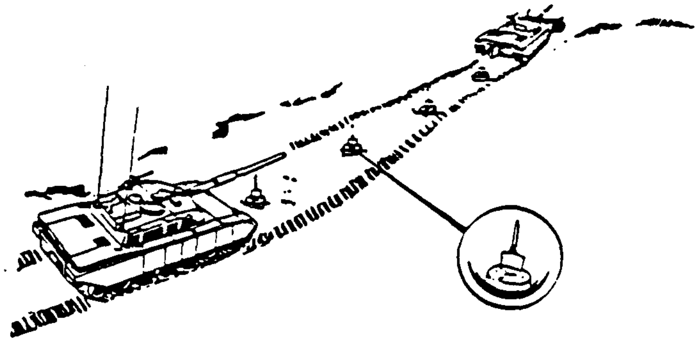
CREW SIZE: 4 MEN TO CARRY

DISTRIBUTION:

2 PER ENGR CO

STATUS: STANDARD

CLEAR LANE MARKING SYSTEM (CLAMS)



PHYSICAL CHARACTERISTICS: NOT AVAILABLE

ENGINE: NONE

TRACTION SYSTEM: NONE

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

GRAVITY FEED DISPENSER, MARKING KIT OF 150 INDIVIDUAL MARKERS, VEHICLE MOUNTING KIT, AND CONTROL ASSEMBLY

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: NOT AVAILABLE

CREW SIZE: NONE

DISTRIBUTION:

1 PER ROBAT, TANK WITH TRACK WIDTH ROLLER SET, OR OTHER ASSAULT BREACH VEHICLES

STATUS: DEVELOPMENTAL

TACTICAL EXPLOSIVE SYSTEM (TEXS)

(ILLUSTRATION NOT AVAILABLE)

PHYSICAL CHARACTERISTICS: WEIGHT: NOT AVAILABLE - SYSTEM NOT YET DEFINED

LENGTH: WIDTH: HEIGHT:

ENGINE: NONE

TRACTION SYSTEM: NONE

ARMOR: NONE

MAJOR COMPONENTS/ATTACHMENTS:

PIPE, EXPLOSIVE COMPOUND, DETONATING SYSTEM

PERFORMANCE CHARACTERISTICS:

SET-UP TIME: NOT AVAILABLE

CREW SIZE: NO DEDICATED CREW

DISTRIBUTION: NOT AVAILABLE

STATUS: DEVELOPMENTAL

ANNEX B

THREAT TO THE COUNTEROBSTACLE SYSTEM (U)

Published Seperately

as VOLUME II

ANNEX C

Formulation For Expected Mine Density

1. One Mine Clearing Vehicle:

The mine density will be greatly reduced in those instances when the countermine vehicle survives the breach. When it does, the mine density within the lane is 1-EFF (the mine clearing effectiveness). If the vehicle is killed by direct fire or by mines, that event is equally likely to occur at any point in the minefield. Therefore, the remaining mine density increases linearly to 1.0, which was the initial mine density.

The expected mine density is computed by solving for the area under the curve. This is found by deriving the probability of survival from both direct fire and from mines given that the vehicle has traversed some amount of distance (call that distance X) through the minefield.

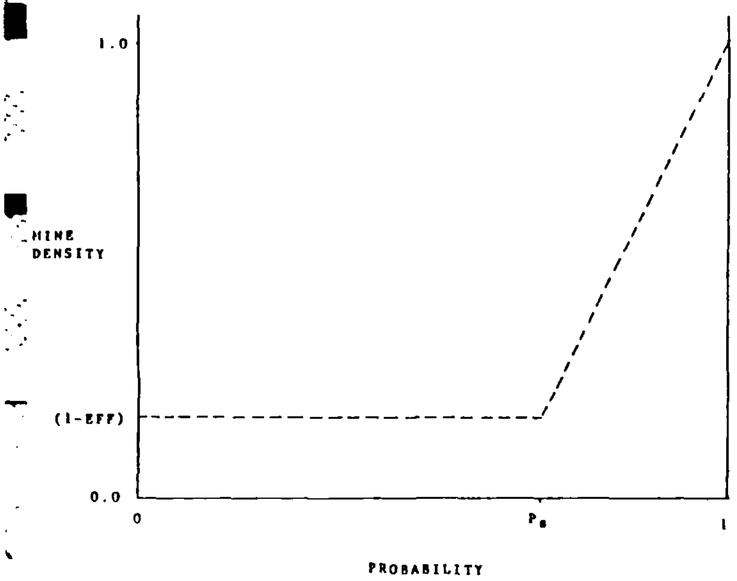


Figure III-5 Probability Distribution of Mine Densities for a Single Countermine System

