Field Manual
NO. 5-101

FM 5-101
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MOBILITY

Preface

PURPOSE

Field Manual (FM) 5-100 prescribes the engineer doctrine for support of United States (US) forces engaged in combat. The contents of FM 5-100 are based on the concepts of US Army tactical doctrine in FM 100-5. As the engineer keystone manual, FM 5-100 describes how engineers provide battlefield support within the framework of Army AirLand battle doctrine in five mission areas:

- Mobility.
- Countermobility.
- Survivability.
- General engineering.
- Topographic engineering.

This manual, FM 5-101, contains the doctrine and procedures for the first of these mission areas, mobility.

SCOPE

Mobility is defined as those activities that enable a force to move personnel and equipment on the battlefield without delays due to terrain or obstacles. The purpose of this manual is to describe the effects of natural and other restrictions to this movement and present methods of counteracting these restrictions. The contents of this manual include discussions of the following six areas of engineering support of mobility:

- Detection, bypass, marking, and breaching (neutralization) of minefield.
- Detection, bypass, marking, and reduction of obstacles other than minefield.
- Gap crossing.
- Construction and maintenance of combat roads and trails.
- Expedient construction necessary to support Army aviation and Air Force ground facility requirements—forward aviation combat engineering (FACE).

- Determination of the effects of terrain and weather on ground vehicle mobility.

All Army combat and combat support units must be capable of countermine and counterobstacle activities. Engineer support of force mobility is necessary when the nature of the terrain or obstacle exceeds the maneuver unit's capability, when the enemy or operational situation dictate, or when speed and timeliness are essential. Engineer combat organizations have the mission and capability to perform the more difficult mobility tasks.

INTENDED AUDIENCE

FM 5-101 was developed for the following reader audience:

- Engineer unit commanders, staff, and personnel who must analyze, plan, and execute engineer support to preserve the combined arms team's ability to maneuver in combat.

- Maneuver unit commanders and staff who will use engineer mobility support.

Users of this manual must adapt the guidance to fit the weapons and equipment found in their organizations. The term "engineer unit" refers to any type of engineer element tasked to provide mobility support.

INTERNATIONAL AGREEMENTS

The provisions of this publication are the subject of the following International Standardization Agreements (STANAGs): STANAG 2010 (Military Load Classification Markings); STANAG 2021 (Computation of Bridge, Raft, and Vehicle Classifications); STANAG 2036 (Land Minefield Laying, Recording, Reporting and Marking Procedures); STANAG 2096 (Reporting Engineer Information in the Field); and STANAG 2889 (Marking of Hazardous Areas and Routes Through Them).

USER INFORMATION

The proponent of this publication is the US Army Engineer School. Submit changes for improving this publication on DA Form 2028 (Recommended Changes to Publications and Blank Forms). Arrange comments in sequence by manuscript page, indicating exactly how a portion should be reworded with a brief reason for the change. Send comments to Commandant, US Army Engineer School, ATTN: ATZA-TD-P, Fort Belvoir, VA 22060-5291.

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CHAPTER 1

Mobility on the Battlefield

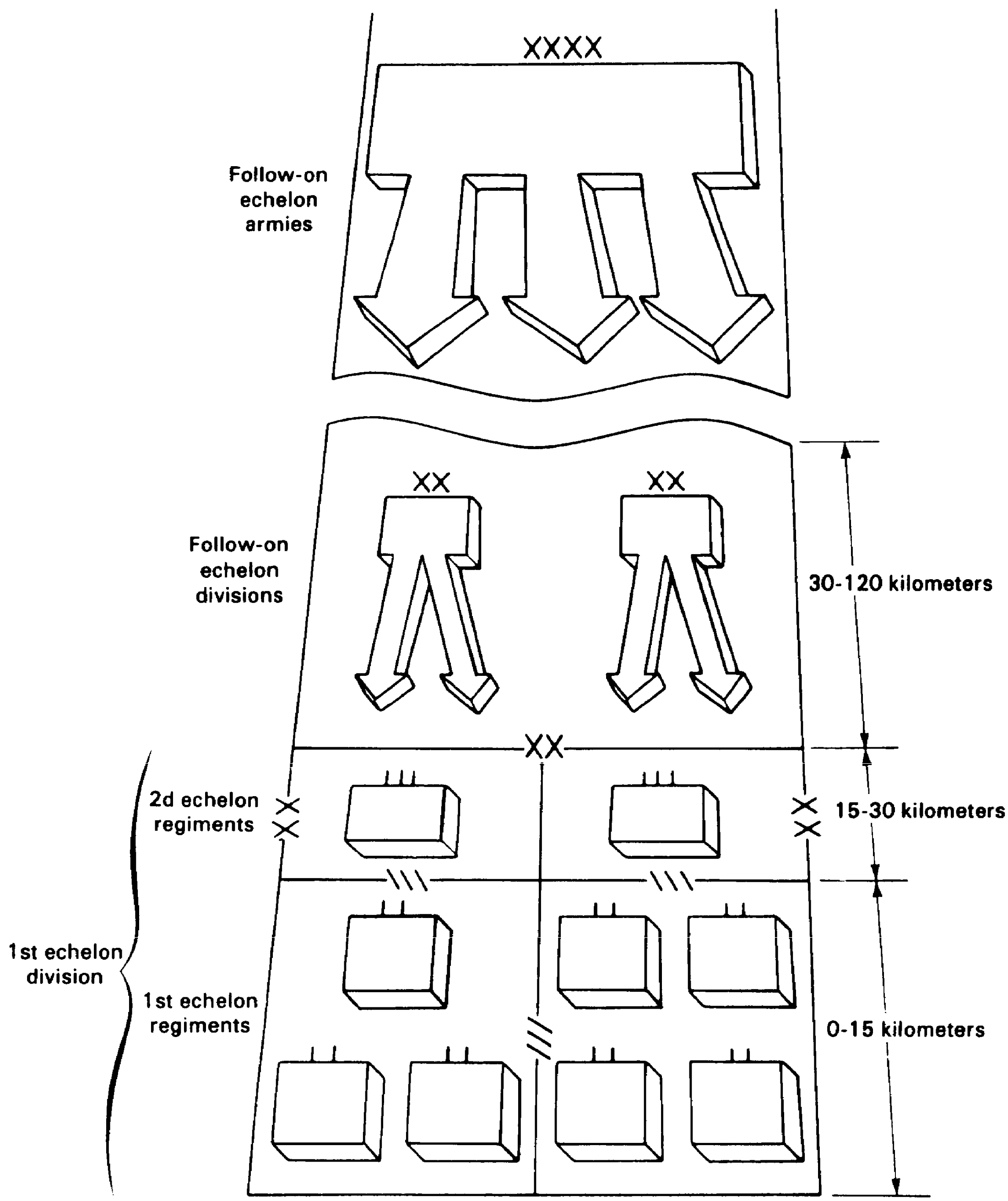
THE AIRLAND BATTLE CHALLENGE

AIRLAND BATTLE DOCTRINE

AirLand battle doctrine, described in FM 100-5, is the Army's "how to fight" doctrine. It applies to deployment and operation of US forces at and between two battlefield extremes—combat areas without existing support bases and lines of communication (LOC) to combat areas where these features exist.

The US forces must be prepared to fight under the most severe of these environments as well as under conditions created by terrorism, unconventional warfare, or minor conventional conflicts. To win the next war, US forces must be able to move decisively in all directions without loss of momentum. They must also analyze and acquire targets quickly and precisely to maintain this momentum. To do this, proper mobility planning is essential. This need for planning becomes evident when comparing the expected strength of Threat to friendly forces. If Warsaw Pact or Soviet-type forces are involved, Threat strength may be superior in terms of personnel and equipment. This superiority would permit the enemy to keep a significant portion of its combat elements out of the battle and provide a large degree of flexibility (figure 1-1 on page 1-2).

FIGURE 1-1. THE FOLLOW-ON ECHELON THREAT



THE AIRLAND BATTLEFIELD

AirLand battle doctrine is based on tactical planning for the use of conventional as well as chemical and nuclear weapons. Massive concentrations of troops and equipment will allow penetrations by both forces. Combat can be expected across the entire depth of the air and land battlefields (figure 1-2). The distinction between rear and forward combat zones will be blurred. Success will depend on the coordinated efforts of personnel and equipment in combined arms teams as well as a close and effective relationship between air and land forces. Winning or losing battles will be based on how well the combat power of our forces, including combat support and combat service support elements, is synchronized. In particular, commanders must know how to best use support units to enhance the combat power of their maneuver units.

TACTICS

The battle in depth should delay, disrupt, or destroy the enemy's uncommitted forces and isolate the enemy's committed forces so they may be destroyed, The deep battle is closely linked with the close-in fight. The battle in depth will give friendly forces additional time to win the close-in conflict before follow-on Threat forces enter the battle. The deep battle attack is made by using long-range weapons, to include electronic warfare (EW) systems, in combination with counterattacks, raids, and ambushes. The three types of combat offensive actions may be used at the same time:

- Army aviation and Air Force missions will locate, harass, and destroy follow-on echelon enemy forces.
- Artillery-delivered munitions and mine-field will delay and disrupt enemy movement.
- Counterattacks will be executed into the enemy's follow-on echelons (figure 1-3 on page 1-4), Thus, mobility of friendly forces takes on additional importance.

FIGURE 1-2. AIRLAND BATTLEFIELD CHARACTERISTICS

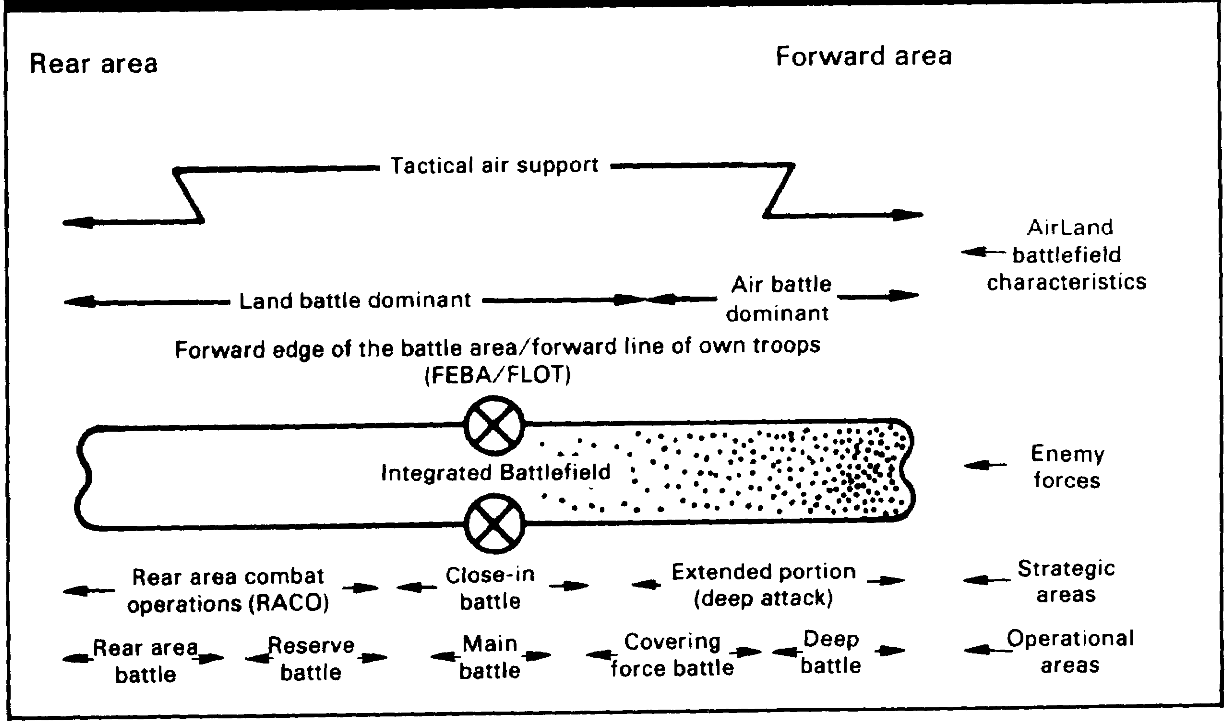
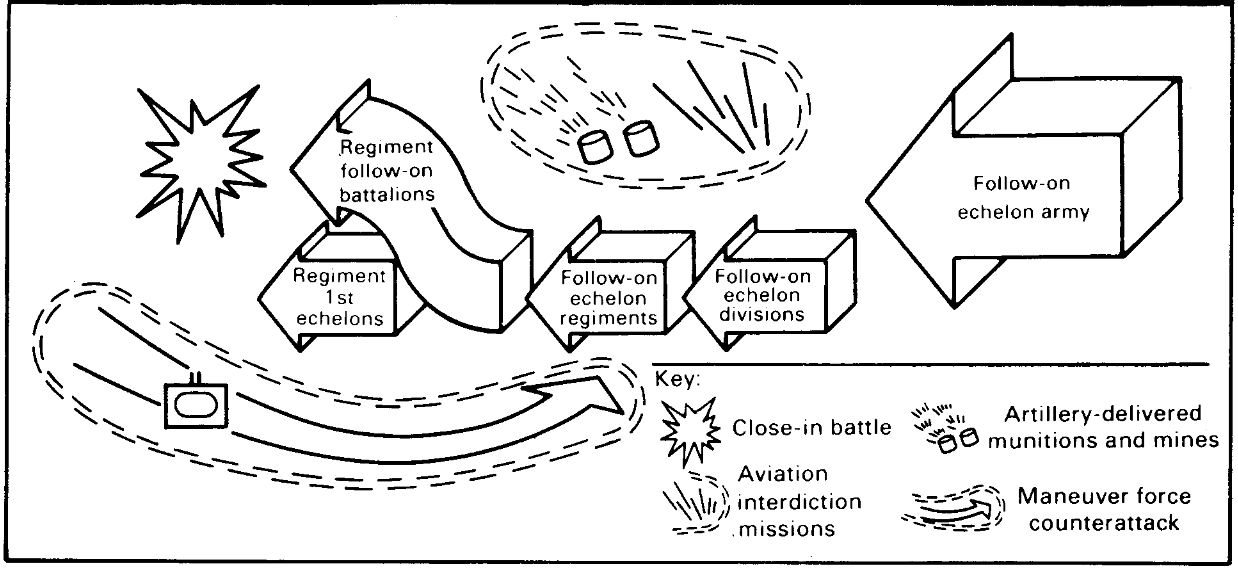


FIGURE 1-3. AIRLAND BATTLE TACTICS



MOBILITY SUPPORT

Mobility support is essential for units, equipment, and supplies to be positioned where and when they are needed on the battlefield. Integral to these tasks is effective topographic support which provides up-to-date maps and terrain information. Maneuver is the movement of combat forces, combined with fire support, to achieve a position of advantage from which to destroy or threaten destruction of the enemy. Missions depend on knowledge of the terrain and cultural features, as well as early detection and effective response to obstacles. Engineer support is needed when an organization can not overcome an obstacle without affecting forward momentum. AirLand battle doctrine requires that units move quickly and at will anywhere on the battlefield. This agility is a key factor for success. The increased use of aviation and mechanized forces, by both the US and the Threat, will permit rapid concentration of combat power. Contact with enemy forces, obstacles, or both, must be expected in any place at any time. The force that can maintain its momentum and agility, under these conditions, has the best chance of winning.

THREAT COUNTERMOBILITY ACTIVITIES

FOCUS

The United States has global interests that could be threatened by a number of military powers. These nations differ in their governments, economies, and cultures. However, most of these potential adversaries model their military after Warsaw Pact-type forces. These countries generally possess well-equipped armed forces that use Warsaw Pact-type weapons and doctrine. Therefore, this section will focus on Soviet countermobility activities as a guide for understanding the threat to US battlefield mobility.

More information on Threat engineer organizations and their capability to counter friendly mobility can be found in FM 100-2-3.

STRATEGY AND TACTICS

Threat forces will use obstacles for countermobility designed to—

- Deny access along selected routes or terrain.
- Hold US forces within target range of Threat weapons systems.

- Economize Threat forces in defense of one area in order to provide forces in another area.

- Force the US to mass combat strength in the area.

Offensive strategy. The Threat plans to use antitank and mobile obstacle detachments to guard against counteroffensive action. They anticipate a fluid battlefield characterized by a series of meeting engagements and deep thrusts. The enemy hopes to advance 40-50 kilometers per day unless the war is escalated by the use of nuclear weapons. In that case, it would try to advance 50-80 kilometers per day.

Tactical defense. The Threat's strategy is to improve its defensive position, through the use of obstacles and minefield, until it can regain the initiative. It will employ obstacles when under fire and at night. Threat doctrine prescribes maximum use of existing rather than reinforcing obstacles to conserve personnel and equipment.

COMBINED ARMS RESPONSIBILITIES

Battlefield countermobility missions are not the exclusive responsibility of engineer units. With increased emphasis on countermobility, Threat combat arms units can now accomplish many of these engineering tasks. For example, tanks can be fitted with a number of "strap-on" items to avoid total dependence on specialized engineer equipment. These items include plows, rollers, and dozer blades. In addition to personnel trained in the use of strap-on components, each maneuver battalion contains soldiers trained to emplace obstacles. This practice insures a countermobility capability at the unit level and reduces the requirement for engineer support in general.

ENGINEER SUPPORT TO THREAT COUNTERMOBILITY

All Threat engineer soldiers are trained to master one of several military tasks. These tasks include demolition, field fortification construction, or technical construction. They must also perform several engineer related tasks. Each engineer soldier is assigned to one of two job categories.

- Special-technical engineer. Units assigned special-technical personnel perform a specific task such as minelaying, bridging, road construction, reconnaissance, and assault crossing. These units are normally organic at all echelons.

- Combat engineer. Engineers, in general combat engineering units, are trained and organized to accomplish general combat engineering tasks requiring the use of handtools to supplement mechanical equipment. Combat engineer units are organic to Threat combined arms forces at regiment, division, combined arms army, and front levels.

Engineer countermobility equipment is frequently single-purpose, rugged, and technically simple. Appendix A provides a detailed discussion of Threat engineer organizations, equipment, and obstacles.

THREAT ORGANIZATION OF ENGINEER UNITS

Engineer troops are assigned down through the regiment level in all Soviet maneuver divisions. Platoons of engineers are sometimes detailed to maneuver battalions for specific missions.

Regiment leveL The engineer company in a motorized rifle or tank regiment is organized into a mine warfare platoon, a technical (construction) platoon, and a bridge platoon. The company illustrated in figure 1-4 on page 1-6 has several armored personnel carriers (BTR or BMP), vehicle-launched bridges, and assorted pieces of mine warfare equipment. Table A-1 in appendix A contains further information on its equipment. The motorized rifle and tank regiments rely heavily on their organic engineer company for the following countermobility support:

- Engineer reconnaissance.

- Mine emplacement.
- Obstacles created mechanically or by hand.
- Construction of trenches or fortifications,
- Technical assistance for camouflage and deceptive measures.

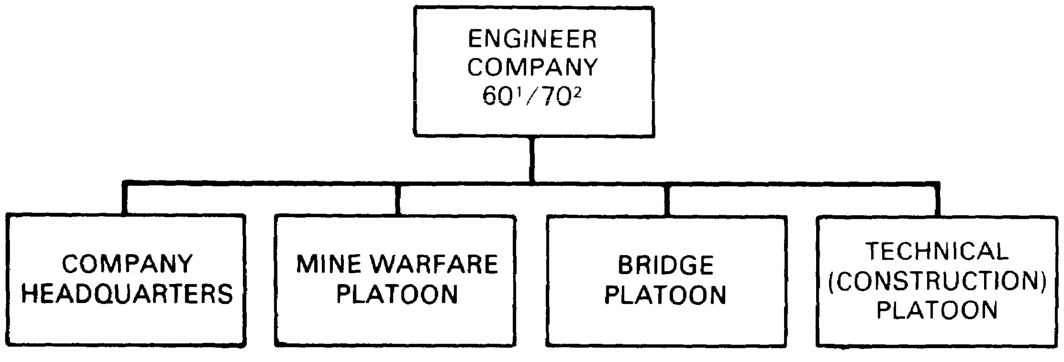
Division level. Engineer battalions assigned to the three types of divisions—motorized rifle, tank, and airborne—serve as backup for the regimental engineers. The divisional engineer battalions are organized in much the same way as the regimental units with the addition of bridging units and combat service support elements (figure 1-5). The engineer battalions in tank divisions have a larger number of heavy amphibious ferries to support the division's armored vehicles. Airborne divisions have an engineer battalion of lesser strength and none of the heavy vehicle-launched bridging equipment, ferries, or ponton bridge sections. All of the engineer battalions at division level can perform the following countermobility missions:

- Provide engineer staff for planning and coordinating organic or attached engineer unit missions.
- Assist in emplacement of obstacles and mines.
- Provide technical assistance in preparation of field fortification.
- Conduct engineer reconnaissance.
- Develop engineer intelligence for use in countermobility operations.

ENGINEER'S ROLE IN MISSION-TAILORED ORGANIZATIONS

With the exception of engineer assault-crossing and ponton bridge units, engineer employment does not always follow strict organizational lines. Tactical employment of sapper or engineer reconnaissance subunits

FIGURE 1-4. THREAT ENGINEER COMPANY, MOTORIZED RIFLE AND TANK REGIMENT



Notes:

1. Personnel for the engineer company, motorized rifle regiment.
2. Personnel for the engineer company, tank regiment.

generally involves the formation of one or both of the following groupings:

- Mobile obstacle detachment: podvizhnoy otriad zagrazhdeniya (POZ).

- Engineer reconnaissance patrol: inzhenerny razvedyvatel'ny dozor (IRD).

The POZ and IRD are ad hoc organizations composed of engineer and combined arms elements task-organized according to the tactical situation. The makeup of these mission-tailored groupings depends on the countermobility tasks required. Attachments from the parent combined arms formation might include tanks, infantry, artillery, air support, and chemical detection units.

POZ mission. The mission of the POZ is generally to block armored counterattacks. The POZ is deployed in the forward security zone in the defense and along the flanks in the offense. It operates independently under the POZ commander, generally an engineer officer, who obtains operational guidance from the divisional engineer.