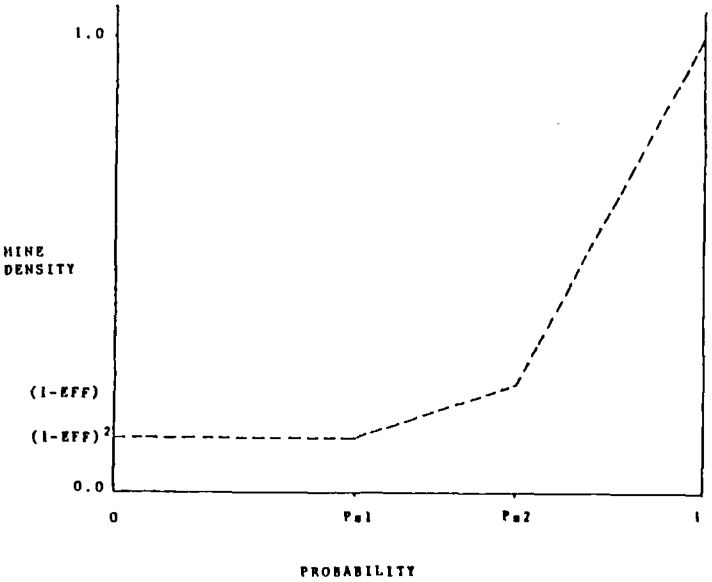


Figure III-6 Probability Distribution of Mine Densities for Two Countermine Systems

$$Psdf(x) = 1 - \left(\frac{xr}{s}\right)$$

where r = casualty rate
s = speed through the minefield (m/s)

$$Psmines(x) = 1 - e^{-\left(\frac{x}{L}\right)(1-EFF)Dw}$$

where L = total mine clearing action distance
D = mine density
w = apparent vehicle width to mines
EFF = mine clearing effectiveness

$$Ps(x) = Psdf(x) * Psmines(x)$$

These values are then computed for x=L and combined with the mine clearing effectiveness to compute the expected mine density. For one mine clearing vehicle, the computation is as follows:

$$E(MD) = (1-EFF) + \frac{(1-Ps)(EFF)}{2}$$

2. Two Mine Clearing Vehicles: When there are two mine clearing vehicles allocated to a single breach lane, then a significantly cleared lane occurs if only one of the vehicles survives, and it is proofed in the distance that both vehicles were functional. Figure III-6 depicts the probability distribution of mine density outcomes for this situation.

In a manner similar to the case with one countermine system, the expected remaining mine density for two mine clearing vehicles is computed from the survival likelihood for two vehicles (Ps2) and for only one vehicle (Ps1). These computations assume that the vehicles' survival probabilities are independent. The key difference here is that the follow-on vehicle faces an apparently reduced mine density. We separately compute the survival probability for the lead vehicle (PsminesA) and the follow-on vehicle (PsminesB). PsminesA is the same as Msmines for the single vehicle case described above.

$$PsmineB(x) = 1 - e^{-\left(\frac{x}{L}\right)(1-EFF)^2Dw}$$

therefore,

$$Ps2(x) = Psdf(x)^2 * PsminesA(x) * PsminesB(x)$$

$$Ps1(x) = 1- (1-Psdf(x)*PsminesA(x))^2$$

$$E(MD) = (c*a) + ((b-a)*(c+d)/2) + ((1-b)*(1+d)/2)$$

where a = Ps2
b = Ps1
c = $(1-EFF)^2$
d = (1-EFF)

AD-A169 309 COUNTEROBSTACLE VEHICLE (COV) UTILITY STUDY VOLUME 1 2/2
(U) MCLEAN RESEARCH CENTER INC VA R D CARPENTER ET AL.
MAY 86 MRC-136-VOL-1 DAAK70-84-D-0052
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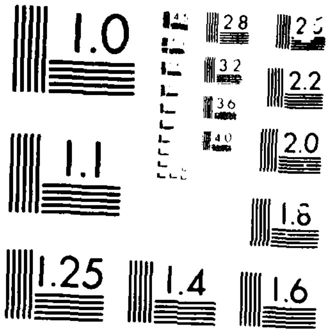

MICROCI

ANNEX D

The following document was published in September 1984 by the Systems Research Laboratory, US Army Research Institute as a suggested technique in presenting human factors as a significant part of the ROC generation process. It is a useful reference for preparers of these documents to insure they have correctly included and emphasized these important concerns. The document included in its entirety in this annex.

Human Factors, Manpower, Personnel and Training Required Operational Capability (ROC) Enhancement

Systems Research Laboratory

U. S. Army
Research Institute for the Behavioral and Social Sciences

September, 1984

REQUIRED OPERATIONAL CAPABILITY
FOR HMPT

Contents

INTRODUCTION

As the Army modernizes with high-technology hardware, it must ensure that it can man new equipment. In the past, system performance requirements presented in requirements documents have not always been met by all soldiers operating, maintaining, and repairing the system in the field. The Army believes that previously developed materiel systems have not performed in the field as desired because these system were not designed with adequate consideration of the performance capabilities and limitations of the soldiers assigned to them.

The performance levels of hardware and software components of a system, in a given setting, are in general predictable with a high degree of certainty. However, performance levels of soldier tasks or sets of tasks typically exhibit significant variation. Repeated trials by individual soldiers will result in a range of task performance levels for which mean values and variances can be determined; similar trials by different soldiers may lead to a range of different mean values and variances. These differences are due to inherent differences in soldier aptitudes. Once a system design is fixed, it is the distribution of aptitudes translated through training into a distribution of task performance levels, that determine <u>system</u> performance, i.e., system performance levels can be expected to vary because of dependence on soldier task performance.

The requirements-driven acquisition process has as its goal the provision of a specified operational capability to the Army in the field subject to budgetary and schedule constraints or objectives. Implicit in this process is the fact that an operational capability derives from the engineering or technical parameters of a system, the role and performance of the soldiers that operate, maintain and repair the system, and the resources required to recruit, train, and maintain those soldiers over the life of the system. All of these factors must be considered in the materiel acquisition process, particularly when making estimates of required or achievable <u>system performance</u> to support design tradeoffs or program decisions.

Enhancement to the Required Operational Capability (ROC) are described here to further the general goals of:

- requiring performance not hardware
- focusing on total system development
- designing systems that consider explicitly the availability of people, skills and training resources

- o assessing system performance through comprehensive test and evaluation

The information constituting and supporting statements in the ROC evolves from preceding requirements documents and products of the Concept Exploration (CE) and Demonstration and Validation (D&V) phases of the acquisition cycle. Parallel modifications to those shown for the ROC have been developed for the CE and D&V RFP's (ARI, 1984).

The ROC formats specified in AR 71-9 (Dept. of the Army, 1984) and the Materiel Acquisition Handbook, DA PAM 70-2, (DARCOM/TRADOC, 1984) are essentially the same. The format appearing in the latter document has been chosen as the basis for presenting changes. In the following material the original text of the Handbook is shown in full: items recommended for deletion are stated with hyphens overstruck (as: ~~and system performance~~) and words and phrases to be added are underlined (as: and system performance). In addition, Annex F, Training Device Annex, is replaced in full by a new Annex F entitled Manpower, Personnel and Training Annex.

ROC FORMAT CHANGES

REQUIRED OPERATIONAL CAPABILITY (ROC) FORMAT

The Required Operational Capability (ROC) is in the format below. Limit information to that necessary for a HQDA decision. The basic document should not exceed four pages.

1. TITLE

   a. Give a descriptive title for the program.
   b. CARDS reference number.

2. NEED/THREAT. Briefly describe the operational/training deficiency need for the system and the reactive threat to the system. Include the enemy's capability to detect, identify, locate, avoid, suppress, destroy, or otherwise counter the system. Describe the responsive threat over time to support evolutionary development when applicable.

3. TIMEFRAME AND IOC. State the IOC date including IOCs for successive evolutionary models, when appropriate.

4. OPERATIONAL AND ORGANIZATIONAL PLAN (O&O Plan). In a brief paragraph state:

   a. How the equipment will be used;
   b. Geographical areas of use;
   c. Weather and climatological factors to be considered during equipment operations;
   d. Battlefield conditions (such as ECM, smoke, and dust) in which the system will operate; and
   e. The type of units that will use and support the equipment.

5. ESSENTIAL CHARACTERISTICS. Describe only main operational features of the system. Included are counter-countermeasure capabilities, health, safety and human factors engineering requirements, and reliability, availability, and maintainability (RAM). Performance must be responsive to battlefield environmental conditions of continuous combat (such as full ECM, smoke, aerosols, rain, fog, haze, and dust).

System performance requirements shall be stated in terms of desired distributions of performance in the field to reflect the range of characteristics of the pool of soldiers from which operators, maintainers and repairers must be drawn. Requirements should be expressed in this style:

REQUIRED OPERATIONAL CAPABILITY (ROC) FORMAT
(continued)

"For any system performance requirement, stated in terms of a given, fixed setting,

- the level of performance, m_1, must be achieved or exceeded at least x_1 percent of the time when system manning is drawn from the designated pool of soldiers..."

At least three sets of values should be stated for each system performance requirement representing:

- a minimum level of system performance to be achieved 95% of the time.

- a mean level of system performance;

- a superior level of system performance to be achieved at least 5% of the time.

~~Express performance and reliability characteristics in bands of performance. Those which are not suitable for banding will be stated as single values.~~ During development, commercial, other Service, NATO, or other allied nation characteristics of existing or programmed systems should be considered for inclusion with a view toward establishing a basis for interoperability, co-production, or standardization. ~~Bands of~~ Performance requirements should be flexible enough to consider competing systems of other Services or allied nations. Stated bands distributions of performance, ~~or single value characteristics~~ are adjusted only after the combat and materiel developers agree that changes are necessary. DCSOPS will approve changes for documents previously approved by DCSOPS. The requirements and provisions for the following must be considered:

a. Interoperability;
b. Continuity of Operations (CONOPS);
c. Security;
d. Reliabiity, availability, and maintainability (RAM) derived from mission performance parameters;
e. Standardization, including commonality for hardware and software to which the system will adhere;
f. Nuclear survivability; NBC contamination survivability;
g. Individual/collective protection equipment;
h. Adverse weather and reduced visibility (smoke and obscurants) operations, and military operations on urbanized terrain (MOUT) where applicable;

REQUIRED OPERATIONAL CAPABILITY (ROC) FORMAT
(continued)

i. Communications;
j. Operation transportability requirements, such as: transportable in C-141 type aircraft requiring not more than...hours teardown and...hours set up by operator and crew; etc.
k. P31

6. TECHNICAL ASSESSMENT. In the ROC, include a brief paragraph about the technical effort required. Address major areas for full scale development in terms of scope, technical approach, and associated risks in high, medium, low, or similar categories. Identify "high driver" tasks* where they either represent or are related to the major areas for development. Indicate the implications of the risks associated with full scale development for system performance and for manpower, personnel and training requirements. For NDI items, briefly outline completed or planned market survey efforts and/or military suitability evaluations.

7. LOGISTICS SUPPORT PLAN. Briefly describe the logistics support concept. The logistics support package will be tested during OT II.