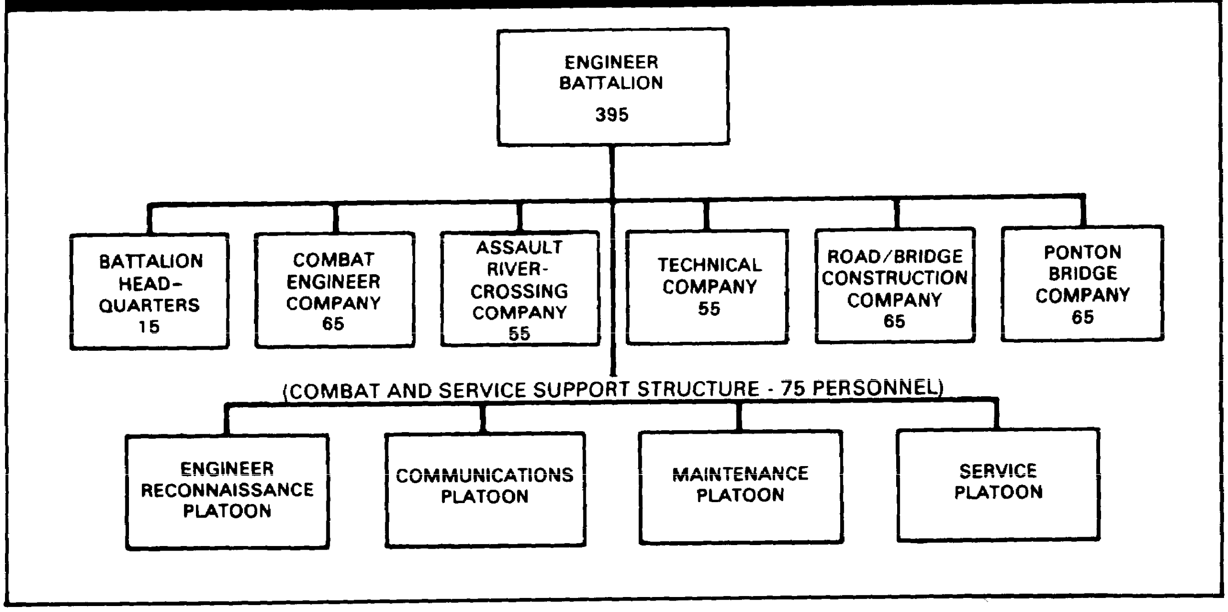
IRD mission. The IRD is formed and tasked with countermobility missions when the Threat must conduct defensive operations. Such missions include determining the protective and camouflage features of the terrain, selecting company strongpoint positions, and locating local materials for the construction of obstacles and fortifications. Finally, the IRDs will deploy into engineer observation posts along the front to detect enemy activities.

COUNTERMOBILITY SUPPORT TO THE DEFENSE

The two major forms of defense are the hasty defense and the deliberate defense.

- Hasty defense. This usually occurs when an offense is temporarily stopped. Units move off the route and deploy into strongpoints. Tanks move to the rear and antitank weapons move forward to protect gaps on the strongpoints. Normally, the area for a hasty defense will be smaller than the area involved in a deliberate defense. In a hasty defense, a motorized rifle battalion, for example, will have 3 to 5

FIGURE 1-5. THREAT ENGINEER BATTALION, MOTORIZED RIFLE AND TANK DIVISION



kilometers of frontage and a smaller security zone.

- Deliberate defense. This is organized in successive belts or areas to provide defense in depth. These areas normally will consist of a security zone, a main defense belt, and second and third defense belts. Defense belts are a series of mutually supported, defense areas (strongpoints). Echeloned in depth, they are designed to be manned by companies and battalions with artillery and tank support. Mobile reserves are held in assembly areas for each defense belt. Obstacles are constructed in front of each belt to impede, channelize, and force the attacker into kill zones.

Engineer reconnaissance is critical in defense planning. The IRD advises the commander on the best manner of using obstacles. The IRD will emphasize the use of lakes, rivers, marshes, densely forested areas, and difficult routes. They advise the Threat commander on the best use of barriers added to the terrain to stop or delay troop movement.

THE THREAT STRONGPOINT

A strongpoint is a fortified unit position designed to defend against heavy attack. Threat forces are required to start the construction of fighting positions immediately upon assuming a defensive posture. These positions are continuously upgraded until eventually a strongpoint is developed.

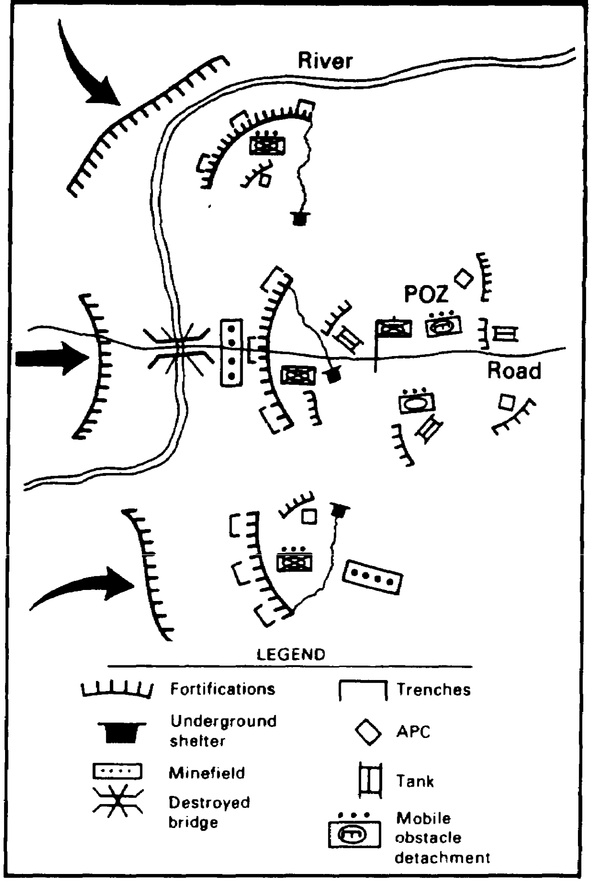
Arrangement. Company strongpoints are based on a three-platoon arrangement (figure 1-6), generally, two platoons forward and one back. Platoon positions are linked with each other through a series of trenches. These trenches connect all individual positions into an intricate defense system. They conceal communication, equipment, rapid troop movement, and resupply from observation.

Obstacle plans. The platoon leader initiates defensive obstacle plans. Obstacles are located immediately to the front of platoon positions. This standard Threat defensive zone of obstacles consists of three rows of antitank and antipersonnel mines and wire, when possible. In addition, an antitank ditch is placed to the rear of these obstacles. The obstacles are used to channelize, disrupt, and disorganize attacking forces.

COUNTERMOBILITY SUPPORT TO THE WITHDRAWAL

Threat forces may withdraw only on the order of the Army or front commander. Plans are made to defend gorges, bridges, stream crossings, and withdrawal routes. Sappers lay mines and perform demolitions on the flanks of withdrawing troops. They may also destroy roads, key facilities, bridges, and crossing sites following troop withdrawal to prevent enemy access in a pursuit.

FIGURE 1-6. ENGINEER DESIGN OF THREAT STRONGPOINT



COUNTERMOBILITY SUPPORT TO THE OFFENSE

Engineer support in the offense is primarily concerned with making the best possible use of available resources. Supply estimates for the course of an attack are made and arrangements for resupply set in motion before the attack begins. The engineers will be competing with artillery and tanks for logistical support. Because of these limitations, POZs are not likely to create elaborate obstacles or deliberate minefield. Such obstacles are labor-intensive and require large quantities of timber, wire, equipment or other supplies.

Obstacle activity. The Threat will limit obstacle activity to protective minefield and small demolition projects designed to enhance existing features. The most important engineer countermobility task in a Threat offensive operation is the creation of protective flank obstacles or minefield using mobile minelayers or helicopters, if necessary. Because of the possible need to recover mines and obstacles as the advance progresses, antipersonnel mines will rarely be used with obstacles.

Role of mobile obstacle detachment (POZ). A POZ can be expected to simultaneously lay up to three minefield and create nonexplosive obstacles at several points on the flanks. Also, the POZ may reinforce key defensive positions at possible strongpoint locations. The POZ would then be supplemented by engineers with earth-moving equipment.

COUNTERMOBILITY SUPPORT TO THE MARCH AND MEETING ENGAGEMENT

Threat forces emphasize attacking directly from march formations. In the meeting engagement, they expect little time for engineer subunits to regroup. The IRDs will be forward of the march formation, with the POZs located just behind the first main body element. The POZ will cover exposed flanks of a maneuvering Threat force.

CAMOUFLAGE AND DECEPTIVE MEASURES

The Threat considers camouflage and deceptive measures equally appropriate in all operations. Camouflage is emphasized, however, in defensive situations. The intent is to confuse enemy intelligence through the use of concealment, deception, and demonstration activities. Obstacles and minefield will be well-camouflaged when the element of surprise might enhance their effectiveness. All soldiers are instructed in tactical camouflage techniques.

MOBILITY REQUIREMENTS

MOBILITY TASKS

US forces conduct mobility tasks to obtain and maintain the freedom of both tactical maneuver and operational movement. These battlefield tasks fall under the following five functional areas:

- Countermine. The detection, neutralization (by breach or bypass), marking, and proofing of mined areas.
- Counterobstacle. The employment of tactics and equipment systems to breach or bypass and reduce obstacles other than mined areas.
- Gap-crossing. The crossing of gaps in the terrain in order to pass equipment and personnel.
- Combat roads and trails. The expedient preparation or repair of routes of travel for equipment or personnel.
- Forward aviation combat engineering (FACE). The preparation or repair of landing zones, landing strips, or low altitude parachute extraction system (LAPES) sites to support aviation ground facility requirements in the forward battle area.

While the five functional areas of mobility are discussed separately in chapters 4-8, they are all used to support an operation and may be accomplished simultaneously. In the offense, the execution of mobility tasks allows forces to overcome known or unexpected obstacles and sustain the momentum necessary to retain the initiative. In the defense, mobility support tasks assist forces to move rapidly, mass, disperse, and be resupplied. Mobility tasks may be linked because of a mutual purpose and the nature of the battlefield. For instance, countermine tasks might be done concurrently with a gap-crossing operation. The preparation, maintenance, and repair of combat roads and trails and FACE activities enhance crossing and breaching missions by providing possible bypass options. The five functional areas of mobility support activities are also similar in the individual missions that they generate. These are shown in figure 1-7.

CRITERIA FOR MOBILITY TASKS

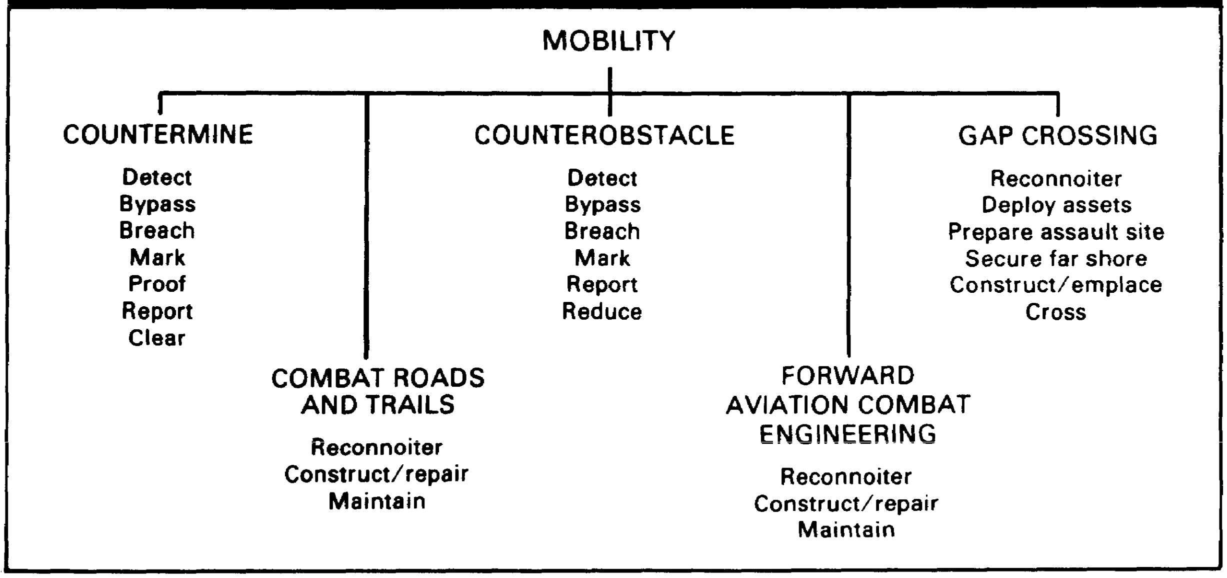
The planning, training, and preparation of mobility tasks must be done long before the battle begins. This advance preparation is important for these reasons:

- Forces that are stopped or delayed will likely be taken under fire.
- Combat units may operate at the end of long and vulnerable lines of supply and communication.
- The introduction of nuclear weapons, chemical contaminants, or biological contaminants may immediately alter troop combat capabilities and areas of tactical importance,

The combination of these factors sets the performance parameters for the conduct of mobility tasks. A highly skilled and organized unit capable of operating under intense combat conditions will be necessary. Training and exercises should aim at the performance of mobility tasks within the following criteria:

- Execute under fire. Troops must be trained to immediately suppress enemy fire and observation. Mobility activities are undertaken after enemy tank, antitank guided missile (ATGM), and artillery fire have been suppressed. They must not be deterred by enemy small arms fire.

FIGURE 1-7. MOBILITY FUNCTIONAL TASKS



- Overcome obstacles in stride. Maneuver forces overcome obstacles with minimum delay by planning operations thoroughly, deploying mobility equipment well forward, and executing standardized drills.
- Execute tasks during periods of darkness. Mobility tasks should be conducted at night whenever possible as the ability to operate during periods of limited visibility reduces the vulnerability of friendly forces.
- Execute mobility tasks in electronic warfare environments. The enemy will anticipate US intentions through electronic detection of mobility activities. All measures should be taken to deny the enemy this information.

CHAPTER 2
Fundamentals of Mobility

THE MOBILITY SCHEME

TYPES OF OBSTACLES

An obstacle is any variation in terrain which stops, delays, or directs movement. Examples include rivers, swamps, marshes, forests, rock outcrops, soft soils, flooded areas, built-up\ urban areas, embankments, ditches, craters, and mines. Obstacles are divided into two major categories, existing and reinforcing. Existing obstacles are natural and cultural features that are already present such as rivers, mountains, and cities. Reinforcing obstacles are created when other obstacles, such as minefield or antitank ditches, are added to the terrain to strengthen existing obstacles.

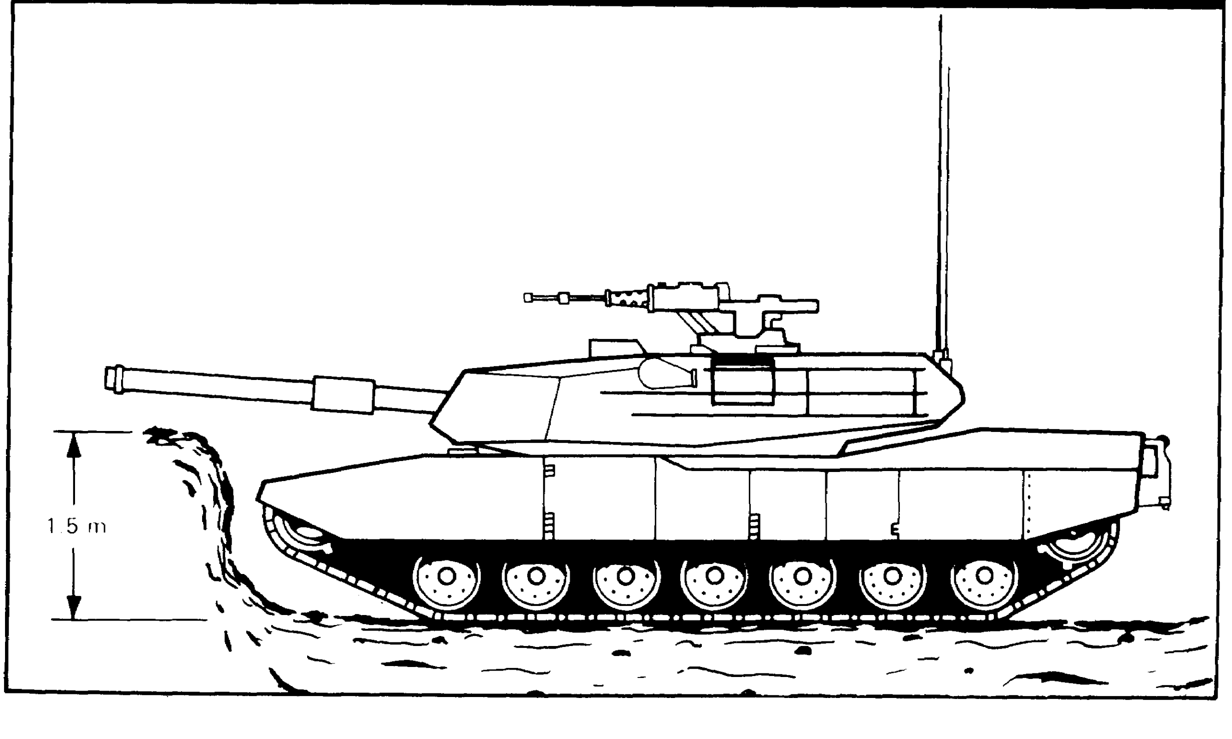
Existing obstacles. Any existing natural (forests, swamps) or cultural (buildings or other) feature which disrupts or impedes the movement of a combat force is called an existing obstacle. All existing obstacles are present before a battle begins. Examples of existing obstacles follow.

Untrafficable soil conditions. Soil trafficability and climate conditions will affect cross-country mobility of troops and equipment. The load-bearing capacity of fine-grained soils such as clay, loam, and silt is affected by soil moisture. Flooding can turn large meadows or paddy fields into obstacles. The combination of soft soils and even slight slopes will stop many vehicles. Tracked vehicles have less difficulty than wheeled vehicles with most soils. Soil trafficability is discussed in detail in TM 5-330.

Drainage features, Drainage or surface water features include rivers, streams, canals, irrigation ditches, ponds, marshes, swamps, and lakes. Crossing drainage features by bridging, rafting, or surface means is determined by width, depth, water velocity, and bank and bottom conditions of the feature. Swamps and marshes, where there is no firm ground or it is 1 meter(m) or 3.3 feet (ft) below water level, are effective obstacles against most nonswimming tracked or wheeled vehicles. They are also difficuIt for infantry to cross, Foldability of a drainage feature is determined by how easily it may be crossed without the use of bridging or rafting equipment. Fordability depends on the capability of the vehicle and the characteristics of the drainage feature. Table B-7 in appendix B provides detailed information on vehicle fording capabilities, Current weather conditions are also important factors in evaluating drainage features. Although streams are normally small and slow during periods of low rainfall, melting snow may cause high water downstream even in regions of low rainfall. In winter months, ice may be strong enough to support traffic and make drainage features the preferred avenues for traffic. Movement on ice is risky, however, because of weak spots. Dry stream channels in arid or desert regions may be the best movement routes during periods of little or no water flow but are subject to flash flooding with little or no warning.

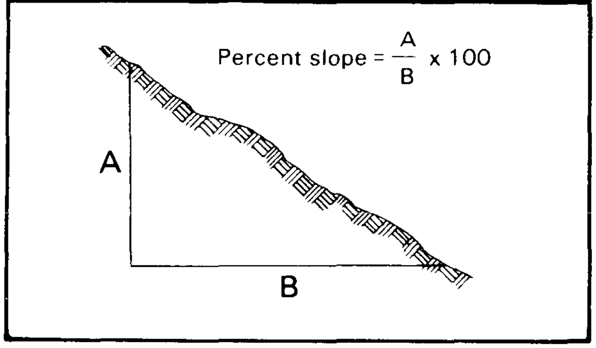
Slope. Flat terrain offers ideal mobility conditions for personnel and motorized equipment. Varying degrees of incline are required to stop or delay different types of vehicles at various times of the year. Land which slopes sharply up or down decreases mobility. VerticaI cuts and walls over 1.5 meters (5 feet) or at least the height of the front or rear idlers cannot be crossed by tracked vehicles without special means (figure 2-l). Wheeled vehicles are usually limited to vertical obstacles of

FIGURE 2-1. TRACKED VEHICLE STOPPED BY 1.5-METER CUT



1/3-wheel height or the ground clearance, whichever is smaller. Thick rock walls, railroad embankments, and steep fills or cuts along highways are examples of existing slope obstacles. Tanks can negotiate slopes as steep as 60 percent on ideal ground conditions (figure 2-2). Trees, loose soil, rocks, or other existing features that do not appreciably hinder movement on level ground can make less than a 60 percent slope impassable. While tanks are designed to negotiate slopes up to 60 percent for military operations, a slope of 45 percent (24 degrees) is considered the practical upper limit. Steep slopes also slow down infantry forces and cause them to tire easily. In evaluating dry, firm terrain for cross-country movement, 60 percent is commonly used as the upper limit for tracked vehicles and 30 percent for wheeled vehicles when numerous passes over the same lane might occur. The formula for computing percent of slope, depicted in figure 2-2, is vertical distance divided by horizontal distance times 100.