8. TRAINING ASSESSMENT. Briefly describe the system training concept. Show its relationship to the elements of the O&O Plan. Summarize the manpower, personnel and training constraints presented in Annex F and their impact on system training. Discuss the need for system training devices. When required, include description of training devices as an annex to the ROC. New equipment training (NET) operator and maintenance personnel training, technical manuals and training materiel requirements will be stated in terms of needs for both institution and unit training levels. The training support package will be tested during OT II.

9. MANPOWER/FORCE STRUCTURE ASSESSMENT. Estimate manpower requirements per system, using unit, and total Army by component (Active, ARNG, USAR). Identify manpower savings resulting from replaced systems, if any. Include a statement to require an assessment of alternatives to reduce manpower requirements and an assessment of force structure implications resulting from system

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* "High driver tasks are those which are either critical (see para 6.2.1 of MIL-H-46855) to system performance and for which required task performance levels are believed difficult to achieve or for which required task performance frequency is uncertain and may have a major impact on manpower levels.

REQUIRED OPERATIONAL CAPABILITY (ROC) FORMAT
(continued)

inclusion in the total force by component. If the force structure assessment exceeds current programmed force structure levels then identification of force structure tradeoffs within mission area or mission elements is required. Tradeoff analyses are addressed to the degree necessary to bring the force structure assessment within current programming levels, if possible. The personnel support package will be tested during OT II.

10. STANDARDIZATION, INTEROPERABILITY . Discuss other Service, NATO, and other foreign interest in the program. Identify similar programs contemplated by other Services, NATO or other allies.

11. LIFE CYCLE COST ASSESSMENT. See appendix 1.

12. MILESTONE SCHEDULE. A listing of significant events with dates to occur between approval of the ROC and next scheduled milestone review. The following should be included: ROC approval, DT/OT/other test (Market/User Survey for OTS), and next scheduled milestone review.

APPENDIX 1 - Life-cycle Cost Assessment. Provide life-cycle costs using mainly summary parametric estimating techniques. State the major life cycle phases of R&D, investment, and operation and support. Also include the design-to-cost goals. As much as possible, show the estimated cost of major items or components below the system level. (These data should be consistent with the Materiel System Requirements Specification (MSRS) and Baseline Cost Estimate (BCE). (See app D, p. D.7, this handbook, for format).

ANNEX A - Coordination. List all major commands, other Services, allied nations and activities with whom the ROC was coordinated. Provide full rationale for nonacceptance of comments, if any.

ANNEX B - Operational Mode Summary/Mission Profile Annex. List tasks and conditions for frequency and urgency viewed for system employment in military operations. The mission profile is logically derived from the operational/training concept. It provides the starting point for developing the system characteristics.

ANNEX C - COEA Annex. Executive summary of the COEA. Classify as required. Withdraw after HQ TRADOC approval of the ROC and handle as a separate document for transmittal as needed.

ANNEX D - Rationale Annex. Support various characteristics stated in the ROC. This provides an audit trail and rationale for determining how the characteristics were derived.

REQUIRED OPERATIONAL CAPABILITY (ROC) FORMAT
(continued)

ANNEX E - RAM Rationale Annex. Executive summary of the RAM Rationale Report. Support the stated RAM characteristics with a logical argument that begins with the task frequency, conditions, and standards described and analyzed in the Mission Area Analysis (MAA). This provides an audit trail and rationale for determining how the characteristics were derived. TRADOC/DARCOM Pamphlet 70-11 contains guidance on the preparation of both the RAM Rationale Report and the RAM Rationale Annex.

ANNEX F - MANPOWER, PERSONNEL AND TRAINING ANNEX. Summary of current status of manpower, personnel and training (MPT) constraints and decisions; statement of major MPT issues to be addressed during full-scale development. The following format is provided for guidance: (Note: This replaces the current ANNEX F - TRAINING DEVICE ANNEX)

FORMAT OF MPT ANNEX

1. Introduction

2. Restatement of MPT Constraints for Materiel Developer

   a. Description of Aptitudes of Intended Operators, Maintainers & Repairers

   b. Limit on Institutional Training Time

   c. Limit on Institutional Training Cost

3. Summary of relationship of soldier performance to measures of system effectiveness

4. Manpower

   a. Confidence levels regarding manpower estimates

   b. Identification of any tasks without associated manpower estimates

5. Remaining Personnel Risks

   a. Tasks yet to be analyzed to determine personnel skill requirements

   b. MOS decisions still to be made

REQUIRED OPERATIONAL CAPABILITY (ROC) FORMAT
(continued)

6. Training

a. Description of alternative training programs resulting from CTEA

b. Identification of decisions yet to be made

c. Identification of remaining critical issues

d. Training Devices Needed (brief description of each device covering)

(1) What skill is to be imparted to personnel of what aptitudes?

(2) What frequency of use is expected?

(3) Plans for simultaneous or contemporary fielding of device with system

(4) Principal (Essential) characteristics of device

(5) Summary of analysis of logistical supportability

(6) Funding

7. Test and Evaluation

a. What data will be needed when to verify that soldiers of the specified aptitudes will be able to perform to the required standards with the training program designed by the contractor?

b. Identification of responsibility for the collection and analysis of MPT data

NOTES: 1. Send annex A with each requirements document.

2. Annex F (~~when prepared~~) must accompany the ROC to HQDA for approval as a package.

3. Send the TBOIP/TQQPRI with the ROC to HQDA for approval. When the TBOIP/TQQPRI are not submitted, the transmittal letter will contain a statement about the projected submission date.