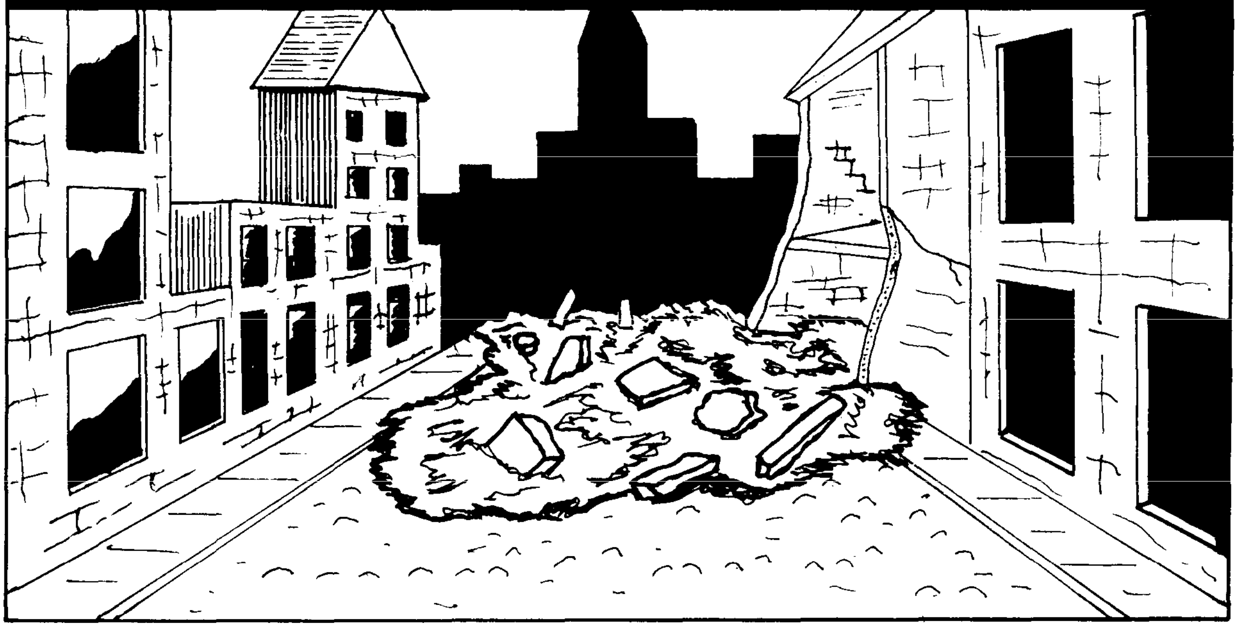
FIGURE 2-2. SLOPE COMPUTATION



Trees. Heavy stands of trees that are 20.5 centimeters (8 inches) or more in diameter and spaced 3-5 meters (10-16 feet) apart or closer are an obstacle to wheeled and tracked vehicles. Forcing through such a stand of trees tends to create a massive obstacle as the fallen trees eventually build on each other.

Built-up areas. The obstacle value of a cultural feature depends on its size, location, and construction. Large cities and towns with masonry buildings located on principal routes can become important obstacles when reduced to rubble (figure 2-3) with streets,

FIGURE 2-3. URBAN RUBBLE



alleys and passageways blocked, cratered or mined. Even if gaps are cleared through the debris, movement is still channelized. Existing road, rail, and waterway networks can directly influence the conduct of the AirLand battle. These lines of communication and transportation facilities are essential to rapid tactical movement, support, and supply. Their existence and trafficability will be a factor in selecting avenues of approach and routes for withdrawal. On the other hand, these features can become obstacles to force mobility. For example, a railroad located across an avenue of approach can create trafficability problems with embankments or lack of enough crossing points.

Snow. Even on otherwise trafficable terrain, accumulation of snow 1 meter (3 feet) deep becomes a major obstacle to personnel and vehicles. Snow less than 1 meter (3 feet) deep is a less effective obstacle but may hide rocks, ditches, small streams, and fallen trees.

In order to judge the ability of wheeled or tracked vehicles to conduct off-route movement, a number of factors are considered. An analysis of existing terrain should include consideration of the critical values cited in table 2-1.

Reinforcing obstacles. Obstacles constructed, emplaced, or explosively created to enhance a military action are called reinforcing obstacles. They can be used to extend existing obstacles or to create obstacle systems in open country. The nature and extent of reinforcing obstacles is limited only by available resources and the imagination of the soldier. Reinforcing obstacles are broadly categorized as mines or other obstacles.

Mines and minefield. Unlike other obstacles, mines can directly inflict personnel casualties and equipment losses. Mines are used to enhance the effect of most other obstacles but may be placed directly on, or in the path of, moving forces. Antitank and antipersonnel mines can be used singly or in combination.

Other obstacles. Other reinforcing obstacles are created by demolition, construction, and contamination of selected areas. Demolition obstacles are created by the detonation of explosives, including nuclear explosives, or the mechanical destruction of existing features. Examples include the rubble of stone structures, flooding from destruction of a dam, or tree blowdown. Constructed obstacles range from tank ditches to extensive concrete and steel obstacles like “dragon’s teeth. ” Also in this category are barbed wire and timber obstacles such as log cribs, hurdles, and log posts. Emplaced contamination obstacles can be nuclear, chemical, or biological. Contaminating agents are difficult to predict and control, however, as they are dependent largely upon winds for placement and are subject to weather and other environmental factors.

OBSTACLE SYSTEMS

The effectiveness of obstacles is increased when they are combined in number and type. These obstructions are called obstacle systems. The combined effect of a number of less-than-critical features can stop or severely delay vehicles. For example, closely spaced trees much smaller than 25 centimeters (10 inches) in diameter will delay vehicles even on level ground. Usually a tree stem spacing of 1.5 times the vehicle width is required for maneuver in forests. An obstacle system is more effective than any type of obstacle alone. Although a variety of types may be combined, it is usually most effective to strengthen other obstacles with mines. For example, mines emplaced in and around a crater make it far more effective in delaying enemy tanks by adding the possibility of casualties and equipment losses (figure 2-4 on page 2-6) .

Combinations of obstacles that do not involve mines are also possible. For example, a crater can be used to deny fording sites across a stream.

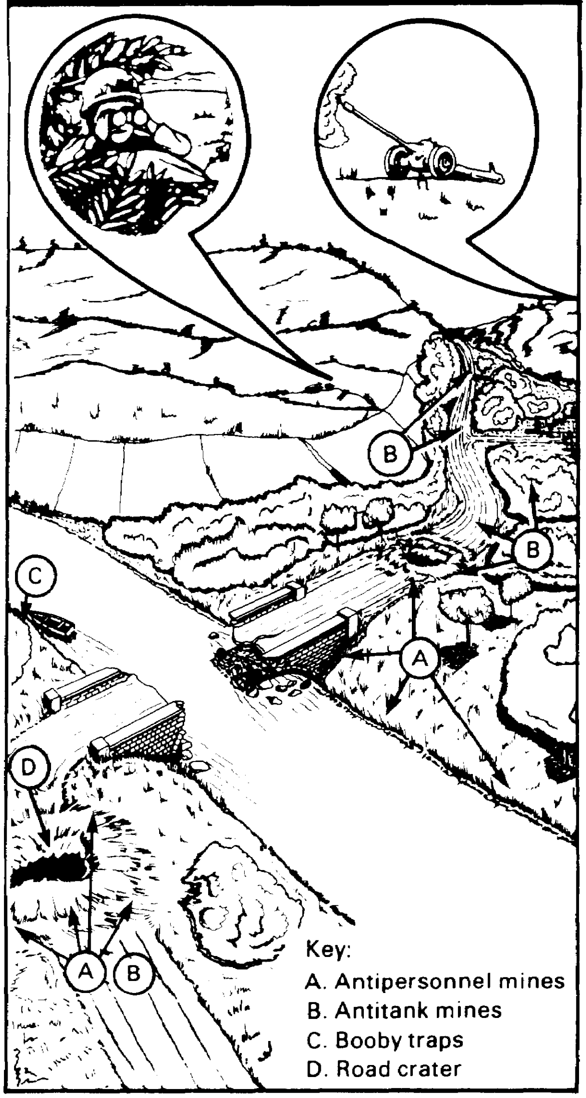
TABLE 2-1. CRITICAL VALUES OF CROSS-COUNTRY MOVEMENT

FEATURE	CRITICAL VALUE		EFFECT
Drainage (rivers and streams)	Width	⩾ 150 m (492 ft)	Requires corps bridging assets. [1]
	Depth	⩾ 1.5 m (5 ft)	Impairs nonswimming vehicles. [1]
	Velocity	⩾ 3.7 m (10 fps)	Impairs rafting, float bridging and swimming vehicles.
Ditch	Width	⩾ 2.8 m (9.2 ft)	Exceeds tank's self-bridging capability.
	Depth	⩾ 1.5 m (5 ft)	Exceeds tank's ability to "step."
Gap	Width	⩾ 18 m (60 ft)	Exceeds most AVLBs.
Ford	Depth	⩾ 1.5 m (5 ft)	Cannot be forded without special equipment. [1]
Soil	Bearing pressure (Soil type and moisture also affect trafficability)	⩽ 8 psi	Hinders tracked and wheeled vehicle movement. [2]
Slope	10% (ice covered)		Delays all vehicle movement.
	20% (snow covered)		Delays all vehicle movement.
	30%		Stops most wheeled movement.
	45%		Delays most tank movement.
	60%		Stops tank movement.
Vegetation	Tree diameter with	20.5 cm (8 in)	Stops wheeled vehicles. Delays tracked vehicles.
	tree spacing	3-5 m (10-16 ft)	Delays tracked and wheeled vehicles.
Snow	Depth	0.5 m (1.6 ft)	Delays/immobilizes wheeled vehicles.
		1.5 m (4.5 ft)	Delays all tracked traffic exceeding 6 psi.
Ice	Thickness	0-8 in	Will not bear wheeled vehicles.
	Thickness	0-31.5 in	Will not bear tanks.

Notes:

1. Also depends on bottom, bank, and water current conditions.
2. See TM 5-330 for details on soil trafficability.
3. Rainfall affects all other features.

FIGURE 2-4. OBSTACLE SYSTEM



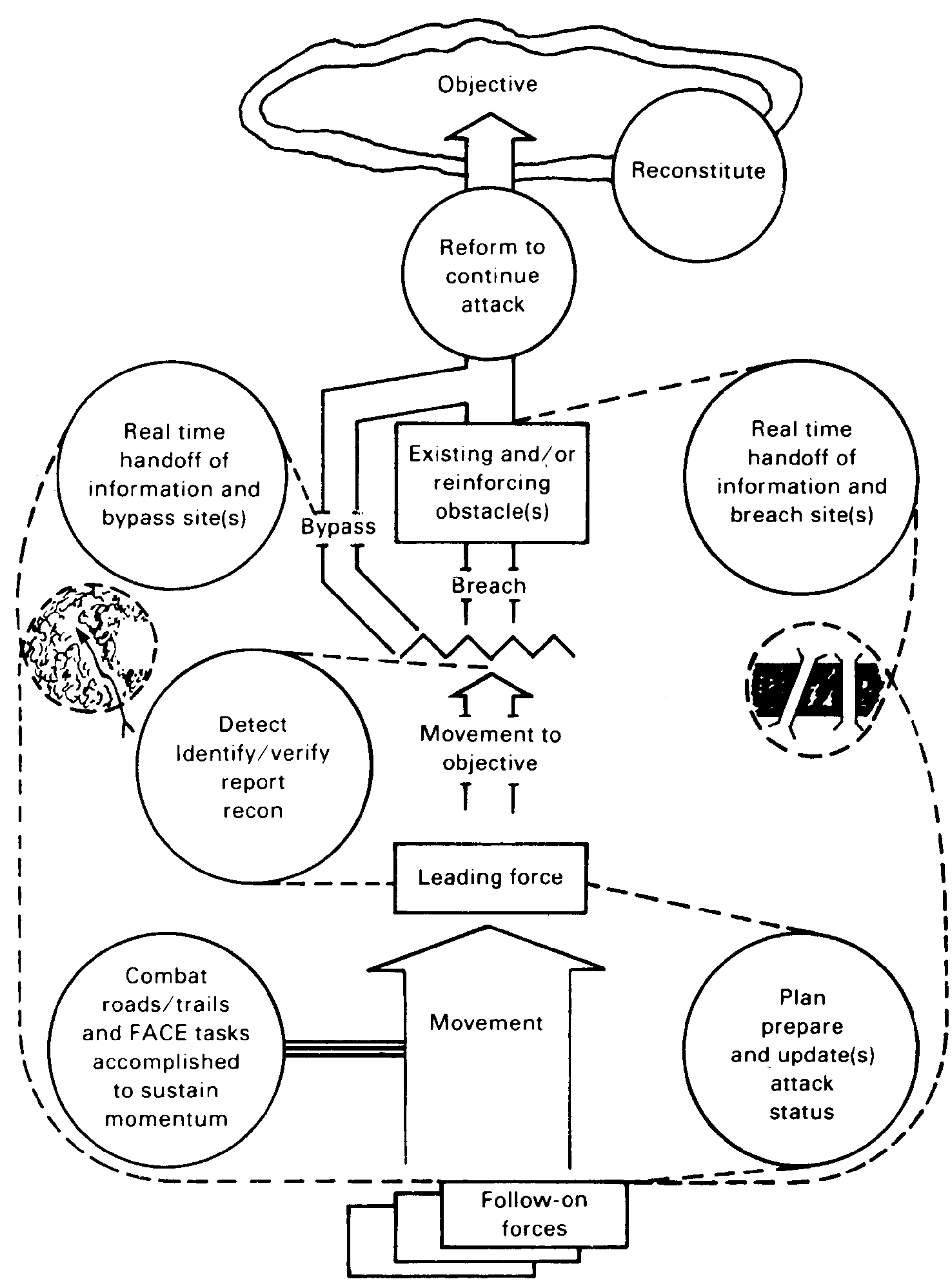
SYSTEMATIC APPROACH

The capability to breach an obstacles not the only factor for success in mobility activities. The ability to overcome obstacles is created through a series of planned engineering activities known as the mobility scheme. This method employs early detection, continuous preparation, and the continuation of tactical movement. It emphasizes the missions necessary to minimize the effects of obstacles. Whether a tactical force is part of an offensive or defensive operation, the principles of the mobility scheme remain the same.

Organizational elements. The mobility scheme revolves around two organizational elements, the leading and follow-on forces. For the purpose of explanation, these elements can be any type or size of tactical unit. The leading force is usually the first in a tactical march unit. However, this element can also be part of the obstacle detection force in, front of a moving tactical unit. For example, the leading force can vary in range from the reconnaissance elements of a battalion task force to the covering force in a divisional movement to contact. The follow-on forces also vary in size and composition. However, they follow the leading force on the battlefield. Their rates of movement and ability to maneuver are directly affected by the actions of the leading force. The availability and trafficability of routes, bypasses, breach lanes, and crossing sites determine the capability of the follow-on forces to provide support to the leading force.

Combined missions. Complete mobility plans are developed and all participating elements briefed. Figure 2-5 depicts how the components of the mobility scheme interact for a maneuver force conducting an attack. Command, control, and communications channels are structured to allow flexibility of action before, during, and after an obstacle is negotiated. This includes plans for alerting other friendly forces also using the same avenue of approach. Leading forces develop plans for consolidating and moving on toward the operation's objectives. Once the objectives are achieved, established methods for reconstituting lost, damaged, or destroyed mobility assets will allow further mobility activities. All of the above actions must be integrated with the tactical scheme of maneuver and fire support. This combination of missions creates a planned method for overcoming obstacles. Thus, the actions of planning, communication, detection, bypass and/or crossing and/or breaching, command

FIGURE 2-5. MOBILITY SCHEME



and control, consolidation, and reorganization are the major components of the mobility system.

INTERACTION OF FORCES

When the mobility system planning scheme (figure 2-5) is reviewed, the following key points should be recognized:

- Both the leading and follow-on forces plan and prepare. This includes developing orders, command and control, and estimates of needed equipment and supplies for all phases of the operation.
- The leading force will usually determine the nature of the obstacle, the possibility of a bypass, and its tactical value.
- The leading force executes the bypass, breach, or gap-crossing task and marks the obstacle, as necessary.
- After the obstacle is bypassed, breached, or crossed, the leading force rapidly builds up combat power on the far side and continues the attack.
- The leading force provides real-time information on the obstacle and a guard element, if necessary, to assure a successful handoff of the obstacle site to follow-on forces.
- The leading force reorients on the objective, including mobility support systems, in order to continue the cycle of mobility tasks.

Note: Leading force and follow-on force size and composition will vary with the maneuver scheme and tactical situation.

PLANNING AND PREPARATION

Mobility scheme planning is the first critical step in mobility operations. Commanders must expect to encounter obstacles and develop countermeasures which will lessen or eliminate their effect. The plans for mobility are necessarily tied to the scheme of maneuver and the fire support plan. Full integration of tactical plans will allow the mobility scheme to function effectively for the combined arms team (figure 2-6). Chapter 3 provides a discussion of the planning process. Within the scope of the total mobility scheme, the priority for mobility support during a defensive operation and that for an offensive operation will differ. The mobility support plan is tailored to enhance mission accomplishment and achieve the objectives of the command. Within the scope of the operation, the leading force and follow-on forces exchange mobility plans. Through coordination and staff cooperation, areas of responsibility for mobility support are assigned. When possible, engineers supporting follow-on forces are tasked to improve and maintain bypass routes, create lanes in obstacles, or completely remove the obstacles when necessary. This support will allow the leading force that first overcame the obstacle to continue its movement and maneuver.

GOAL OF PLANNING

The all-important goal of mobility planning, from receiving plans and orders to encountering an obstacle. is to be prepared. This means having a countermine, counterobstacle, gap-crossing, or engineer work force ready to perform its mission. There are six steps in preparing a unit or individuals for execution of mobility missions within the context of the mobility plan. The commander must—

Determine tasks. Identify tasks that must be done,

Acquire needed resources. Personnel, equipment, and supplies should be requested, organized, and allocated.

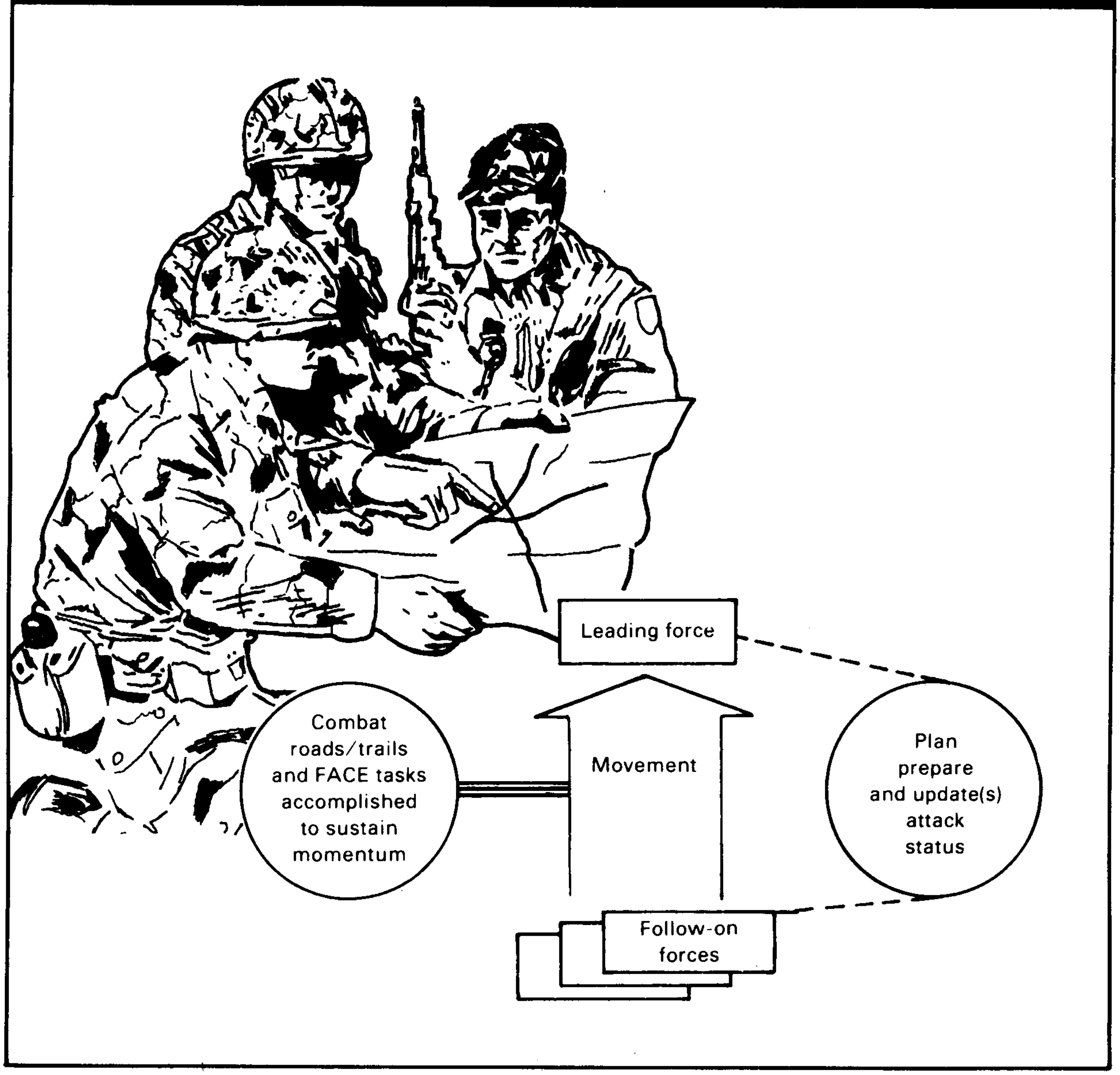
Conduct briefings. Soldiers should be informed as to the nature of the operation, obstacles expected, and the plans for overcoming obstacles.

Inspect equipment, Equipment and supplies that are to be used need to be inspected by leaders. These resources are repaired, maintained or replaced, as required, before the operation begins.

Organize mission forces. In accordance with the plan, personnel and equipment should be organized for movement. This includes placing mobility assets forward in the combined arms teams formations.

Rehearse plan. Critical phases of the plan and the drills required to implement it should be rehearsed thoroughly. Successful mobility activities require participation from the various elements of the combined arms teams. Rehearsals develop understanding of the plan and instill confidence in soldiers. The entire force rehearses critical mobility missions to develop unity of effort.

FIGURE 2-6. PLANNING AND PREPARATION



DETECTION

Detection is the second step in execution of mobility tasks. Detection (figure 2-7) provides the following information:

- Location of obstacle.
- Types of mines in a minefield or types of obstacles.
- Length and width of obstacle area.
- Existence of enemy coverage, including Threat strength, equipment, and fire support.

Early detection of obstacles is preferred and may be done by careful analysis of the terrain and situation in preparation for an operation. This study should include the identification of US-employed obstacles that coincide with possible movement routes. Units should always organize with detection means deployed forward as this increases the likelihood of detection. The methods for obstacle detection include—

- visual detection,
- Physical contact.
- Probing.
- Aerial detection (including reconnaissance aircraft, remotely piloted aerial vehicles, satellites, and radar).
- Electronic detection (including robotics).
- Intelligence reports and staff-produced estimates. Detection methods are most successful when used in combination. Physical contact with an obstacles almost always undesirable except by physical probing of scouts and reconnaissance elements.

RECONNAISSANCE

Mobility reconnaissance can be divided into two categories, hasty and deliberate.

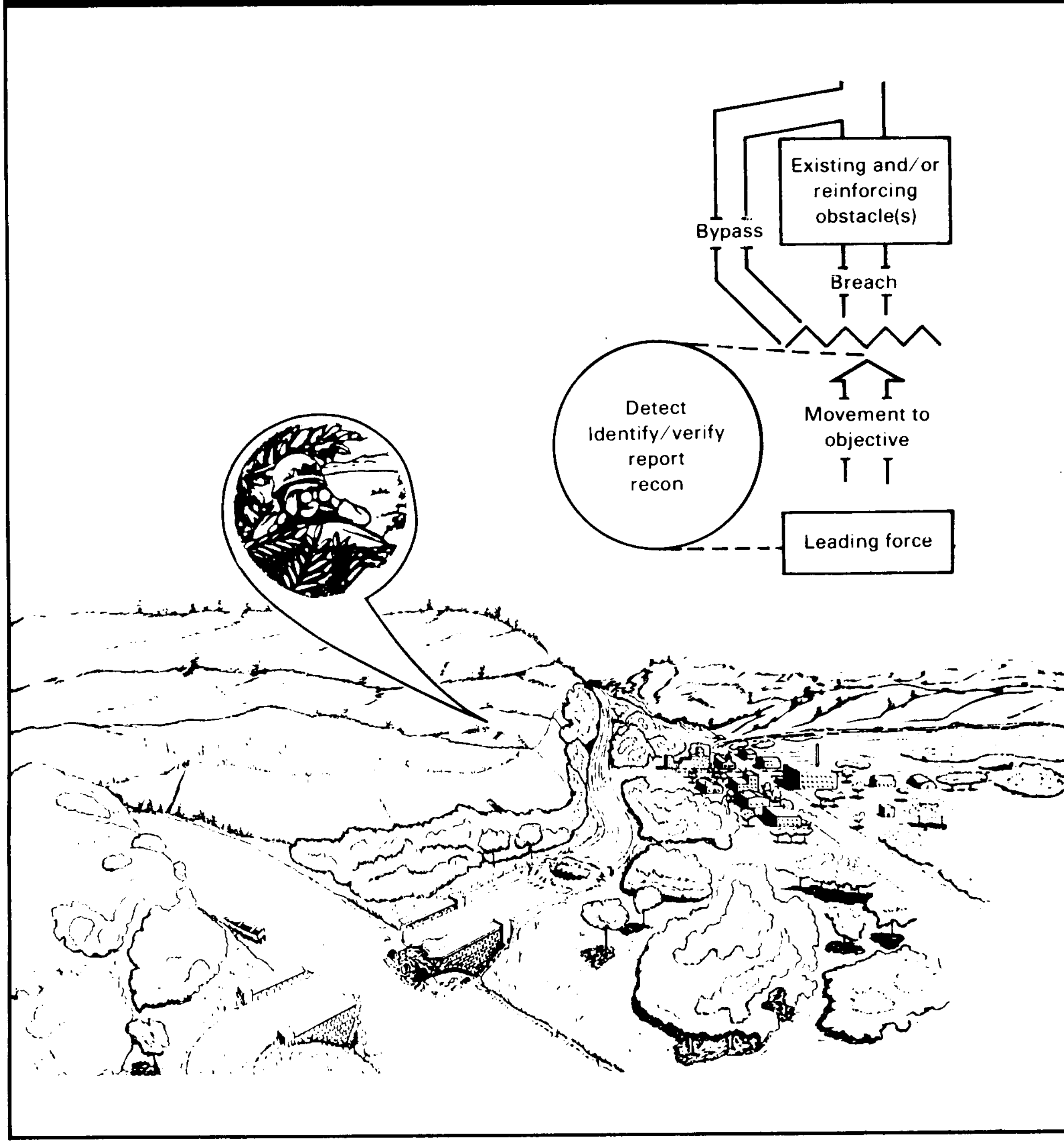
- Hasty reconnaissance is done by personnel of all units. It provides limited route information for planning and executing movement and maneuver.
- Deliberate reconnaissance provides essential and additional mobility data. This information forms the basis for technical classification, estimates of required engineer work, and a thorough analysis of the road and trail network throughout an area of operations. The deliberate reconnaissance, usually performed by engineers, determines the potential for supplementary combat roads and trails and forward aviation sites. Hasty and deliberate reconnaissance reports will be forwarded in accordance with the parent unit's reporting procedures and directives.

Most reliable method. The most reliable method of mobility reconnaissance is a physical ground reconnaissance. This method can be performed only as far forward as the tactical situation permits. The ability to obtain timely information depends on several factors. These include the unit's equipment, means of communication, and training. The principles of ground reconnaissance are—

- A review of available maps, photographs, and intelligence should precede reconnaissance.
- Aerial reconnaissance, if available, should precede ground reconnaissance.
- Reconnaissance must be repeated as often as necessary to keep information current. Though reconnaissance units usually have a specific mission, personnel should be alert for other useful intelligence information. Attention to detail is important. Quantities, sizes, and other data should be counted or measured in numbers. The ground reconnaissance party should avoid enemy contact or observation unless it is necessary for mission completion.

Aerial reconnaissance. Aerial reconnaissance is fast and covers areas which cannot be seen by ground observers. However, it can be hindered by poor weather conditions. The aerial observation of some mobility factors, such as stream fordability or location of a minefield's near edge, is limited at the present time.

FIGURE 2-7. MOBILITY SCHEME: DETECTION



TWO OPTIONS

Units encountering mines and obstacles have two immediate options for action, to bypass or breach the obstacle. These choices apply to existing, reinforcing, or obstacle systems. Bypass is the preferred method when it offers a quicker, easier, and tactically sound means to avoid obstacles. Bypassing is done by maneuvering around, under, or over the obstacle or minefield. However, obstacles should be bypassed with maneuver only after consideration of the advantages and disadvantages in each case.

BYPASS ANALYSIS

The leading force commander must assess the advantages and disadvantages of executing a bypass. The commander must weigh the availability of bypass routes against the likelihood of being further channelized or ambushed.

Considerations. The commander also considers missions and boundaries of adjacent units and time restrictions. A good bypass allows the entire force to avoid the primary obstacle without risking further exposure or ambush. It also allows the leading force to conserve breaching assets and maintain momentum. If only portions of the force (infantry on foot or mounted in carriers) can get through a bypass, these troops may be able to maneuver into a position to suppress or destroy the enemy covering the primary obstacle.

Alternative solution. In some cases, breaching may be a better tactical solution than bypassing. Examples of such cases are-

- The best available bypass channelizes friendly forces into a kill zone or ambush.
- The force has the mission of opening the original route for follow-on traffic. Bypass in this case would still necessitate breaching or clearing.
- The best available bypass route will not allow required vehicular rates of speed. The obstacle is still effective in delaying movement.
- Development of a bypass may require more time or assets than breaching the primary obstacle(s).

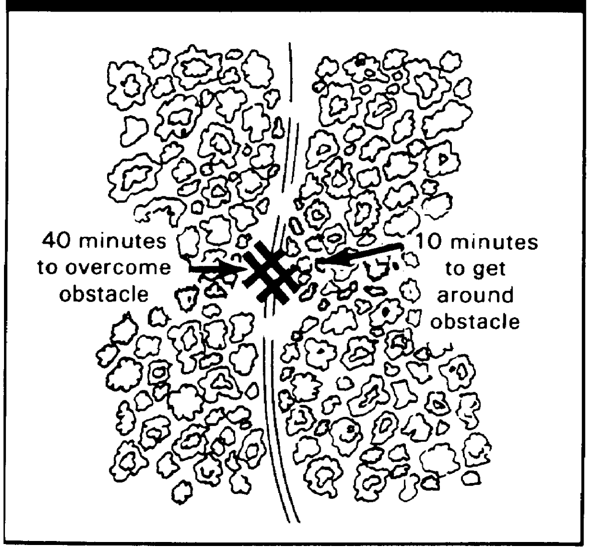
If a suitable bypass is decided upon, the tactical commander should advise and integrate the forces accordingly. The force then moves rapidly through the bypass using available cover, concealment, obscurants, artillery suppression, and electronic warfare.

BYPASS CATEGORIES

When choosing the best bypass route, the commander must consider terrain, intensity of enemy contact, and friendly equipment that will travel the bypass. There are three categories of bypass.

Bypass easy. Bypass easy requires little effort to clear an existing route or force a trail around the obstacle area. In this case, the unit may be able to complete the bypass without additional supplies or equipment. An example of an easy bypass is the clearing of a path around an obstacle using the lead tank or dozer tank organic to the leading force (figure 2-8).

FIGURE 2-8. BYPASS EASY



Bypass difficult. In this case, a suitable bypass may require additional resources, resulting in a temporary loss of momentum. Before a difficult bypass is executed, the commander should consider attempting both a breach and bypass simultaneously. This option would require swift coordination of assets, but would allow the maneuver force the possibility of extending two lanes past the obstacle site. An example of a difficult bypass is the construction of a 100-meter" combat trail through a wooded area around a crater (figure 2-9).

Bypass impossible. Here, the obstacle is tied into existing terrain or other obstacles in such a way as to make all bypass efforts impractical. Major demolition or construction effort is necessary to develop a bypass, and it would take longer to establish the bypass than to successfully breach the obstacle. This situation might occur with an enemy minefield sown in the most constricted area of either a mountain pass or a bridge, as shown in figure 2-10.

FIGURE 2-9. BYPASS DIFFICULT

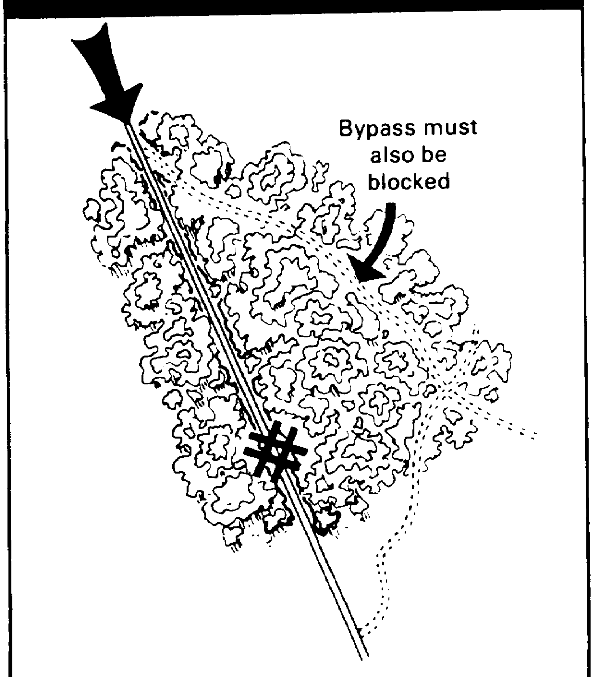
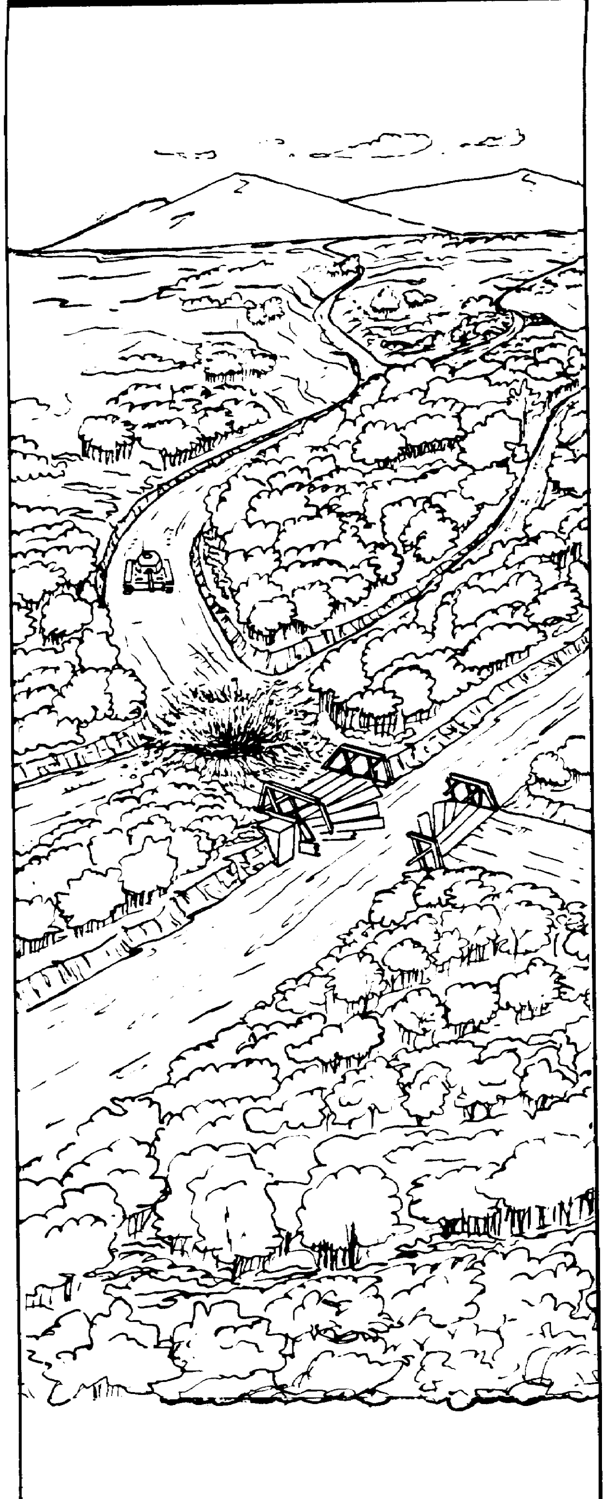


FIGURE 2-10. BYPASS IMPOSSIBLE



OBSTACLE NEGOTIATION

Existing and reinforcing obstacles should be bypassed wherever possible.

Maneuver commanders are responsible for insuring their force has plans and is organized to overcome obstacles and minefield. Existing and reinforcing obstacles should be bypassed wherever possible. When bypass is not possible or tactically sound, breaching or crossing activities should begin immediately. Engineer support to the leading elements can help in the development of an obstacle breaching or gap crossing.

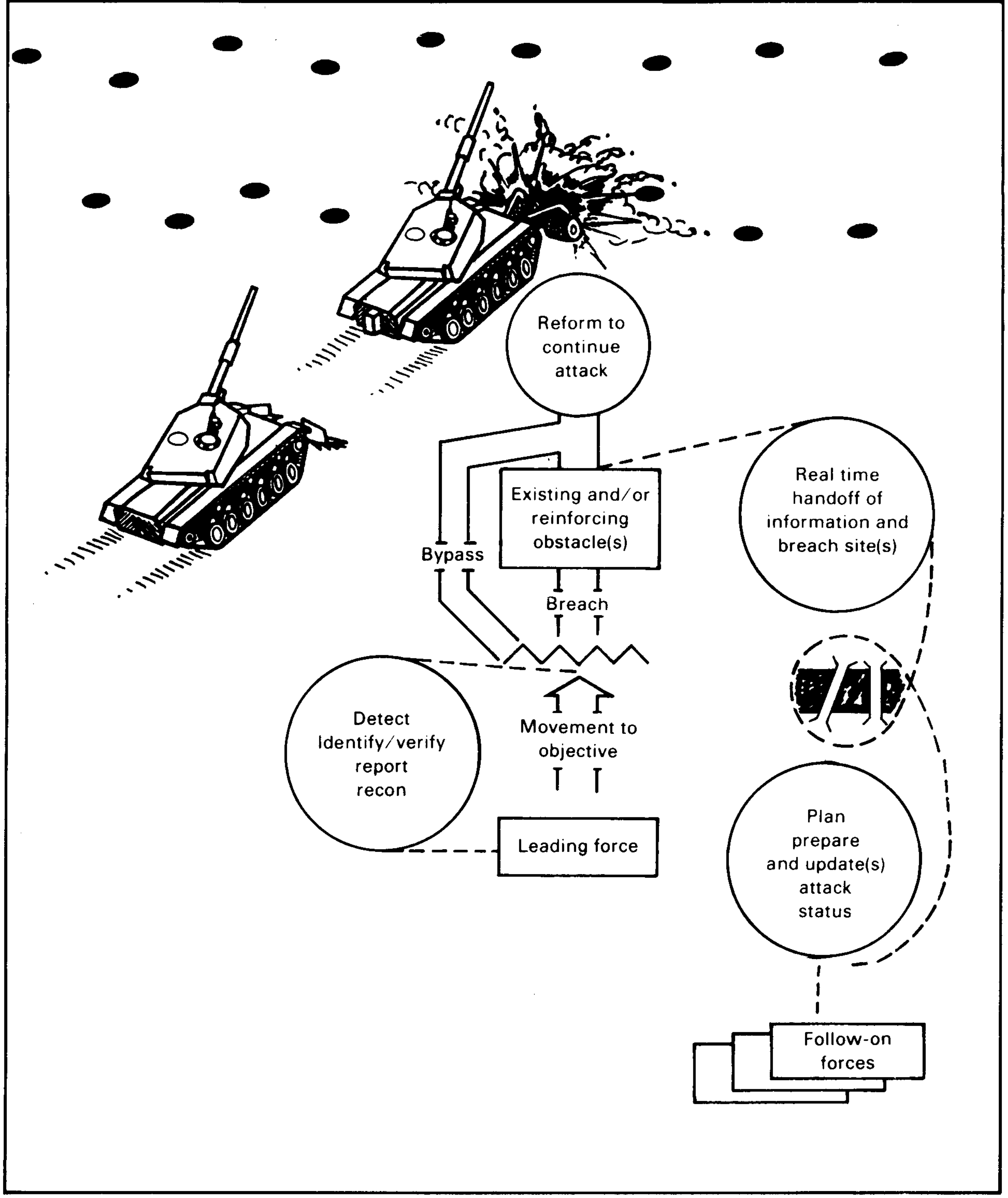
FORCE PREPARATION

The maneuver commander, with help from the staff and engineer, will develop plans and procedures to maintain the momentum of the force. These plans for breaching or crossing obstacles should be part of the combined arms movement plan (figure 2-11). Engineers should be well forward in advancing columns to assist in mobility tasks. Countermine equipment which may be organic to maneuver forces, such as rollers and plows, also should be located well forward. The initial objective of the breach or a gap crossing is to make a safe route, either vehicle or foot lanes, to the far side. The number and types of lanes breached or crossing sites depend on—

- The number of transit points on the far side of the obstacle required by the maneuver force to execute its mission,
- The size and equipment of the maneuver force.
- The amount and type equipment of mobility support assets.
- The type and size of minefield, obstacle, or gap.
- Time, terrain and enemy disposition.

Threat forces will normally employ mines and obstacles together (figure 2-12 on page 2-16). Plans must be flexible. Where resources permit, commanders should allow for shifts in breaching or crossing locations and the

FIGURE 2-11. OBSTACLE NEGOTIATION



configuration of backup teams and equipment. The specific techniques and preparations for gap-crossing tasks are discussed in chapter 6.

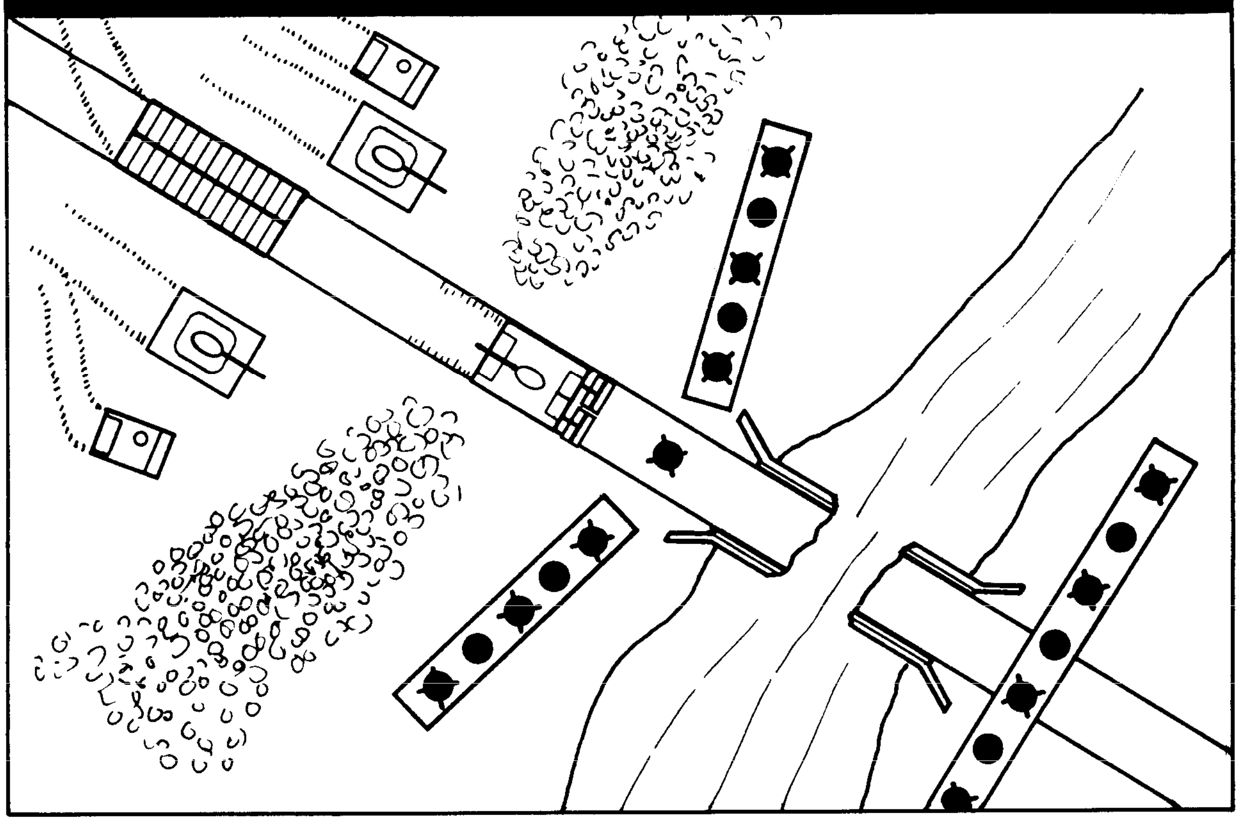
FUNDAMENTALS OF BREACHING

The primary goal of forces encountering an obstacle is to continue the mission as swiftly as possible. Breaching, like bypass, is a means to that end. It follows that the immediate goals of breaching are to—

- Suppress enemy direct fire and observation of the obstacle or minefield.
- Establish forces on the far side of the obstacle or minefield.
- Neutralize or reduce a portion of the obstacle or minefield.
- Cross the main body safely through the minefield or obstacle.