REFERENCES

Department of the Army, Headquarters. Force Development Materiel Objectives and Requirements. Army Regulation 71-9, August 15, 1984.

U.S. Army DARCOM and TRADOC, Headquarters. Materiel Acquisition Handbook, DARCOM and TRADOC, 1984. Pamphlet 70-2, January 29, 1984.

U.S. Army Research Institute. Human Factors, Manpower, Personnel and Training Clauses for the Concept Exploration and the Demonstration and Validation Requests for Proposal. Research Product, In Press.

ANNEX E - DETAILED RATIONALE FOR MATRIX ELEMENTS

Since each entry is not obvious in itelf, the following pages reflect the detailed rationale behind each entry of Table III-3, main report. Note once again that the entries in the matrix follow the following convention:

1 = no significant problem
2 = Minor problem
3 = Moderate problem
4 = Serious problem
5 = No solution or no mitigation of the problem

M1-1 is the entry in the first row and the first column and rates the ability of the 1965 era system(s) to perform the Class I missions in a benign environment and is rated at 2.5, meaning that minor to moderate problems existed in performing the mission in that time base even in a benign environment. It is an average of the entries under load and accuracy ratings of Table III-2.

M1-2 is the entry in the first row, second column and rates the ability of the 1965 era system(s) to perform the Class I missions in an NBC environment and, considering the lack of availability of good individual and collective NBC equipment, there were serious problems in performing this mission in such an environment. Note that the probability of this mission/environment combination occurring is not an issue in the rating.

M1-3 is rated as a 5 since essentially nothing was available to mitigate the problem of indirect enemy fire during the performance of this mission in this era, when the rate of human performance was very slow (see III-2).

M1-4 The same is true for the direct enemy fire threat as indirect, so this element is also 5.

M1-5 cannot be smaller than the larger of M1-2 or M1-3, so it must also be a 5.

M1-6 rates the difficulty of training individuals to perform the tasks critical to the Class I mission in 1965. In general, the tasks were relatively simple but many individuals were (and still are) incapable of distinguishing the audio signals which varied in the detectors as a function of the mass of metal or density difference in the soil. Thus, finding individuals who could be trained to perform some functions posed a moderate problem and a rating of 3 is applied.

M1-7 is rated at 4 because mine clearing was a very labor intensive mission given the era's systems. Relates directly to number of personnel required (III-2).

M1-8 The ability to control the environment that the soldier worked in was essentially unavailable. He could dress lightly in summer or heavily in winter, but this was not a change or mitigation of the environment hence, a rating of 5 is assigned. Consider also workspace (unlimited but unprotected).

In order to complete a Mission/Era submatrix, we now move to the second row:

M2-1 This element is concerned with the ability to perform required Repair and Maintenance of Mission I equipment in a benign environment. It is not felt that this presented even a moderate problem since only the hand held detectors would require any significant R&M. A value of 2 is therefore applied to this task area.

M2-2 In an NBC environment in 1965, any activity would have represented a serious problem and, while avoided where possible, would be required at least for decontamination. Again, the probability of occurrence of the mission/environment is not an issue in the rating. Therefore, this element is rated at 4.

M2-3 Performing R&M in an indirect fire environment would be extremely hazardous and would be postponed whenever possible but no ability to mitigate the environment existed in 1965, so a rating of 5 is applied to this element.

M2-4 The same considerations as M2-3 suggest a 5 for this element.

M2-5 Same as M2-4.

M2-6 The training to perform the R&M on mission critical equipment was less of a problem than the training to perform the mission (element M1-6) since individual variability in audio sensitivity did not enter into the problem. Hence, this element is rated at 2 rather than the 3 value ascribed to M1-6.

M2-7 The value of 1 for this element indicates that the level of effort required to perform mission critical R&M was not significant.

M2-8 Once again, there was no way of mitigating the ambient environment while performing mission critical R&M so this element is rated at 5.

Again, in order to complete a reference submatrix, we move to:

M3-1 deals with the stress on the individual while performing his mission. Even in a benign environment, mine clearing in 1965 was a high stress task. FM 30-2 recommends changing detector operators every half hour to maintain efficiency. The threat of making one very hazardous mistake in identifying and removing a mine would create significant stress in any individual. A rating of 4 is therefore applied to this matrix element.

M3-2 In a chemical environment, the stress would be even higher. Hence, while there was some mitigation (a gas mask and poncho) of the added stress in 1965, a rating of 4.5 appears reasonable.

M3-3 Stress in performing the Class I mission in an indirect enemy fire environment would have been extreme as it would have been in a direct enemy fire environment. A rating of 5 is assigned.

M3-4 Same as M3-3.

M3-5 Same as M3-3.

M3-6 Stress in training for this mission area was probably a minor problem in 1965, merely due to the potential for fear relating to the possibility of ultimately performing such a task and thus a rating of 2.

M3-7 This element is not really a meaningful relationship since stress and level of effort are not amenable to differentiation in a fashion which can be quantified at this level.

M3-8 This element implies that, while there was no control over the environment during the performance of a Class I mission, this fact presented, at most, a minor problem and thus, a rating of 2.

Having now reasoned through a submatrix of the M Mission/Era matrix, we can relate later submatrix elements to the existing M matrix elements in the following fashion:

MATRIX ELEMENT	REFER TO	ADDITIONAL COMMENTS
M1- 9	M1- 1*	Newer systems improve mission capability
M1-10	M1- 2	Improved MOPP ensemble reduces rating
M1-11	M1- 3	No significant change (NSC)
M1-12	M1- 4	NSC.
M1-13	M1- 5	Larger of M1-10 or M1-11.
M1-14	M1- 6	More systems and greater operater interaction requires more training.
M1-15	M1- 7	NSC.
M1-16	M1- 8	No environmental control for either, plus exposed workspace.
M1-17	M1- 9	COV provides improved mission capability.
M1-18	M1-10	SCALP reduces ingress/egress problem.
M1-19	M1-11	No EVA required.
M1-20	M1-12	No EVA required. COV provides small arms direct fire protection. MBT and AT gun, ATGM still serious.
M1-21	M1-13	Larger of M1-18 or M1-19 is used.

* From this point forward in the analysis of the matrix, reference is made to either the last mission or the former time base. The choice was made based on the one easiest to explain or gauge.

MATRIX ELEMENT	REFER TO	ADDITIONAL COMMENTS
M1-22	M1-14	Reduces dependence on limited pool of soldiers capable of detecting sensitive audio signals on hand held detectors; interaction of crew more easily accomplished in single vehicle.
M1-23	M1-15	COV not labor intensive.
M1-24	M1-16	No EVA. COV provides climate control; protected workspace.
M2- 9	M2- 1	More systems imply more R&M.
M2-10	M2- 2	Improved MOPP reduces rating.
M2-11	M2- 3	NSC.
M2-12	M2- 4	NSC.
M2-13	M2- 5	NSC.
M2-14	M2- 6	More systems imply more R&M.
M2-15	M2- 7	NSC.
M2-16	M2- 8	NSC.
M2-17	M2- 9	COV more complicated.
M2-18	M2-10	While COV more complicated, SCALP and collective protection reduce threat in external and internal R&M, no change in rating.
M2-19	M2-11	NSC.
M2-20	M2-12	NSC.
M2-21	M2-13	NSC.
M2-22	M2-14	COV more complicated.
M2-23	M2-15	COV more complicated.
M2-24	M2-16	Vehicle environmental control reduces rating.
M3- 9	M3- 1	NSC.
M3-10	M3- 2	Improvement from better individual MOPP.
M3-11	M3- 3	NSC.
M3-12	M3- 4	NSC.
M3-13	M3- 5	NSC.

MATRIX ELEMENT	REFER TO	ADDITIONAL COMMENTS
M3-14	M3- 6	NSC.
M3-15	M3- 7	Not meaningful.
M3-16	M3- 8	NSC.
M3-17	M3- 9	COV reduces AP mine threat as well as AT mine threat but advances in Soviet mines retain problem.
M3-18	M3- 9	SCALP system reduces ingress/egress problem in NBC environment and collective protection system in COV improves CW survivability. Advanced mine threat stress may still remain.
M3-19	M3-11	No EVA required by COV hence, indirect enemy fire is not a significant problem. Advanced mine threat stress may still remain.
M3-20	M3-12	All missions are performed in COV with protection against $\leq$ 30 mm direct fire.
M3-21	M3-13	Larger of M3-18, M3-19 used.
M3-22	M3-14	NSC.
M3-23		Not meaningful.
M3-24	M3-16	Collective protection of COV and SCALP individual/collective protection impact reduces rating.
M4- 1	M1- 1	Benign environment has less of a mine threat than in M1-1 hence, less likely to have mission terminated by missed or sophisticated mine. Average of load and accuracy ratings (III-2).
M4- 2	M1- 2	NBC threat same. NSC.
M4- 3	M1- 3	Similar threat. Less EVA required. CEV provides indirect fire protection. Permits somewhat higher performance rate and overall time.
M4- 4	M1- 4	Similar threat. Less EVA required. CEV provides protection from small arms direct fire.
M4- 5	M1- 5	Larger value of M4-2 or M4-3 is used.
M4- 6	M1- 6	Identical evaluation.
M4- 7	M1- 7	Identical evaluation.
M4- 8	M1- 8	CEV provides protection from elements and heating plus better workspace; other systems do not.

MATRIX ELEMENT	REFER TO	ADDITIONAL COMMENTS
M4- 9	M4- 1	NSC.
M4-10	M4- 2	Some EVA may be required for this mission but MOPP ensemble improves 1965 rating M4-2.
M4-11	M4- 3	NSC.
M4-12	M4- 4	Some improvements due to improved MOPP but indirect fire threat during EVA still serious.
M4-13		Larger value of M4-10, M4-11 used.
M4-14	M4- 6	NSC.
M4-15	M4- 7	NSC.
M4-16	M4- 8	NSC.
M4-17	M4- 9	COV with arm and attachments improves mission capability.
M4-18	M4-10	EVA reduced or eliminated, SCALP system minimizes EVA problems.
M4-19	M4-11	Reduced EVA lessens indirect fire threat; improved rate and time of performance (III-2).
M4-20	M4-12	Reduced EVA lessens direct fire small arms threat; MBT gun, ATGM still serious.
M4-21		Rating equal to largest of M4-18, M4-19.
M4-22	M4-14	While more complex COV enters, CEV, CRANE, DOZER, removed from mission requirement, therefore no net increase in rating.
M4-23	M1-23	NSC.
M4-24	M1-24	Some possible EVA not under environmental control.
M5- 1	M2- 1	More varied equipment for mission and multiple vehicles increases R&M required.
M5- 2	M2- 2	NSC.
M5- 3	M2- 3	NSC.
M5- 4	M2- 4	NSC.
M5- 5	M2- 5	NSC.
M5- 6	M2- 6	More vehicles and equipment for mission requires more R&M training.