Thus, a breaching activity starts with direct and indirect fires against defending enemy forces. Concurrently, it obscures the far side of the breach area with smoke to conceal breaching assets. A series of foot-lane breaches is created when dismounted infantry troops are available for assault against hastily prepared positions, or lightly defended positions, or in terrain where armored vehicles cannot operate. Available organic mechanized breaching equipment is used to create an initial vehicle-lane breach when a dismounted assault is not possible or practical. In both cases, the lanes are then widened, proofed, and marked for further dismounted or vehicular traffic. The maneuver force then swiftly reconstitutes and continues its mission.

FIGURE 2-12. INTEGRATION OF OBSTACLES AND MINEFIELDS



BREACHING ELEMENTS

The leading force in the mobility system, faced with an obstacle, organizes into three elements.

The support force. The support force (figure 2-13) consists of combat and combat support elements. The force lead element contacts the obstacle, moves to an overwatch position, and becomes the base unit of the support force. These forces deliver direct fire on defended obstacle areas. The support force also includes all units providing over-matching fires and other support (such as electronic warfare and artillery, including counterbattery fire and smoke) to support the entire breaching process. As required, the support force fires are directly controlled by the assault or breaching force commander to insure the necessary close coordination.

The assault force. The mission of the assault force (figure 2-14 on page 2-18) is to quickly suppress enemy fires in the breach area, cross the obstacle, and destroy the enemy on the far side. An assault force is built around infantry and armor units. Engineers assist the movement of the assault force through the obstacle.

The breaching force. The primary mission of the breaching force (figure 2-15 on page 2-18) is to create, and if necessary, mark lanes in the minefield or obstacle which allow passage of the assault force into the objective. Once the initial passage is completed, the breaching force prepares and marks the necessary lanes to safely pass the remainder of the force. Breaching forces normally are composed of engineers, infantry, and armor. After the required lanes are completed, the breaching force assists the assault force as required. A detailed discussion of breaching

FIGURE 2-13. THE SUPPORT FORCE

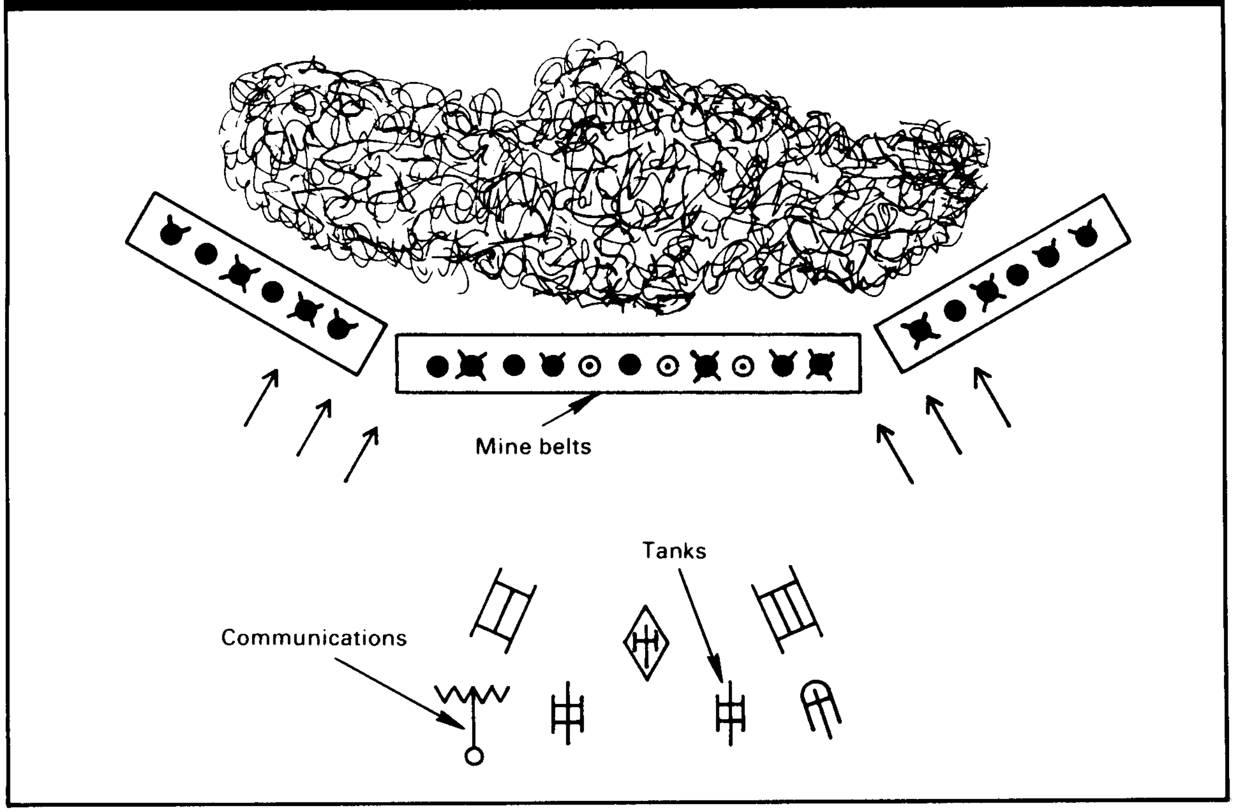


FIGURE 2-14. THE ASSAULT FORCE

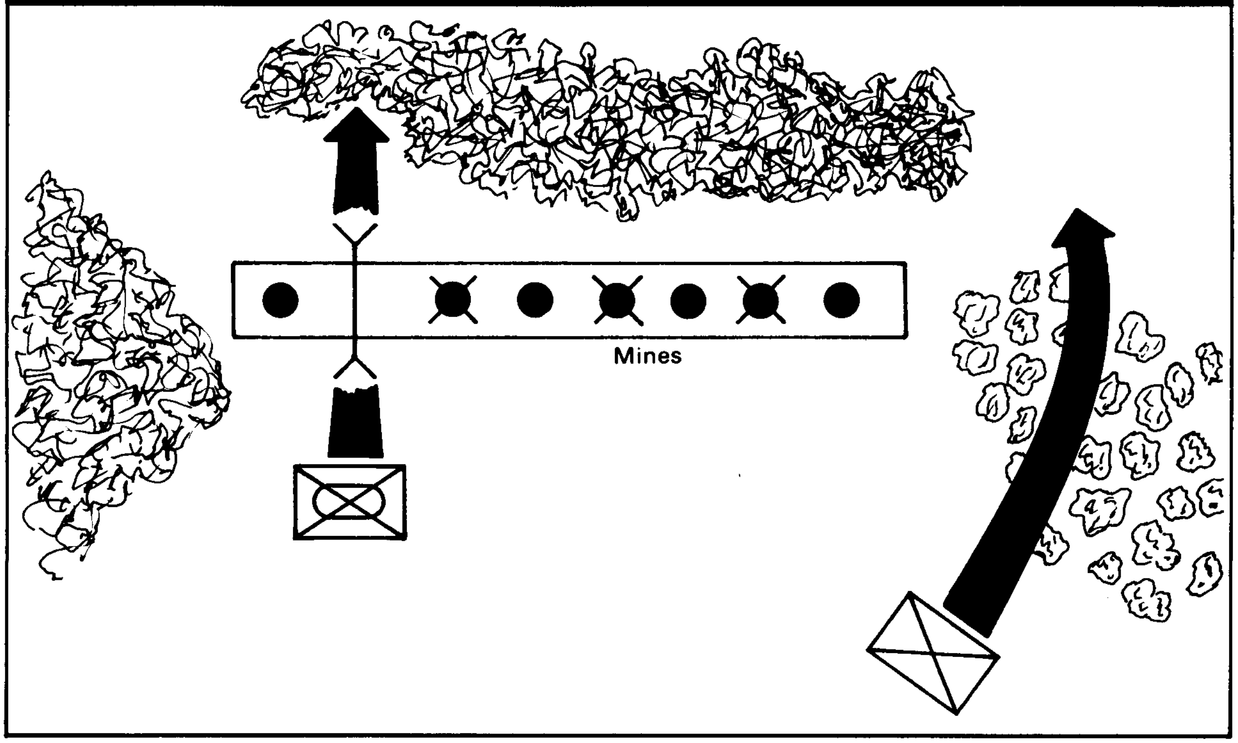
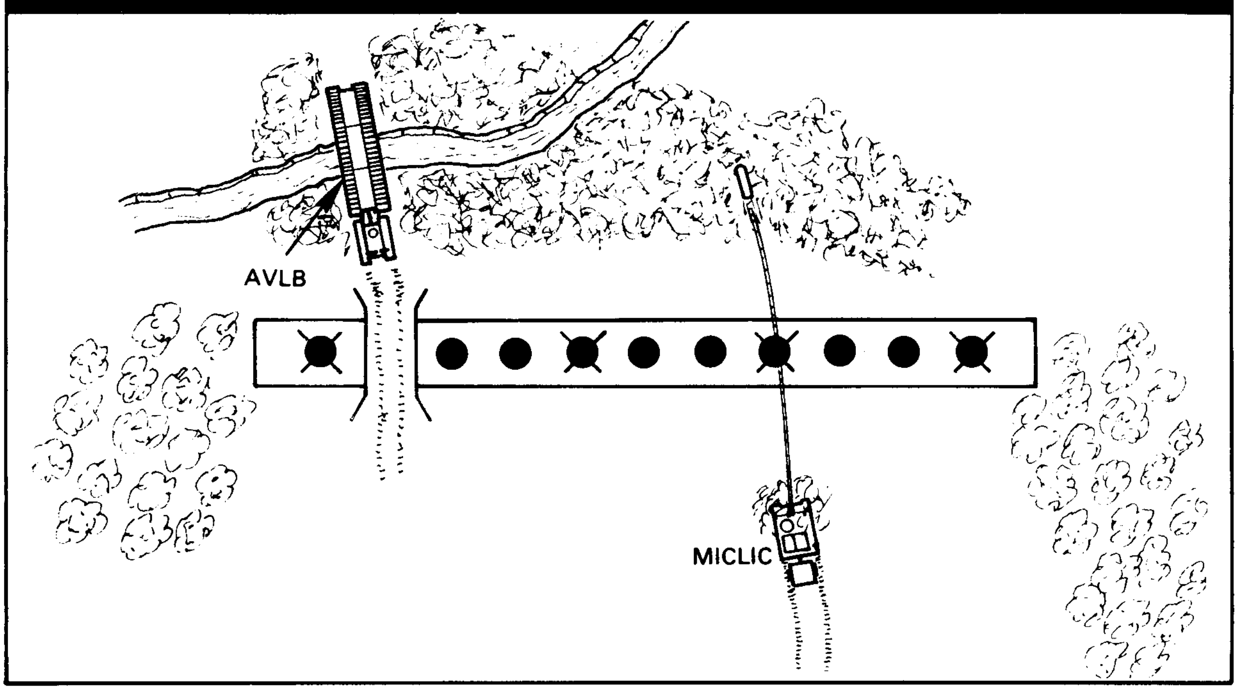


FIGURE 2-15. THE BREACHING FORCE



techniques applicable to each mobility task is provided in chapter 4 (countermine) and chapter 5 (counterobstacle).

Upon completion of the breach, the support force will be the last element of the force to cross the obstacle. Normally the base element of the support force would then become the assault force. Conversely, the previous assault force would become the base element of the support force.

METHODS OF BREACHING

There are three methods of breaching available to the force commander.

Hasty breaching. In the hasty breach, the attacking force maintains the momentum of the attack by attempting to breach "in stride" as it encounters the minefield or obstacle. A hasty breach is conducted by maneuver units with immediately available assets and often without combat engineer participation. The breach is based on mobility drills and is executed aggressively.

Deliberate breaching. The deliberate breach is conducted when it is not possible to take the minefield or obstacle in stride or after a hasty breach has failed. Combat engineer support is essential. A deliberate breach will normally be conducted after momentum has been lost. More time is required for reconnaissance, planning, and build-up of necessary resources than is possible for a hasty breach.

Forcing through. Forcing through is the crossing of an obstacle without the benefit of countermine or counterobstacle equipment. Visual observation is the only means used by dismounted troops or vehicle drivers to avoid obstacles or mines. Negotiating the obstacle in this manner involves the highest risk and is attempted only when it is imperative to maintain the momentum of the attack or no other means is available.

CLEARANCE OR REDUCTION

Minefield clearing or obstacle reduction is the complete removal or destruction of an obstacle which has been bypassed or breached. It is generally conducted after enemy presence has been eliminated from the obstacle site. Thoroughness and safety, not speed, are the most important considerations here. Manual removal or demolition are used to clear and/or reduce minefield. Mechanical means and demolition are used to reduce obstacles other than minefield. Obstacle clearance and reduction are generally conducted by engineer units. A minefieid is cleared or an obstacle reduced in order to—

- Regain full use of maneuverable terrain.
- Regain full use of a route.
- Eliminate danger to personnel, equipment, and noncombatants.
- Regain full use of a support facility.

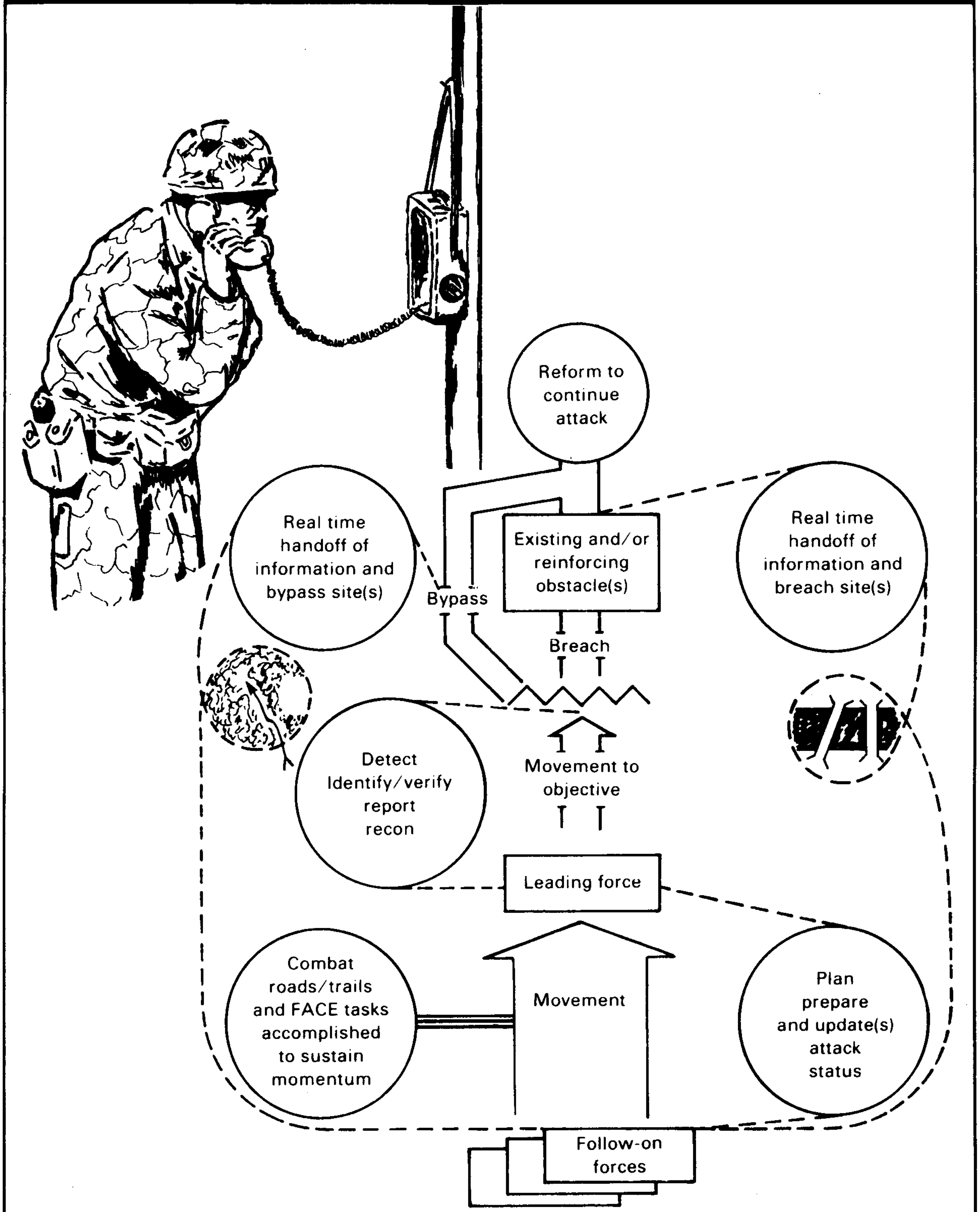
COMMAND AND CONTROL
OF MOBILITY MISSIONS

A command, control, and communications (C^3) system was developed in the planning and preparation phase. The resulting network links all elements of the combined arms team including engineers providing mobility support and follow-on forces (figure 2-16 on page 2-20). This system may be in the form of radio contact of the engineer element with its parent unit and its supported unit. It may also be simply an engineer guiding traffic safely through a minefield safe lane.

REPORTING, RECORDING, AND MARKING

Reporting, recording, and marking of an encountered minefield during the execution phase are necessary to alert other members of the leading force. These tasks also serve as the basis for handing off the bypassed or breached obstacle to follow-on forces. Command and control of mobility activities are especially crucial at this time. Plans and procedures for reporting, marking, and transfer of obstacle sites are coordinated with follow-on forces.

FIGURE 2-16. COMMAND AND CONTROL



Reporting. Untimely, incorrect, or inadequate obstacle reporting can delay or distort the decision to breach and reduce the dispersion between tactical units. The tactical commander is responsible for reporting any contact with friendly or enemy obstacles to the next higher echelon. When necessary, adjacent units will also be informed. This process allows plans and orders at higher headquarters to be revised and reduces maneuver delay. There are three categories of reports which pertain to the transfer of tactical information involving mobility activities:

- Detection reports alert the force to the location, nature, and when possible, extent of an observed obstacle. Examples are obstacle, situation, and spot reports.
- Reconnaissance reports provide detailed information on the extent of an obstacle, both existing or reinforcing. Route reconnaissance, ford, and terrain reports are examples of this type.
- Minefield reports describe any previously undetected minefield, both enemy and friendly. This type of report should always include a sketch showing minefield location, dimensions, and any other available information. FM 5-102 contains specific information on this subject.

Recording. This activity involves recording obstacle data and transferring this information to tactical status records, maps, and the terrain analysis data base. The data is gathered from combat road, trail, and FACE reconnaissance missions. Specific detail on reporting and recording procedures for each of the mobility missions is included in chapters 4-8.

Marking. This task involves placing visual signals on or around an obstacle, combat road, combat trail, minefield breach or forward aviation facility. Marking is done to prevent accidental contact or exposure with the obstacle or safety hazard. A minefield or obstacle should be immediately marked with marking systems or available resources. In the case of nonmine obstacles, marking should be located in positions **to** warn any follow-on forces. Most obstacles, when breached, become defiles. The use of STANAGs or other agreed upon procedures is required to insure that minefield are clearly marked as to extent, width, and perimeter of the breached lanes. Breached lanes may be effectively controlled by fire support. If necessary, breached lanes or bypasses are also guarded by maneuver elements to insure safe transfer of follow-on elements. Guard forces are left by the leading force or provided, in advance, by follow-on forces. Road warning signs are provided on combat roads and trails to warn traffic of mined areas, obstacles, or difficult driving conditions. Air marking panels are provided on landing zones, airstrips, and low altitude parachute extraction system (LAPES) zones to warn pilots of ground level, release points, or hazardous obstructions. In all cases, temporary markings will be replaced by standard marking materials as soon as the tactical situation permits.

TRAFFIC CONTROL

In all mobility missions, the maneuver commander is responsible for establishing a traffic control system. The commander will appoint a designated representative to control and monitor this system at obstacle sites. The objective of traffic control is to expedite tactical movement and prevent the unnecessary massing of personnel and equipment on either side of the obstacle. Plans for a traffic control system include arrangements for staging and holding areas as well as movement.

Staging areas. Staging areas are waiting spaces for forces not engaged in supporting the leading force or convoys. They are located far enough from the obstacle site to facilitate use of alternate routes. Areas selected for staging require—

- Cover and concealment.
- Easy accessibility.

- Sufficient areas for personnel and vehicle and equipment dispersion.

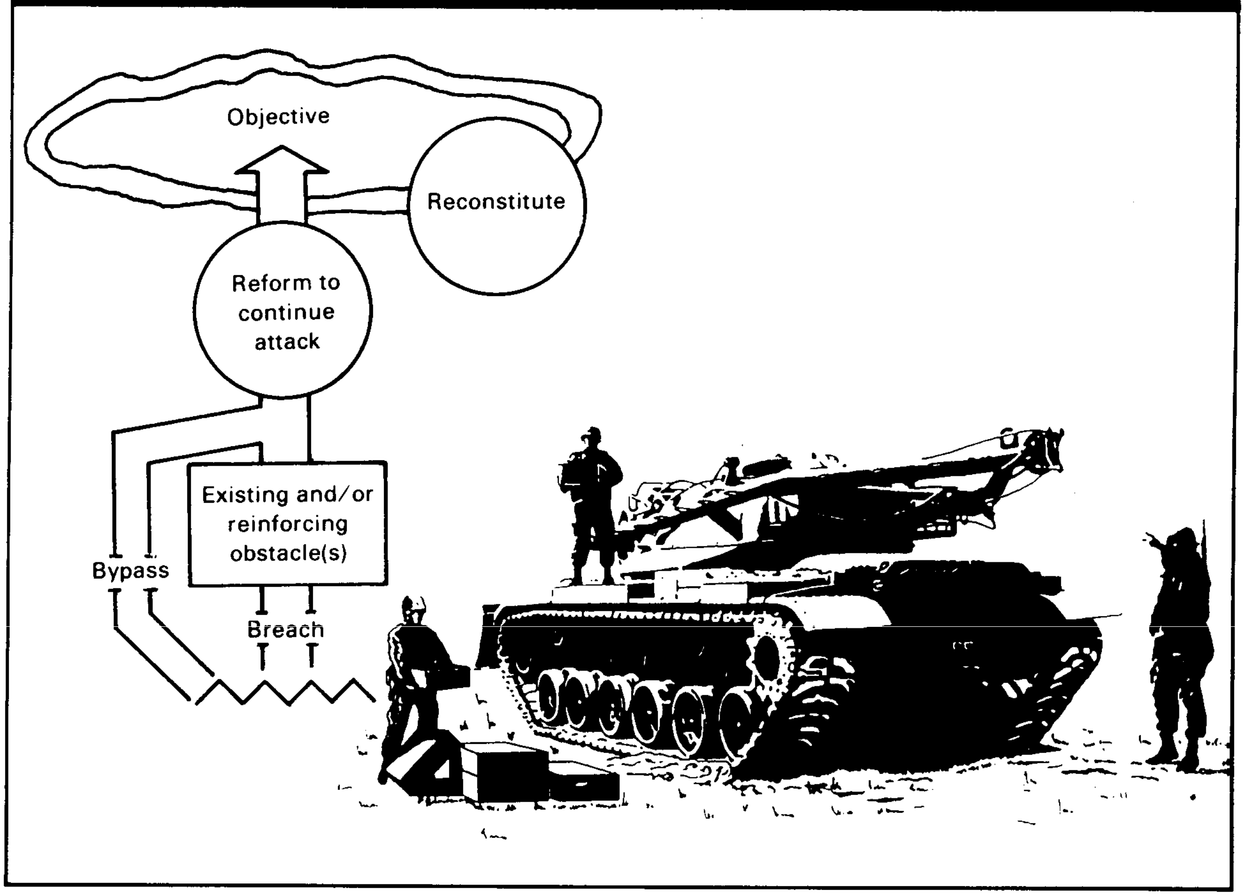
Holding areas. Holding areas are waiting spaces both near and within obstacle areas. They are selected to accommodate vehicles should a sudden interruption occur in the movement of traffic across the obstacle. Vehicles move into these areas and disperse rather than remain on trafficable routes or restrict the flow of traffic through breach lanes or bypasses.

Order of movement. Breaches or bypasses tend to channelize traffic. A prearranged order of movement, disseminated to all elements of a force, will facilitate speedy movement through or around the obstacle area. If necessary, guides will assist in movement through the obstacle. When possible, light traffic should go through first to prevent ruts formed by heavy vehicles from becoming obstacles to lighter vehicles. The combat situation will dictate the vehicle crossing priorities.

RECONSTITUTION

Successful completion of breaching or bypassing activities depends on how quickly a force can consolidate on the far side and continue its mission (figure 2-17). The traffic control plan should include plans for dispersing forces on the far side once the obstacle is overcome. It should recognize that movement rates for the forces past the obstacle and those negotiating the obstacle are critical. An effective consolidation and traffic

FIGURE 2-17. RECONSTITUTION



control plan will prevent forces from becoming too far apart to provide mutual support on the far side of the obstacle.

LOGISTIC SUPPORT

Logistic support is the provision of adequate material and services to a military force to assure completion of the mission. The execution of bypasses, breaches, or combat construction can be expected to result in some equipment damage or loss. These conditions should be thoroughly anticipated in the planning phase. Logistic support consists of the following four sequential subtasks which apply to all mobility activities:

- Identify mobility systems still available,
- Identify equipment, personnel, supplies (including munitions) required,
- Request and acquire replacements.
- Repair/resupply/decontaminate.

The most important aspect of logistic support is that the process occur swiftly. Mobility logistic support cannot be allowed to delay the continuing movement of forces or critical supplies.

OPERATIONAL CONSIDERATIONS

OPERATIONS SECURITY

Operations security (OPSEC) refers to those measures taken to deny the enemy tactical information until it is too late for them to react. Security must be maintained throughout all phases of mobility activities. Unless steps are taken to deny the Threat knowledge of when, where, how, and with what our forces intend to move, the Threat can react by creating obstacles which will effectively delay any movement or maneuver. Adherence to a well-thought-out OPSEC plan will provide maneuver units and support engineers with an added measure of security against enemy observation and fire. The maneuver force operations staff officer (G3/S3), assisted by the intelligence staff officer (G2/S2), develops the OPSEC plan. A successful security effort includes an integrated effort by commanders, staff, and each soldier of the combined arms team. There are three types of OPSEC measures.

Countersurveillance. Those measures taken to protect the true status of friendly activities and operations are countersurveillance. These include measures to insure the authenticity of communications, the physical protection of radio transmissions (such as radio-listening silence), and the control of information sent over radio equipment. Preventing classified and unclassified information from falling into enemy hands is also a part of countersurveillance. Physical security measures are those that protect equipment, facilities, and activities. These measures are enhanced by camouflage, concealment, and noise and light discipline.

Countermeasures. Those activities which are designed to overcome enemy intelligence collection are OPSEC countermeasures. Countermeasures are designed to reduce the risk of friendly detection and vulnerability. These include the locating, targeting, and destruction of enemy intelligence systems.

Deception operations. Most deception operations involve the creation of false impressions for the enemy force. They include sight, sound, smell, or electronic “pictures” painted by friendly forces that will cause the enemy to react incorrectly. Within the context of mobility tasks, engineer forces conduct deceptive measures as directed. They may include the following:

- Use of dummy equipment.
- Conduct of an activity so it is not what it seems.
- Falsification of material which can be detected or photographed.

- Manipulation of electronic signals.
- Use of feints or movement of a force in a direction intended to mislead.

NUCLEAR, BIOLOGICAL, AND CHEMICAL WEAPONS

Threat doctrine puts a premium on the ability to maneuver and mass troops at critical battlefield locations. Threat forces will employ nuclear, biological, or chemical (NBC) weapons in order to deny that ability to enemy forces. These weapons will likely be used in combination with other obstacles. Initial employment will create confusion and massive casualties. Continued use of these munitions will delay and degrade further friendly operations.

Terrain alteration. Nuclear weapons can alter terrain. Nuclear detonations will produce large amounts of debris such as tree blowdown, craters and building rubble. Also, these weapons will leave radioactive contamination and make areas useless to unprepared units.

Restoration of mobility. Tactical commanders and supporting engineers must be prepared to restore mobility in a nuclear, chemical, or biological environment. As much as possible, forces should avoid contaminated and disrupted areas and still accomplish given missions. In some cases where bypass is impossible or impractical, contaminated areas will have to be crossed. The degree of risk in planning specific routes must be weighed in terms of personnel exposure to nuclear radiation or chemical/biological contamination. Unit NBC officers and elements will assist in this planning.

Personnel considerations. On the next battlefield, heavy losses are likely to occur from nuclear and chemical weapons. The psychological effects on surviving soldiers will be severe, but these effects can be limited, to some degree, through realistic training. The soldier who is taught how to survive and accomplish missions on a nuclear battlefield will be crucial to mission success. High casualty rates will require two important reactions. First, surviving leaders must be aggressive in taking charge, assessing damage, and continuing the mission. Second, units must be reorganized and supplied.

Mobility countermeasures-NBC. Regardless of the mobility support task required, commanders and engineers must consider the enemy’s nuclear, chemical, and biological capability. Random use of chemical mines should be expected as a form of harassment. The enemy is expected to use persistant chemical agents to restrict our movements and to protect its flank, Units must be dispersed before executing mobility support tasks, although massing will be required at the critical time to accomplish the task. Units must be prepared to conduct bypassing, breaching, or clearing activities in a high state of mission oriented protective posture (MOPP).

Logistic consideration. Delays in battlefield logistics may occur as a result of the effects of nuclear weapons. This may result from damage to or contamination of supplies, facilities, and food/water sources.

CHAPTER 3

The Mobility Planning Process

MOBILITY SUPPORT PLANNING

FACTORS

In order to develop and execute a tactical maneuver plan, the force commander must be aware of the factors and requirements regarding the plan to include the degree of risk. This knowledge tells the commander what resources to use to overcome obstacles and improve trafficability. This chapter outlines command and staff procedures for gathering mobility information, preparing estimates, and making decisions required for mobility support. The mobility planning process allows the commander to establish priorities, task organize the forces, and generate plans and orders.

DECISION-MAKING PROCESS

The military decision-making process refers to those steps which a commander and staff take to arrive at decisions. The process provides the commander with enough information to choose the best course of action. The preparation of estimates and plans and/or

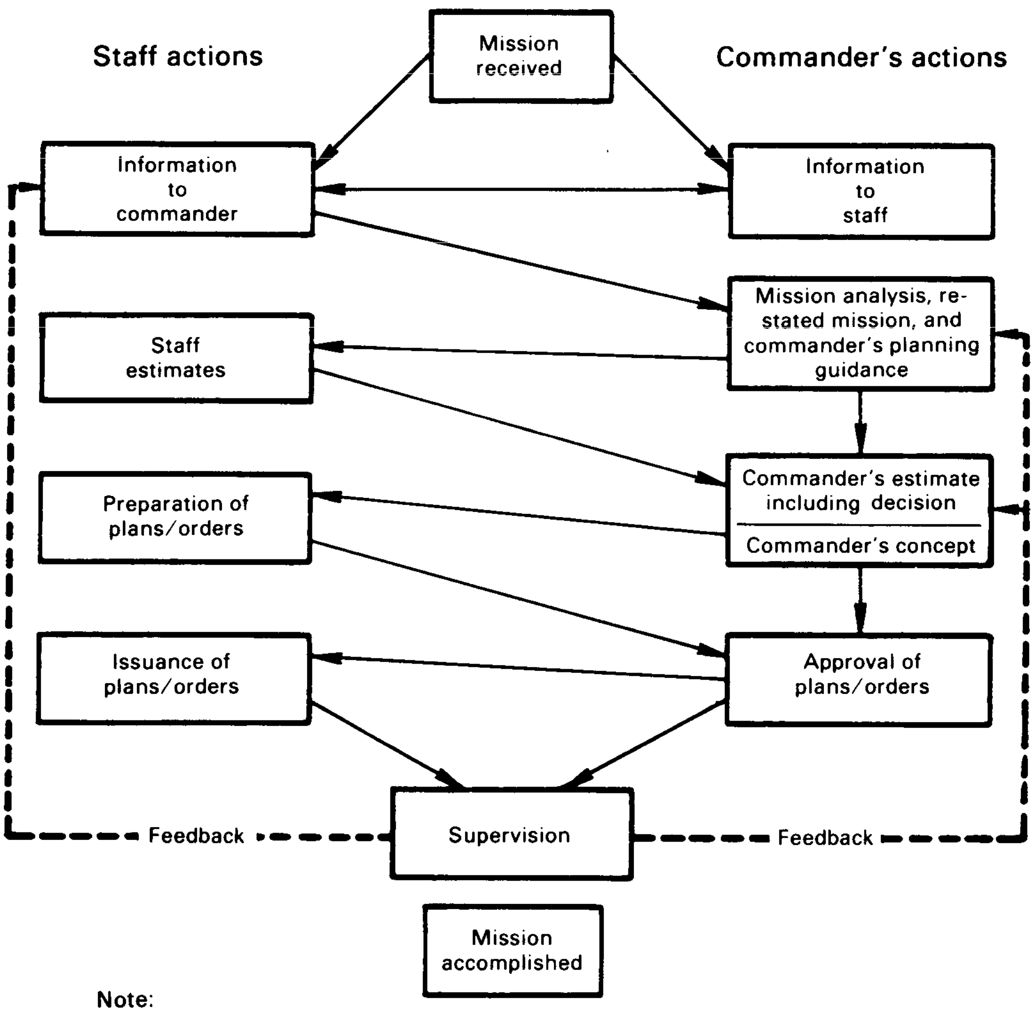
• obstacles against

orders is controlled by the chief of staff, executive officer, or operations officer. Possible courses of action are first studied and analyzed by the staff before presenting them to the commander for approval and action. Areas of staff input for this process include—

- Military intelligence (enemy activity, terrain, and weather).
- Intelligence preparation of the battlefield (IPB).
- Operations (tactical maneuver, fire support, and engineer support).
- Administration/logistics (personnel and combat service support activities).
- Civil affairs.

Figure 3-1 shows how the actions of the commander and staff are woven into this process.

FIGURE 3-1. MILITARY DECISION-MAKING PROCESS



Note:

In time-critical situations, the commander may be forced to make a decision and issue oral orders based only on personal knowledge of the situation.

PRIORITIES

Because of increased engineer requirements, commanders must establish clear priorities for mobility, countermobility, survivability and general engineering in support of their operations. For example, a maneuver company team is likely to encounter an obstacle every 3 kilometers. With such a high rate of occurrence, early identification, planning, and organization for mobility tasks are crucial to success.

ENGINEER INPUT

The military decision-making process is used in planning mobility activities within an operation, especially those that involve combat engineer assistance. The engineer prepares or assists in preparation of mobility estimates and plans. In organizations without a staff engineer, the operations officer does the analysis and formulation of mobility plans. In any case, the development of mobility support options and plans follows these steps:

- Receipt of the mission and the commander's guidance.
- Consideration of time available.
- Analysis of Threat situation and Threat countermobility assets.
- Evaluation of friendly situation and mobility support resources (including mobility of equipment).
- Collection of mobility data, including terrain analysis results.
- Development of possible courses of action.
- Preparation of the mobility portion of engineer estimate.
- Constraint of courses of action with actual engineer resources and other requirements.
- Request for additional engineer support, if needed to support plan.
- Preparation of plans, issuing of orders, and conduct of staff supervision.

The engineer contribution to the planning process is completed when the estimates, and then plans, for mobility are combined with those for countermobility, survivability and general engineering. This will provide the commander the basis for deciding task priority and allocation of support. Appendix C, Engineer Mobility Estimate, depicts a typical format of the mobility estimate report outline.

COLLECTING DATA

INFORMATION SEARCH AND ANALYSIS

In the initial stage of planning, an information search and analysis is performed based on the factors of mission, enemy, terrain and weather, troops and resources available, and time and space restrictions (METT-T). The engineer or staff officer conducting the search and analysis applies the factors of METT-T to mobility tasks and requirements.

Mission. The staff mobility planner first considers the mission and guidance given by the commander. The planner examines what mobility missions have been tasked and how these supplement the requirements for countermobility and survivability, The planner deliberately considers both stated and implied mobility requirements.

Enemy. An analysis of the enemy's countermobility capability is a critical step in planning and organizing mobility support assets. The mobility planner must determine the Threat's ability to emplace mines and obstacles, as well as other capabilities. Can the enemy overwatch obstacles by direct or indirect weapons fire? Is the enemy capable of using nuclear munitions or chemical agents in the area of operations?

Terrain and weather. The mobility planner must have complete knowledge of the types and locations of key terrain, soil types, and the probable weather conditions in the area of operations. With this information, the planner can indicate where mobility support is a crucial factor in mission success. Information on terrain adjacent to the tactical boundaries should also be included to isolate routes and terrain that might affect friendly freedom of movement.

Available troops and resources. While planning mobility activities, the staff officer should identify the equipment, personnel, and materiel available for the mission. These resources come from three sources, the maneuver unit troops and mobility support equipment of those organizations, the engineer elements supporting the maneuver force, and indigenous (host nation/local area) support such as engineer equipment, construction materials, or supplies.

Time and space restrictions. Within the framework of an operation, certain limitations are imposed by the commander. These restrictions are the time available to plan and execute the mission and the area on the battlefield in which the force is controlled.

SOURCES OF INFORMATION

Most of the information necessary to analyze an operation in terms of mobility is available through staff coordination. The what, when, and why aspects normally remain constant. The where and how aspects vary, depending on the assessment of friendly forces and the analysis of enemy forces, terrain, and weather. The planner first considers the type, size, and equipment of the force being used in the operation. Specific mobility characteristics of the unit will affect all further analysis.

Role of the intelligence officer. Most Threat intelligence data and terrain information is obtained through the staff intelligence officer. The battalion or brigade intelligence officer (S2) relies on several sources for the collection and update of this information. These sources include reconnaissance, intelligence, and weather experts at and above division level. Staff engineers or mobility planners also use the division intelligence system. This system provides timely information such as Threat order of battle and observed countermobility activities. Also, maneuver units obtain terrain and intelligence data by using their organic reconnaissance elements.

Standard military map. The collection of terrain information begins with the standard military map with a scale of 1:50,000. The commander and staff conduct map studies using the military aspects of terrain as they relate to mobility. The five factors (known as OCOKA) are—

- Observation and fields of fire.
- Concealment and cover.
- Obstacles.
- Key terrain.
- Avenues of approach.

The standard military map, however, will not provide all of the detailed information required for a thorough mobility assessment. For instance, the standard map does not show the following terrain characteristics:

- Tree spacing and diameter that will impede the movement of wheeled and tracked vehicles.
- Canopy closure and density of vegetation that will provide concealment or cover.
- Height of vegetation and built-up areas that will obscure horizontal line of sight.
- Soil characteristics that will limit number of vehicle passes.
- Slope and other surface conditions that make cross-country movement difficult.
- Stream width, depth, and velocity and bank depth for determination of possible crossing points.

- Effects of climatic conditions and seasonal changes as they relate to mobility.

OTHER RESOURCES

In order to supplement the military map analysis, the planner makes use of other resources and documents. These include a current description of the area of operations, intelligence appraisals, results of actual ground reconnaissance, current photographic products, and special terrain analysis studies and special maps such as road and bridge maps and cross-country movement maps. Specifically, terrain analysis products are produced by terrain analysis detachments at division, corps and echelons above corps (EAC). These detachments and teams provide direct support to divisions and corps and general support to a combat theater. Each detachment or team is equipped with a tactical terrain analysis data base. This data base is composed of information on existing terrain of tactical military significance within a given area. The information is placed on transparent overlays provided to appropriate unit commanders and staffs which highlight different terrain mobility factors. The individual factor overlays follow.

Transportation factor overlay. It depicts selected roads, bridges, tunnels, ferries, railroads, and airfields over which troops and supplies can move during a military operation. The data includes route classification, widths, slopes, dimensions, areas under construction, fords, bypasses, and bridge tables.

Obstacles factor overlay. It depicts natural or artificial terrain features which hinder military movement. Obstacles may be escarpments, embankments, hydrologic features, or depressions.

Water resources factor overlay. It is found only in 1:250,000-scale products. It shows the water resources (wells, springs, groundwater) which may be found in the area. This overlay is made only for arid or desert areas of the world.

Surface configuration factor overlay. It depicts categories of slope in combinations from 0-45 percent and open water.

Vegetation factor overlay. It depicts all the information on vegetation of an area. This includes type of vegetation canopy closure (percentage of ground covered by the tree crowns), undergrowth (vegetation between the canopy and above the ground), vegetation height, vegetation roughness factor (an estimate of the degree of degradation of vehicle speed through a type of vegetation on level ground), and stem diameter/tree spacing/vegetation roughness table.

Surface materials factor overlay. Surface materials are limited to those which are significant to military operations. Shown on the overlay are soils (according to the Unified Soils Classification System), depth of surface material, soil moisture, potential landslide areas, and the surface roughness factors (similar to the vegetation roughness factor, but for a vehicle traveling over level ground and influenced by ground conditions).

Surface drainage factor overlay. This overlay depicts shorelines, offshore islands, large rivers, and lakes. Information on width, depth, velocity, bank heights and slopes, bottom materials, dams, fords, and locks is given for each feature. An example of a factor overlay is shown in figure 3-2 on page 3-6. Several factor overlays may be combined in one transparent overlay, as shown in figure 3-3 on page 3-6. Vegetation patterns shown in this figure may favor certain tactical movement areas because of natural concealment available.

WEATHER INFORMATION

The impact of seasonal conditions and current weather is a major consideration in the collection of mobility data. The interaction of terrain and weather can affect an operation’s outcome. Changes in weather tend to alter the condition of terrain surfaces. This alteration is not always predictable. The same weather condition may produce different effects depending on the type of terrain. For

FIGURE 3-2. INDIVIDUAL FACTOR OVERLAY

FIGURE 3-3. COMBINED OBSTACLES FACTOR OVERLAY

Note: The combined obstacles overlay integrates all obstacles to vehicular movement into one display. Obstacles are crossed-hatched or shaded. Blank areas on the overlay depict where friendly or enemy forces can move unimpeded.

example, rainfall on a clay road makes it less trafficable, while a sandy road may become firmer. Conversely, terrain relief can affect weather conditions such as rainfall, snow depth, wind velocity, and humidity. Moist air moving rapidly up the slopes of a mountain, hill, or ridge may cause fog, mist, or low-lying clouds over elevated terrain, while the adjacent valleys remain clear. Rain at low elevations may be snow at higher elevations.