MATRIX ELEMENT	REFER TO	ADDITIONAL COMMENTS
M5- 7	M2- 7	LOE to do mission oriented R&M on more equipment and vehicles is larger.
M5- 8	M2- 8	CEV provides protection from elements and heating; other systems do not.
M5- 9	M5- 1	NSC.
M5-10	M5- 2	Better MOPP ensemble lowers rating but more R&M implies higher rating than M2-10.
M5-11	M5- 3	NSC.
M5-12	M5- 4	NSC.
M5-13	M5- 5	NSC.
M5-14	M5- 6	NSC.
M5-15	M5- 7	NSC.
M5-16	M5- 8	NSC.
M5-17	M2-17	Mission is more complex in equipment required than M2-17 so even though comments associated with M4-22 are valid, rating is still somewhat higher.
M5-18	M2-18 M5-10	SCALP improves rating over M5-10 but comments on M5-17 restore.
M5-19	M5-11	NSC.
M5-20	M5-12	NSC.
M5-21	M5-13	NSC.
M5-22	M2-22	Mission required equipment is more diverse; learning R&M is more difficult.
M5-23	M2-23	More complex mission oriented equipment required higher LOE for R&M.
M5-24	M2-24	More EVA for R&M on arm and external equipment raises rating.
M6- 1	M3- 1	Much less fear in reducing passive obstacles but booby traps remain possible problem.
M6- 2	M3- 2	Less fear due to reduce mine threat, but environment still serious.
M6- 3	M3- 3	NSC.

MATRIX ELEMENT	REFER TO	ADDITIONAL COMMENTS
M6- 4	M3- 4	NSC.
M6- 5	M3- 5	NSC.
M6- 6	M3- 6	Training would not raise significant fear of mines.
M6- 7	M3- 7	
M6- 8	M3- 8	NSC.
M6- 9	M6- 1	NSC.
M6-10	M6- 2	Improved MOPP.
M6-11	M6- 3	NSC.
M6-12	M6- 4	NSC.
M6-13	M6- 5	NSC.
M6-14	M6- 6	NSC.
M6-15	M6- 7	Not meaningful.
M6-16	M6- 8	NSC.
M6-17	M6- 9	Improved equipment in COV eases job stress and work.
M6-18	M3-18	No stress from mine threat.
M6-19	M3-19	NSC.
M6-20	M3-20	NSC.
M6-21	M3-21	NSC.
M6-22	M6-14	NSC.
M6-23	M6-15	Not meaningful.
M6-24	M6-16	Less EVA required.
M7- 1		Primarily earth moving, digging missions only minor problem; good man-machine interface, reasonable load and accuracy (III-2).
M7- 2	M4- 2	NSC.
M7- 3	M4- 3	No EVA. Reflects increased rate and time of performance.

MATRIX ELEMENT	REFER TO	ADDITIONAL COMMENTS
M7- 4	M4- 4	No EVA; CEV protects against small arms direct fire; MBT and AT gun serious.
M7- 5		Larger value of M7-2 or M7-3.
M7- 6	M4- 6	Less complicated and fewer mission oriented tasks, less operator interaction.
M7- 7	M4- 7	Less labor intensive.
M7- 8	M4- 8	NSC.
M7- 9	M7- 1	NSC.
M7-10	M7- 2	Improved MOPP reduces rating.
M7-11	M7- 3	NSC.
M7-12	M7- 4	ATGM added threat but not rated as 5 since small arms still countered by CEV.
M7-13		Larger value of M7-10 or M7-11.
M7-14	M7- 6	NSC.
M7-15	M7- 7	NSC.
M7-16	M7- 8	NSC.
M7-17	M7- 9	COV provides improved mission capability, reflects improved rate and accuracy evaluation (III-2).
M7-18	M7-10	No EVA; SCALP and collective protection minimize threat.
M7-19	M7-11	No EVA.
M7-20	M7-12	No EVA, reduces rating.
M7-21	M7-13	Larger value of M7-18 or M7-19.
M7-22	M7-14	COV more complex, requires more training, greater crew interaction.
M7-23	M7-15	COV more efficient.
M7-24	M7-16	No EVA for mission; vehicle provides environmental control.
M8- 1	M5- 1	Less mission oriented equipment (no grapple, saws, demo) to R&M.
M8- 2	M5- 2	NSC.