Trafficability tables. A "hasty" means of evaluating the trafficability of equipment and vehicles has been developed (table 3-1 and table 3-2 on page 3-8). This information is based on comparison of vehicle reactions to specific soil conditions and weather. However, this method only provides data on the vehicles and soil conditions shown. Conditions other than those in the tables must be evaluated using the equipment and techniques in TM 5-330 or TM 5-530. The tables were designed specifically to provide engineers and maneuver units with a rapid means

TABLE 3-1. WHEELED VEHICLE TRAFFICABILITY

Season	Topo Position	Moisture Condition	Soil Group	Vehicles by VCI Category						
					M151 FAV M274 M656 M561 M551 HMMWV	BRDM2 GAZ66 M35 M123	KRAZ 255B URAL 375D ZIL 131 ZIL 132 GAZ 69 ZIL 135 LARC5 M813 M37	M51 LAV	GOER5	MAB
				1	2	3	4	5	6	7
Dry	High	All	All	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)
	Low	Low	All	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)
		High	A	3(1)	3(0)	2(0)	2(0)	1(0)	0(0)	0(0)
			B	3(3)	3(3)	3(2)	3(1)	3(0)	3(0)	3(0)
			C	3(3)	3(2)	3(0)	3(0)	3(0)	2(0)	2(0)
			D	2(0)	2(0)	1(0)	0(0)	0(0)	0(0)	0(0)
Wet	High	All	A	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)
			B	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)
			C	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(3)
			D	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(3)
	Low	Low	A	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)
			B	3(3)	3(3)	3(3)	3(3)	3(3)	3(3)	3(3)
			C	4(4)	4(4)	4(4)	4(4)	4(3)	4(2)	4(1)
			D	3(3)	3(3)	3(3)	3(2)	3(2)	3(0)	3(0)
		High	A	3(1)	3(0)	2(0)	2(0)	1(0)	0(0)	0(0)
			B	3(3)	3(3)	3(2)	3(1)	3(0)	3(0)	3(0)
			C	3(3)	3(2)	3(0)	3(0)	3(0)	2(0)	2(0)
			D	2(0)	2(0)	1(0)	0(0)	0(0)	0(0)	0(0)

One-pass trafficability
(50-pass in parentheses):
0 = NO GO
1 = marginal
2 = OK
3 = good
4 = very good

Soil group:
A = sands and gravels.
B = heavy clays - sticky, moldable, much like modeling clay.
C = clays with sand and/or gravel, and lean clays - difficult to mold.
D = soils with a high percentage of silts and/or very fine sand, also organic soils - musty, offensive odor.
(See TM 5-330 for more detailed definitions.)

of evaluating trafficability in the conditions shown.

Sources of data. Since weather will affect the mobility aspects of each course of action, the planner collects weather data from traditional weather products and weather overlays. Both types of weather products are available through the staff intelligence officer. Traditional weather products include light data charts, 12-, 24-, 36-, and 72-hour forecasts, long-range forecasts, and climatological studies. Intelligence weather overlays include those showing ground fog, cloud coverage, rain (and storm) effects, wind direction, ice thickness, and snow depth. The unpredictability of weather conditions must be considered when collecting weather data. This is particularly true when the operation is planned in advance. Updated weather reports should be regularly requested and mobility planning revised as a result.

TABLE 3-2. TRACKED VEHICLE TRAFFICABILITY

Season	Topo Position	Moisture Condition	Soil Group	Vehicles by VCI Category						
				M116 M571 M729	M88 M3 M2 M551 D7 ACE M113 M578 M60 ZSU23-6 PT76	AVLB M48 M1 MTU20 BMP T62 T72	CEV			
				1	2	3	4	5	6	7
Dry	High	All	All	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)
	Low	Low	All	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)
		High	A	3(2)	3(0)	3(0)	2(0)	1(0)	0(0)	0(0)
			B	3(3)	3(3)	3(3)	3(2)	3(0)	3(0)	3(0)
			C	3(3)	3(2)	3(0)	3(0)	3(0)	2(0)	2(0)
			D	2(0)	2(0)	1(0)	0(0)	0(0)	0(0)	0(0)
Wet	High	All	A	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)
			B	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)
			C	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(3)
			D	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(3)
	Low	Low	A	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)	4(4)
			B	4(4)	4(4)	4(4)	4(4)	4(3)	4(3)	4(3)
			C	4(4)	4(4)	4(4)	4(3)	4(3)	4(3)	4(2)
			D	4(3)	4(3)	3(3)	3(3)	3(2)	3(0)	3(0)
		High	A	3(2)	3(0)	3(0)	2(0)	1(0)	0(0)	0(0)
			B	3(3)	3(3)	3(3)	3(2)	3(0)	3(0)	3(0)
			C	3(3)	3(2)	3(0)	3(0)	3(0)	2(0)	2(0)
			D	2(0)	2(0)	1(0)	0(0)	0(0)	0(0)	0(0)

One-pass trafficability
(50-pass in parentheses): 0 = NO GO
1 = marginal
2 = OK
3 = good
4 = very good

Soil group: A = sands and gravels.
B = heavy clays - sticky, moldable, much like modeling clay.
C = clays with sand and/or gravel, and lean clays - difficult to mold.
D = soils with a high percentage of silts and/or very fine sand, also organic soils - musty, offensive odor.
(See TM 5-330 for more detailed definitions.)

EVALUATION AND ESTIMATES

COMPARISON OF OPTIONS

Once the collection of mobility information is complete, the planner begins to develop courses of action. The planner applies analysis of the data to specific mobility considerations. The planner must confirm where the forces are going (by identifying the objectives), where they cannot move (by identifying hindering terrain), and where they can move (by confirming the avenues of approach). The next step is to outline the effects and potential effects of the terrain and weather (by analyzing each avenue of approach). The planner then compares and analyzes all possible courses of action. The last step is to develop task organizations and mobility work priorities for each course of action. The planner then recommends a mobility option to the maneuver commander based on thorough analysis and military judgment, and on the commander's guidance.

OBJECTIVES

The objectives for an operation are usually provided in the commander's restated mission and planning guidance (figure 3-1 on page 3-2). Defensive and retrograde operations may include terrain which must be retained as the operational objective. The mobility planner studies the mission, essential tasks, and terrain to grasp the intent of the commander and confirm the objective, Objectives determine where the force must move and designate the location of key terrain. The planner must always keep in mind the purpose behind the objectives.

HINDERING TERRAIN

The most useful products for the identification of hindering terrain are the cross-country movement (CCM) maps (overlays) or the combined obstacles overlay made by terrain teams or detachments. These maps or overlays graphically separate terrain into different degrees of cross-country movement (CCM) for armored or mechanized forces. CCM predictions are tailored to friendly or Threat vehicles. An example of mobility categories for planning requirements is shown in table 3-3. The planner may use these categories depending on the detail required. As a minimum, the locations of GO/NO GO terrain are considered.

TABLE 3-3. MOBILITY CATEGORIES

Category	Estimated Maximum Speed	Maneuverability
1	40 km/hr	GO
2	32 to 40 km/hr	GO
3	16 to 32 km/hr	SLOW GO
4	8 to 16 km/hr	SLOW GO
5	Less than 8 km/hr	NO GO
6	Passage blocked	NO GO
7	Built-up area	NO GO

Shading in difficult terrain. Where time is limited or factual terrain data is unavailable, the planner may conduct an analysis by shading in hindering terrain on the military map. This is done to identify terrain that is impassable or will severely slow down cross-country movement. The planner would shade in such features as steep slopes, heavily wooded areas, swampy or unstable soils, river/stream confluences, other water obstacles, and built-up areas. This technique is shown in figure 3-4 on page 3-10.

Modifying terrain data. Terrain data should be modified by the planner using tactical judgment. Combined obstacle products and the shading technique tend to overlook the road and trail network. If a hindering area has two or more trafficable routes per grid square for vehicle movement, the area should not be considered hindering. Engineer terrain studies do not count urban areas of less than 0.25 square kilometers. Urban areas must be analyzed in relation to obstacles and other hindering terrain. Small towns of less than about 1 square kilometer may not be considered hindering if they can be easily bypassed or they do not reinforce other hindering terrain.

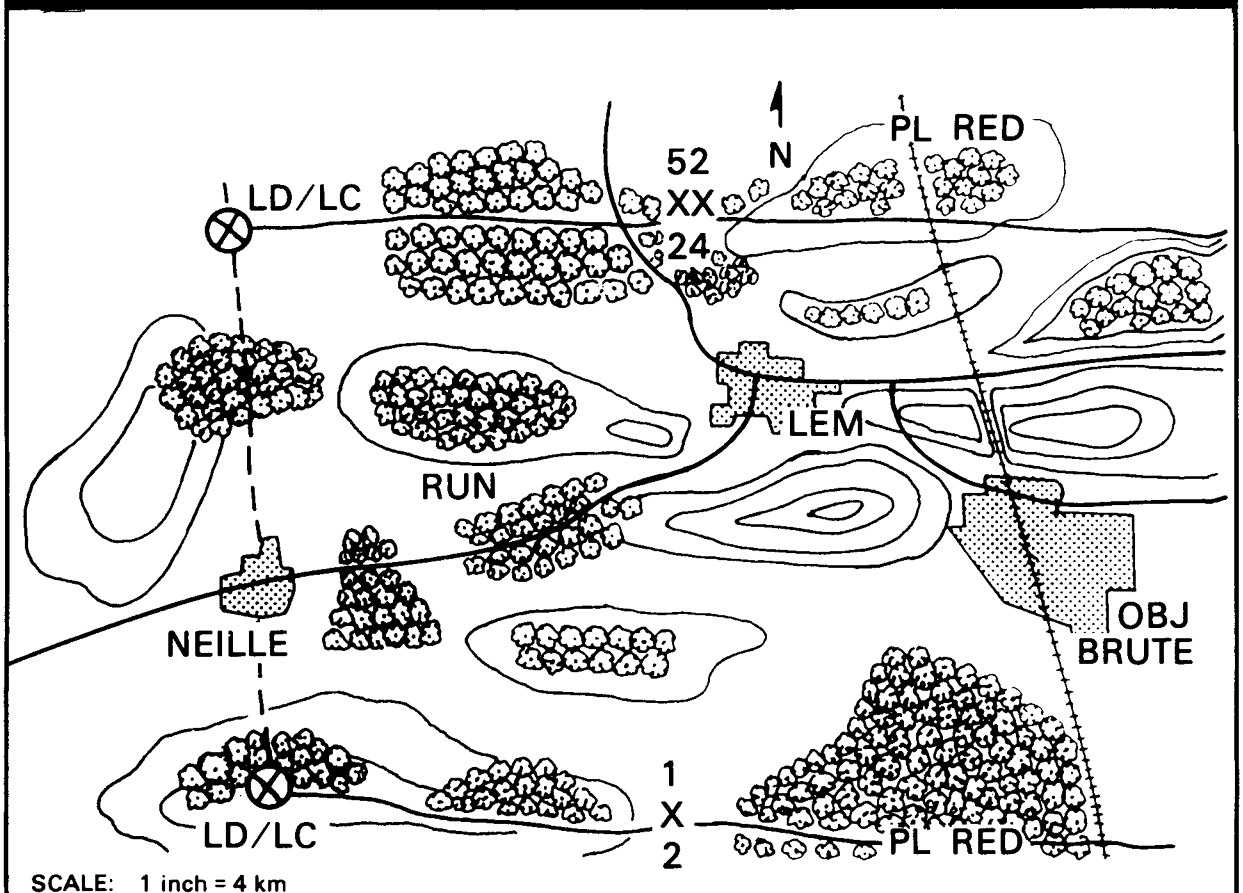
FRIENDLY AVENUES OF APPROACH AND ROUTES FOR MOVEMENT

The identification of hindering terrain will isolate routes where forces can move and maneuver. These areas are the mobility corridors. The planner also identifies cross-over corridors for lateral movement. Compared with the commander's guidance, the planner confirms the avenues of approach, if stipulated, in the courses of action. The planner selects avenues of approach based on the number of mobility corridors and the likely composition and possible formation of the maneuver force. The recommended frontages for an avenue of approach at each echelon of maneuver unit are shown in table 3-4. The mobility planner takes into account the road and trail network that would be used for combat support elements and the movement of follow-on maneuver forces. Avenues of approach include such existing transportation networks. Figure 3-5 shows how two

TABLE 3-4. WIDTHS FOR AVENUES OF APPROACH

UNIT	WIDTH (for penetration)
Division	6 to 10 kilometers
Brigade	3 to 6 kilometers
Battalion	1 kilometer
Company	500 meters

FIGURE 3-4. HINDERING TERRAIN



avenues have been identified on the situational map used in figure 3-4.

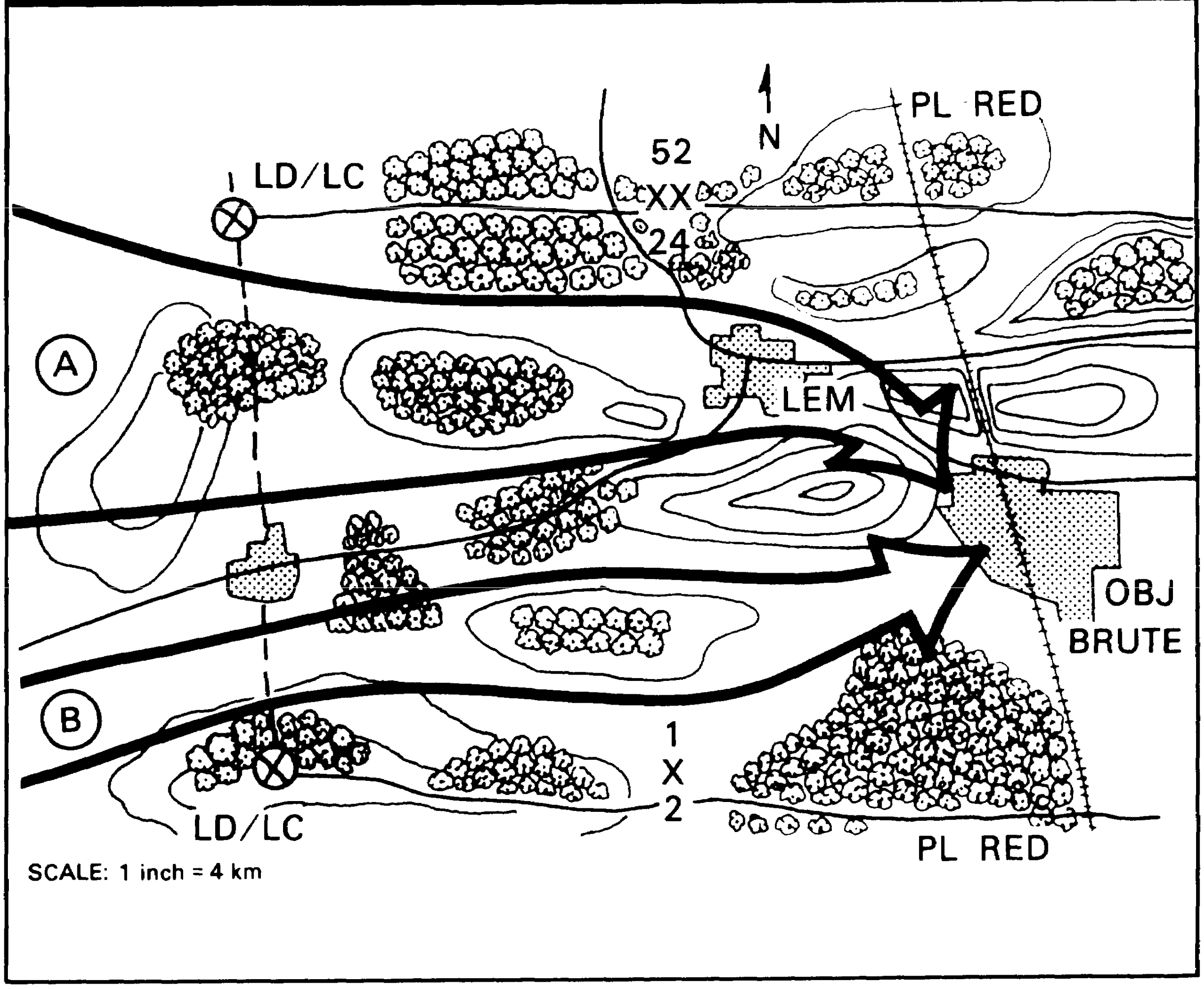
ANALYSIS

Each avenue of approach confirmed by the mobility planner should be analyzed in detail to determine the tactical merits and potential problems of each avenue. All the collected terrain and weather information should be used for this analysis and should follow OCOKA sequence. The analysis should include the following considerations, from both the friendly and enemy points of view.

Observation and fields of fire. The ability of friendly forces to overwatch and fire along the avenue is determined, Also, the enemy's ability to observe and fire on the avenue from various positions is considered. The friendly capability to overwatch the avenue with direct fire weapons from certain positions can be defined by drawing fans of weapons coverage for the different weapons systems.

Cover and concealment. Concealment is protection from observation while cover provides protection from weapons' effects. Having considered those areas over which the enemy has observation and fire, the planner studies those areas where friendly

FIGURE 3-5. LOCATION OF AVENUES OF APPROACH



forces can maneuver or move with concealment. Such areas include woods and low ground. Areas that provide concealment and cover for the enemy are considered, particularly those providing concealed counterattack routes. Often, the planner will consider concealment and cover in conjunction with observation and fire.

Areas providing concealed counterattack routes are especially considered.

Obstacles. The planner considers both existing and reinforcing obstacles. Areas where existing obstacles can be easily reinforced are noted. The mobility corridors coming into the avenue from the flanks could be used by the enemy for the counterattack. They are therefore good locations for obstacles to protect friendly forces. These corridors can be covered with fires, smoke, obstacles (planned or emplaced), forces in blocking positions, or a combination of these measures. An example is shown in figure 3-6.

Key terrain. Key terrain is an area offering a considerable advantage to either side occupying it. The mobility planner considers key terrain in view of the objectives and avenues of approach determined earlier. The planner is looking for terrain features that, if occupied by the enemy, would dominate the avenues of approach, intermediate objectives, or final objectives. An example is shown in figure 3-7.

Adequacy of maneuver space. The planner has already identified mobility corridors and from these decided on the avenues of approach. The planner knows where forces can move down the avenues and must consider how to overcome potential enemy observation and fire from key terrain. This analysis includes how to use, bypass, or capture key terrain, and how much free maneuver is available on the avenue. This will determine how restrictive the avenue is and where chokepoints are located.

Ease of movement. This factor is primarily one of time and space. The planner considers the overall trafficability of the avenue, its length compared to other avenues, and the directness of the approach as a means of

FIGURE 3-6. ENEMY FLANK AVENUES

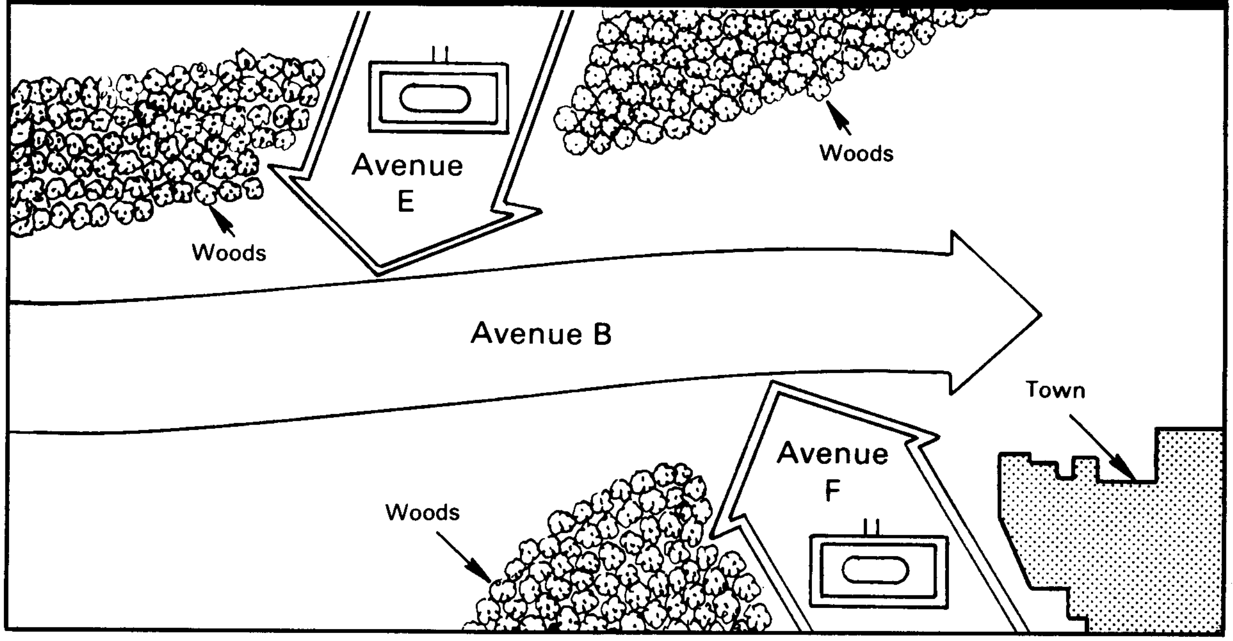
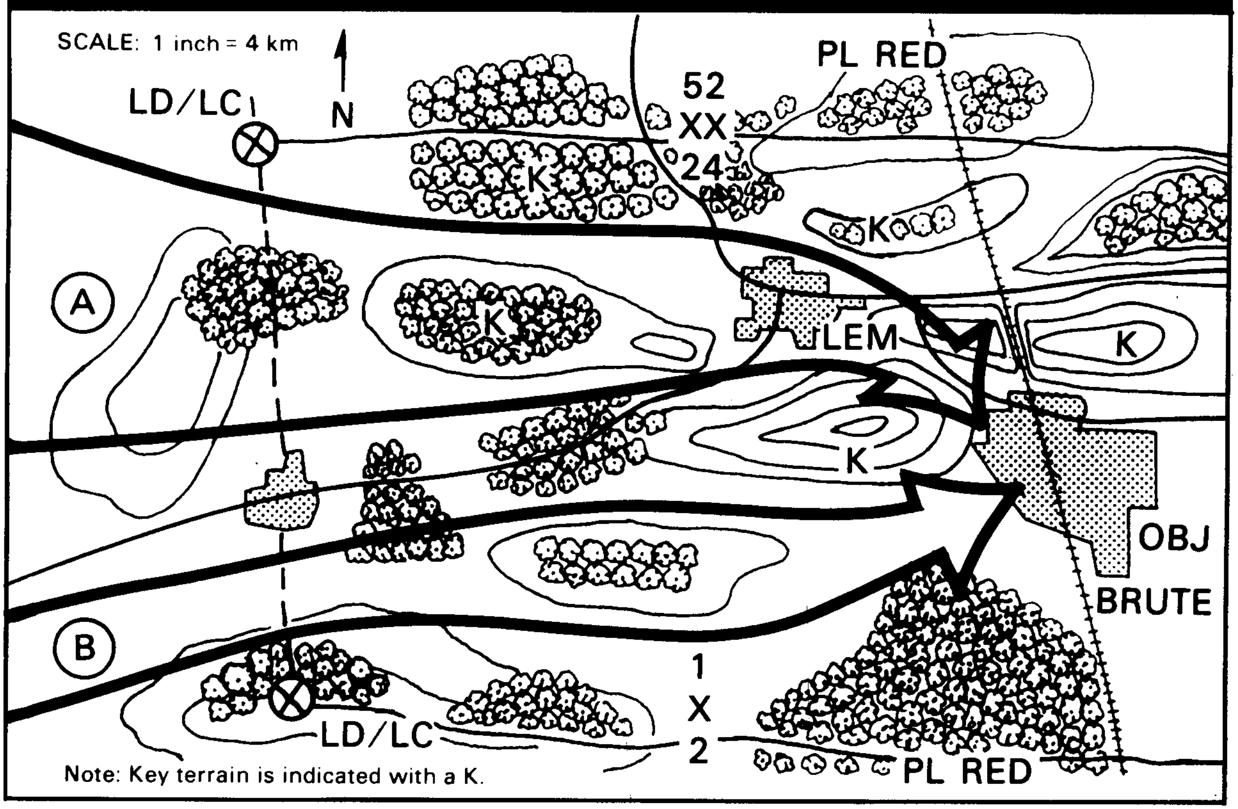


FIGURE 3-7. ANALYSIS OF KEY TERRAIN



gaining the objective. This should lead to an estimate of travel time along the avenue. An estimate of the fighting time will depend on the degree of enemy resistance, the possible firepower superiority of the attacker, and the type of battlefield terrain.