MATRIX ELEMENT	REFER TO	ADDITIONAL COMMENTS
M8- 3	M5- 3	NSC.
M8- 4	M5- 4	NSC.
M8- 5	M5- 5	NSC.
M8- 6	M5- 6	Less mission oriented equipment; fewer mission oriented skills to train for R&M.
M8- 7	M5- 7	Less equipment for mission implies lower LOE for R&M.
M8- 8	M5- 8	NSC.
M8- 9	M8- 1	NSC.
M8-10	M8- 2	Improved MOPP.
M8-11	M8- 3	NSC.
M8-12	M8- 4	NSC.
M8-13	M8- 5	NSC.
M8-14	M8- 6	NSC.
M8-15	M8- 7	NSC.
M8-16	M8- 8	NSC.
M8-17	M8- 9	COV more complex but arm not necessarily required; hence, less than M5-17.
M8-18	M5-18	Mission oriented equipment simpler.
M8-19	M8-11	NSC.
M8-20	M8-12	NSC.
M8-21	M8-13	NSC.
M8-22	M5-22	Mission oriented equipment simpler.
M8-23	M5-23	Mission oriented equipment simpler.
M8-24	M5-24	NSC.
M9- 1	M6- 1	NSC.
M9- 2	M6- 2	NSC.
M9- 3	M6- 3	No EVA.

MATRIX ELEMENT	REFER TO	ADDITIONAL COMMENTS
M9- 4	M6- 4	No EVA; protected from small arms direct fire but MBT and AT gun still serious threat.
M9- 5		Larger of M9-2 or M9-3.
M9- 6	M6- 6	NSC.
M9- 7	M6- 7	NSC.
M9- 8	M6- 8	NSC.
M9- 9	M9- 1	NSC.
M9-10	M6-10	NSC.
M9-11	M9- 3	NSC.
M9-12	M9- 4	NSC.
M9-13		Larger of M9-10 or M9-3.
M9-14	M9- 6	NSC.
M9-15	M9- 7	NSC.
M9-16	M9- 8	NSC.
M9-17	M6-17	NSC.
M9-18	M6-18	NSC.
M9-19	M6-19	NSC.
M9-20	M6-20	NSC.
M9-21	M6-21	NSC.
M9-22	M6-22	NSC.
M9-23	M6-23	NSC.
M9-24	M6-24	NSC.
M10- 1		Mission generally would be performed in acceptable time frame, in non-hostile exposure, load and accuracy not a problem (III-2).
M10- 2	M 7- 2	NSC.
M10- 3		Assumes no direct or indirect fire threat during mission.
M10- 4		Assumes no direct or indirect fire threat during mission.

MATRIX ELEMENT	REFER TO	ADDITIONAL COMMENTS
M10- 5		Assumes no direct or indirect fire threat during mission.
M10- 6	M 7- 6	Aside from earth moving, EOD must be considered; requires careful crew interaction.
M10- 7	M 7- 7	Aside from earth moving, EOD must be considered.
M10- 8	M 7- 8	NSC.
M10- 9	M10- 1	NSC.
M10-10	M10- 2	Improved MOPP.
M10-11	M10- 3	
M10-12	M10- 4	
M10-13	M10- 5	
M10-14	M10- 6	NSC.
M10-15	M10- 7	NSC.
M10-16	M10- 8	NSC.
M10-17	M10- 9	COV has equal mission capability.
M10-18	M 7-18	NSC.
M10-19	M10- 3	
M10-20	M10- 4	
M10-21	M10- 5	
M10-22	M10-14	COV in this role may require arm, hence more training, greater crew interaction (III-2).
M10-23	M 7-23	NSC.
M10-24	M 7-24	NSC.
M11- 1	M 8- 1	NSC.
M11- 2	M 8- 2	NSC.
M11- 3	M10- 3	N/A
M11- 4	M10- 4	N/A
M11- 5	M10- 5	N/A

MATRIX ELEMENT	REFER TO	ADDITIONAL COMMENTS
M11- 6	M 8- 6	NSC.
M11- 7	M 8- 7	NSC.
M11- 8	M 8- 8	NSC.
M11- 9	M11- 1	NSC.
M11-10	M 8-10	NSC.
M11-11	M10- 3	N/A.
M11-12	M10- 4	
M11-13	M10- 5	
M11-14	M 8-14	NSC.
M11-15	M 8-15	NSC.
M11-16	M 8-16	NSC.
M11-17	M 5-17	NSC.
M11-18	M 5-18	NSC.
M11-19	M10- 3	N/A.
M11-20	M10- 4	N/A.
M11-21	M10- 5	N/A
M11-22	M 5-22	NSC.
M11-23	M 5-23	NSC.
M11-24	M 5-24	NSC.
M12- 1	M 9- 1	Stress due to threat of unplanned EOD explosion or delayed effects munitions (mines) employed in conjunction with runway attack is between stress rating for M9-1 and M3-1.
M12- 2	M 9- 2	NSC.
M12- 3	M10- 3	
M12- 4	M10- 4	
M12- 5	M10- 5	
M12- 6		Even in training, high stress from threat suggested in M12-1.

MATRIX ELEMENT	REFER TO	ADDITIONAL COMMENTS
M12- 7	M 3- 7	
M12- 8	M 9- 8	NSC.
M12- 9	M12- 1	NSC.
M12-10	M12- 2	Some improvement from better MOPP
M12-11	M10- 3	
M12-12	M10- 4	
M12-13	M10- 5	
M12-14	M12- 6	NSC.
M12-15	M 3- 7	
M12-16	M12- 8	NSC.
M12-17	M12- 1	Use of arm allows standoff to reduce threat of EOD explosion.
M12-18	M12-17	No increase over ambient environment due to improved individual and collective protection.
M12-19	M10- 3	
M12-20	M10- 4	
M12-21	M10- 5	
M12-22	M12- 6	NSC.
M12-23	M 3- 7	
M12-24	M 9-24	NSC.

END

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