COMPARISON

In order to rate the merits of each course of action, the planner orders the avenues based solely on terrain considerations. To do this, a matrix is often used. By assigning a relative value to each factor, the mobility planner attempts to identify the best avenue of approach. An example of a matrix is shown in table 3-5. The desirability of using each avenue is now reevaluated in light of likely weather conditions. If a change in weather is expected, the planner tries to predict its impact on each avenue of approach. Major river valleys are high-speed approaches most likely to be affected by weather conditions. Rain and boggy conditions can severely limit mobility along these low-lying routes. Also,

TABLE 3-5. MOBILITY ANALYSIS MATRIX (TERRAIN)

CONSIDERATION	AVENUE OF APPROACH A	AVENUE OF APPROACH B	REMARKS
As support objective	3	5	"B" supports current disposition and be prepared order.
Observation and fire	2	4	
Cover and concealment	4	4	"B" and "A" masked from objective and key observation points.
Obstacles	2	4	"A" has two chokepoints; "B" has one.
Uses key terrain	1	2	Flanking terrain "A" has 5; "B" has 4.
Adequate maneuver space	2	4	"B" is less restrictive: battalion plus space for maneuver.
Ease of movement	3	5	"B" has 2 LOCs and 3 natural LZ/DZs.
Total—	17	28	Avenue "B" has most merits-weather not considered.

Key:
Provides major advantage = 5
Provides slight advantage = 4
Equal advantage to both forces = 3
Provides enemy slight advantage = 2
Provides enemy major advantage = 1

fog in low-lying areas or low clouds can conceal movement and limit visibility, thereby limiting close air support, attack helicopter, airmobile, and other air operations of both friendly and enemy aircraft. A weather analysis matrix, as shown in table 3-6, can graphically portray the effects of inclement weather.

TASK ORGANIZATION

The engineer or mobility planner must organize mobility assets to support the maneuver commander's plan. Command or support relationships between engineers and maneuver units must be such that they insure supporting engineers enhance mobility mission accomplishment. Table 3-7 on page 3-16 lists these relationships and how they affect the engineer planner and leader.

PRIORITY OF WORK

As mentioned earlier, priorities for engineer support are established between mobility, countermobility, and survivability efforts.

TABLE 3-6. MOBILITY ANALYSIS MATRIX (WEATHER)

CONSIDERATION	AVENUE OF APPROACH A	AVENUE OF APPROACH B	REMARKS
Temperature			Impacts on ground moisture content and trafficability.
Humidity			Density/altitude affect aircraft performance.
Wind			Affects aviation, smoke, and NBC operations.
Visibility			Impacts on concealment, observation, fire, and aviation restrictions.
Light data (day/night visibility)			Impacts on terrain and maneuver and aviation restrictions.
Rain			Affects soil trafficability and drainage features along avenues and is an aviation restriction.
Snow/ice cover			Affects trafficability, observation, concealment, and effectiveness of obstacles.

Note: Weather forecast for operation is applied to each avenue of approach in the matrix.

Key:

Provides major advantage	= 5
Provides slight advantage	= 4
Equal advantage to both forces	= 3
Provides enemy slight advantage	= 2
Provides enemy major advantage	= 1

TABLE 3-7. COMMAND AND SUPPORT RELATIONSHIPS

ELEMENT	SUPPORT RELATIONSHIPS		COMMAND RELATIONSHIPS	
An engineer element with a relationship of—	Direct support (DS)	General support (GS)	OPCON	Attached/ assigned
Is commanded by—	Parent unit [1]	Parent unit [1]	Supported unit	Supported unit commander
Maintains liaison and communication with—	Supported and parent units	Supported and parent units	Supported and parent units	Supported unit
May be task organized by—	Parent unit	Parent unit	Supported unit	Supported unit commander
Can be— [2]	Dedicated support to a particular unit. May be given task/ area assignment.	Used only to support the parent force as a whole. May be given an area/ task assignment.	Placed OPCON to other engr/ maneuver units, or made DS to bdes or task forces.	Further attached, OPCON, or DS to bdes or task forces, or retained GS.
Responds to support request from—	Supported unit	Parent unit	Supported unit	Supported unit
Work priority established by—	Supported unit	Supported unit	Supported unit	Supported unit
Spare work effort available to—	Parent unit	Parent unit	Supported unit	Supported unit
Request for additional support forwarded through—	Parent unit	Parent unit	Supported unit	Supported unit
Receives logistical support from— [3]	Parent unit	Parent unit	Parent unit	Supported unit

Notes:

1. It is possible that units will receive additional support without a command relationship, the support relationship of DS to the division.
2. Regardless of type of relationship, activities of engineer units working in an area are under the staff supervision of the engineer.
3. The supported unit, regardless of command/support relationship, is to furnish engineer materials to support engineer operations.

The amount of effort and resources applied to each function are constantly changing with the tactical situation. For example, the mobility requirements within an offensive operation might receive the commander's first priority for engineer work. However, these tasks may only require using 30 percent of the resources while countermobility tasks (flank protection or mining of enemy counterattack routes) demand 60 percent and survivability 10 percent of available engineer assets. The establishment of engineer work priorities is the maneuver commander's decision. This decision includes establishing priority for tasks within the three functions. Using the analysis of each avenue of approach, the intelligence assessment of enemy countermobility activities, and the knowledge of obstacles emplaced by friendly forces, the commander can set individual priorities for mobility work. Generally, these priorities of work are recommended by the mobility planner or staff engineer.

ENGINEER STAFF ESTIMATE

The means through which collected data and recommendations are presented by the engineer to the commander or supported unit is the engineer staff estimate. It enables the engineer to quickly, thoroughly, and logically present an analysis. The engineer estimate should include a recommendation for task organization and priorities of efforts between mobility, countermobility, survivability, and general engineering tasks. It should state the recommendations for mobility support based on an analysis of existing and reinforcing obstacles to be overcome and the amount of movement support (roads, trails, and forward aviation/combat engineering) required. The engineer compares this data and recommends the most favorable course of action. The following is the format used for the engineer staff estimate:

- Mission.
- Situation and courses of action.
  - METT-T analysis.
  - Tactical courses of action given by commander.
- Analysis of opposing courses of action.
  - Enemy Threat to each course of action.
  - Estimation of outcome of all courses of action.
- Determination of successful course of action.
- Recommendation of course of action.
  - Task organization.
  - Command or support relationships.
  - Priority of effort.

EXECUTION

ORDERS

Operations orders are issued by a commander or leader following the estimating and planning process. Written orders should follow the standard five-paragraph operations order format. Mobility tasks may be assigned subsections for specific units in the operations order for all units, including both engineers and nonengineers. The order will describe the command or support relationship for engineers that the mission requires and any special operations or areas of responsibility. Priorities will be specifically defined in the coordination portion of the operations order.

RESPONSIBILITIES

The responsibility of leaders in the planning and conduct of mobility tasks is divided three ways, the maneuver commander's responsibilities, the staff engineer's responsibilities, and the engineer commander's responsibilities.

Maneuver commander. The maneuver

commander is in charge of organization, planning, coordination, and effective use of engineer resources in performing the mobility function. The maneuver commander relies on the unit engineer or engineer staff officer for analyses and recommendations for use of mobility assets. Also, the maneuver commander implements decisions through the unit engineer by providing guidance, priorities, and tactical constraints, such as time and space restrictions.

Staff engineer. The staff engineer, in addition to fulfilling advisory responsibilities to the maneuver commander, has the following specific responsibilities:

- Develops mobility plans as part of the operations plan.
- Monitors execution of mobility tasks by engineer units.
- Coordinates execution of mobility tasks with operational maneuver and movement.
- Insures timely reports concerning mobility tasks are forwarded to the G3/S3.

Engineer commander. Using a knowledge of mobility support capabilities, the engineer commander advises the maneuver commander throughout an operation. The engineer commander insures that the plans and tasks developed for an operation are executed.

STAFF COORDINATION

As a special member of the commander's staff, the engineer interacts with other staff personnel. The object of staff coordination is to provide the commander, and the forces under the commander's control, with up-to-date plans and orders. This is done by integrating mobility considerations with plans and actions of the other staff members. Staff responsibilities concerning mobility plans and execution are as follows:

The staff engineer works closely with the G3/S3 to develop the staff estimate of the situation.

The G2/S2 uses all available intelligence sources to detect, locate, or isolate likely areas of emplaced obstacles, and receives minefield/obstacle reports and records from the G3/S3, disseminates the information, and forwards records to the senior theater Army engineer. The G2/S2 is also responsible for preparing and disseminating the intelligence preparation of the battlefield (IPB).

The logistics/supply officer (G4/S4) works closely with the staff engineer and the division ammunition officer (DAO) to insure that breaching munitions are available in the types and quantities needed. These staff agencies, the G4/S4, engineer, and DAO, gather data for the required supply rate (RSR) and assist in establishing the controlled supply rate (CSR), The G4/S4 is responsible for coordinating transportation and equipment which provides engineer supplies and materiel in accordance with the commander's priorities for engineer support.

The civil affairs officer (G5/S5) is responsible for the coordination necessary to repair damaged lines of communication or utilities and return them to use.

MOBILITY DRILLS

A unit's immediate response to an obstacle or mined area may mean the difference between quick passage and a critical loss of time, equipment, and personnel. Tactical proficiency is built upon training by the combined arms team. This training should focus on the specific tasks needed when encountering an obstacle. Units able to quickly implement well-rehearsed battle drills have the best chance to bypass, breach, or cross an obstacle in stride. Both commanders and staffs have the responsibility to see that mobility drills are incorporated in their organizational training.

CHAPTER 4

Countermine Tasks

HISTORY OF MINES

CLASSIFICATION

Obstacles are divided into two major classifications, existing and reinforcing. Within the category of reinforcing obstacles, there is a distinction between obstacles and mines. Mines are explosive devices designed to damage soldiers or vehicles. When actuated, as a result of other than a self-destruct feature, mines kill, damage, or destroy, thereby delaying or disrupting planned movement. This lethal capability separates mines from other obstacles that restrict movement by their existence or by being militarily reinforced.

Although the fundamentals of the mobility scheme are similar for countermine and counterobstacle tasks, the techniques for overcoming mines and minefield take into account their unique destructiveness.

EARLY USES

The use of mines to disrupt and delay highly mobile and mechanized military maneuvers began in World War II. Beginning with the campaigns of North Africa and spreading to all theaters of operation, enemy mines stopped well-planned armored and mechanized attacks by friendly forces. At the battle of Kursk in July 1943, the Soviet Army successfully used strongpoints reinforced by minefield to slow the attacking German Army and channelize it into kill zones. Expedient mines, fuzing devices, and other mine warfare techniques were used against US forces in Korea and Vietnam to harass and create confusion. They also took a heavy toll in equipment and unprepared soldiers. As a result, US forces became extremely mine-conscious.

LESSONS FROM HISTORY

The more significant lessons from military history apply to the AirLand battlefield today and include the following:

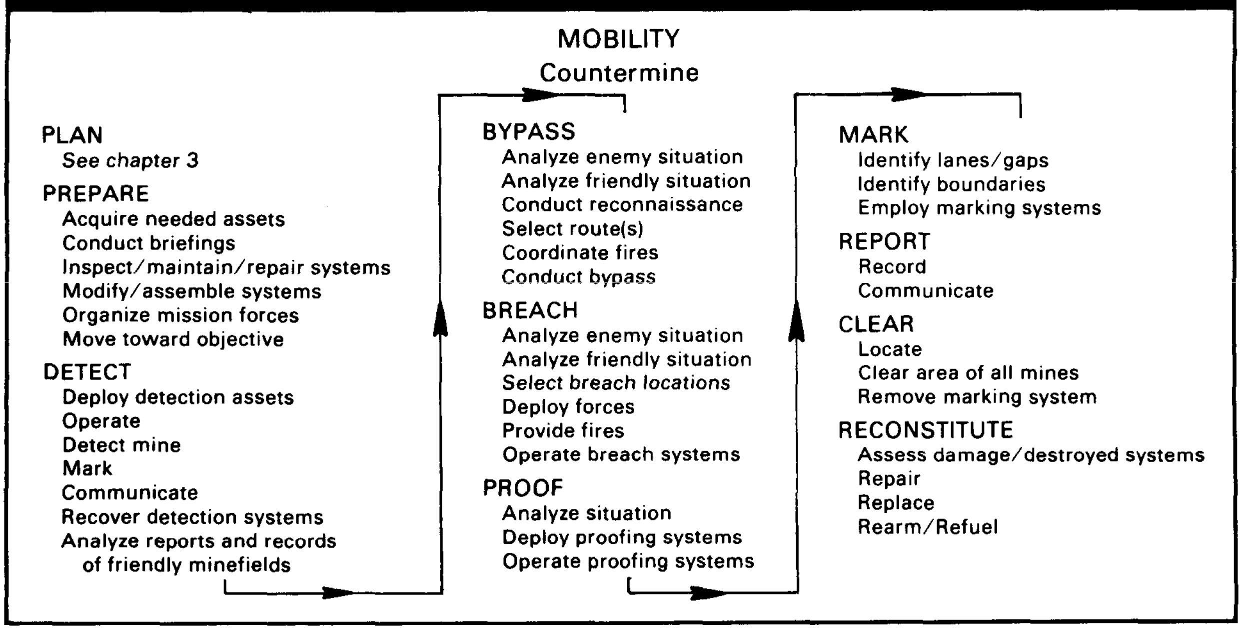
- Mines can decisively influence the outcome of battles.
- Most enemy minefield are covered by direct and indirect fire.
- Minefields are usually placed in conjunction with other obstacles and barriers.
- Friendly mines, as well as enemy mines, are a threat to force mobility. Current mines do not distinguish between friend and foe.

From these principles, it can be seen that mines are a significant combat power multiplier. Their use by Threat force on the battlefield requires immediate counteractions to restore freedom of movement for all US forces.

COUNTERMINE ACTIVITIES

Figure 4-1 shows the major subtasks involved in the conduct of countermine activities. During the conduct of a given countermine mission, however, not all of the functional subtasks may be required. For example, in the bypass analysis, if the bypass is tactically sound, all further tasks may be unnecessary. Similarly, the steps under "PLAN" can be adopted from tasks initiated for counter-obstacle and gap-crossing activities. The fundamentals of these are described in chapter 3. The following sections provide specific guidance and techniques applicable to countermine activities.

FIGURE 4-1. POSSIBLE COUNTERMINE SUBTASKS



PLANS AND PREPARATIONS

IMPORTANCE OF PLANNING

Countermine operations are an important part of combined arms planning. Advance planning will enable the force to detect and neutralize the effects of mined areas. The commander's effective preparation and use of countermine resources may determine force mobility and, ultimately, success or failure. This section supplements the discussion of mobility planning in chapter 3.

All mines affect maneuver. The intelligence officer and engineer must include both friendly and enemy mined areas in their analysis. In coordination with the operations officer, the engineer develops plans for bypassing or breaching mined areas as an integrated part of the maneuver plan. Where mines are suspected, countermine assets should be placed well forward in advancing columns. Maneuvering forces must have the capability to rapidly breach mined areas under fire. Careful planning should provide for maximum use of all countermine assets.

BREACHING PREPARATIONS

Several prerequisites for the planning of successful breaching tasks are—

- Adequate and timely reconnaissance.
- Sufficient intelligence, particularly engineer and tactical intelligence.
- Necessary breaching equipment.
- Deception and surprise.
- Security.
- Good communications and flexible command and control.

Lanes. The number and types of lanes planned for minefield breaching depend on the size of the breaching force and the equipment available. As the far side of the minefield is secured, initial foot lanes, if established, are widened to accommodate one-way vehicle traffic. Each maneuver company requires a minimum of one vehicular lane for passage. Approaches, lanes, and exits must be marked, and provisions made for minefield traffic control.

Concealment. Planning for breaching operations should include steps for concealing the breaching effort. Minefield breaches should be conducted at night whenever possible. Night vision equipment and night operation capability should be exploited.

Fire support. Fire support protects the breaching force in three possible ways. These fires neutralize enemy weapons systems which cover the minefield (both direct and indirect), provide smoke to prevent enemy observation of the breach, and can support the force as it moves through the minefield. Fire support must be capable of rapid adjustment and massing. It is used to exploit the developing success of a breach. The commander must identify the indirect fire assets available and set priorities for suppression, smoke, and counterbattery fire. In addition to supporting mortars and field artillery, the commander plans the employment of aviation assets to support the scheme of maneuver.

DETECTION

METHODS

Mine detection is performed by all soldiers in all phases of combat. Methods include detection by intelligence sources, anticipation of likely mined areas by the mobility planner, and mine searching. Searching is a deliberate set of actions taken by single soldiers, teams, or units to locate mines or minefield. The types and characteristics of mine detection methods follow.

Intelligence reports. This method of detection relies on available sources such as staff-produced intelligence, reconnaissance reports, remote sensors, aerial photography analysis, side-looking airborne radar (SLAR), and the questioning of prisoners of war (POWs) and local noncombatants. It provides both general and specific indications of minefield locations.

Mobility plan. The mobility plan provides a detailed analysis of the terrain and weather. It also identifies likely areas for enemy minefields as well as trafficable routes and transportation networks that could be easily constricted or denied through the use of mines. All of this information is included in the planner's estimates, plans, and orders.

Visual detection. This method requires visual inspection of the terrain for physical signs of mine emplacement. These signs include disturbed earth, unusual or out-of-place features, surface-laid mines, and trip wires. This method does not detect well-concealed or camouflaged mines.

Physical detection. There are two categories of physical detection, detonation and probing. Discovery by detonation occurs when a vehicle, soldier, or countermine system physically encounters a mine. Detection in this manner does not indicate the boundary of a mined area. After detonation, the commander may have rollers/plows attempt to locate the minefield boundaries. Probing is used to detect the exact location of buried mines. It is done by pushing a sharp object into the ground at an angle to detect solid objects. Probing is slow, careful work, and is very personnel-intensive. It may be used in clearing, but generally is too inefficient for hasty breaches as it exposes soldiers to enemy fire for long periods of time.

Electronic detection. Electronic detectors are effective when used with visual and probing techniques. Two types of electronic detection devices, metallic and nonmetallic, have been developed to locate buried or hidden mines. Both types will locate objects other than mines (false returns) and neither works well in heavy rain or wet soil. Metallic detectors are used to locate buried metal mine casings or components. Nonmetallic detectors recognize changes in density.

Airborne detection systems. Aircraft detectors have a limited capability to detect mines directly or locate disturbed earth patterns. These detection systems are based on several types of technology, including radar, infrared imagery, thermal imagery, and high resolution photography.

Thermal sight system. Combat vehicles equipped with thermal sights may detect surface-laid metallic mines even in periods of limited visibility. These sights provide images for items that have different heat retention characteristics than their surrounding environments,

RULES

The following rules apply when visually and physically detecting mines and booby traps:

- Do not wear sunglasses. With sunglasses, you are less able to detect trip wires and camouflage.
- Be alert for trip wires.
- Look for signs of road repair. Look for new fill or paving, road patches, ditching, or culvert work (figure 4-2).
- Be alert for any signs placed on trees, posts, or stakes. Most of these signs are small and not easy to spot. They may indicate the presence of mines in the area.
- Watch for wires leading away from the side of a road. They may be command firing wires, They may be partly buried, or not buried at all.
- Watch for odd features in the ground or patterns not present in nature (figure 4-3 on page 4-6). Plant growth will wilt or change color. Rain may wash away some of the cover. The cover may sink or crack

around the edges. Some covered places may begin to look like mounds; when there are several of the same size, it can be a mined area.

- Watch the civilians. They may know where mines or booby traps are located in and around where they live. When the civilians stay away from certain places or keep out of certain buildings, it may be because of mines or booby traps. Question them to find the exact places.

- Watch for pieces of wood and other debris on a road. They may show the place where the enemy has put pressure or pressure release firing devices. These devices may be on the surface or partly buried.

- Keep in mind that the enemy can use mines fired by command. Search road shoulders and areas close to them. Watch for patterns of objects which might be used as a sighting line.

- Visually inspect all antitank and anti-vehicular mines for antihandling devices.

- Probe on hands and knees or prone. The prober first feels upward and forward to find trip wires and pressure prongs. To enhance the sense of touch, the prober should roll up sleeves and remove rings and watches. After looking and feeling, the prober pushes the probe gently into the ground at an angle less than 45 degrees from the horizontal, putting just enough pressure on the probe to sink it slowly into the ground. If pushed straight down, the tip of the probe may detonate a pressure mine. When a solid object is touched, probing is stopped and the surrounding earth removed. When probing, special attention should be given to the texture

FIGURE 4-2. MINED HARD-SURFACE ROAD

and hardness of the soil. A patch of unusually soft or loose soil indicates that it may have been disturbed recently. If a mine is found, enough earth is removed to show its type. It is then marked and reported. Special caution is taken not to disturb mines physically as they can be equipped with explosive antihandling devices.

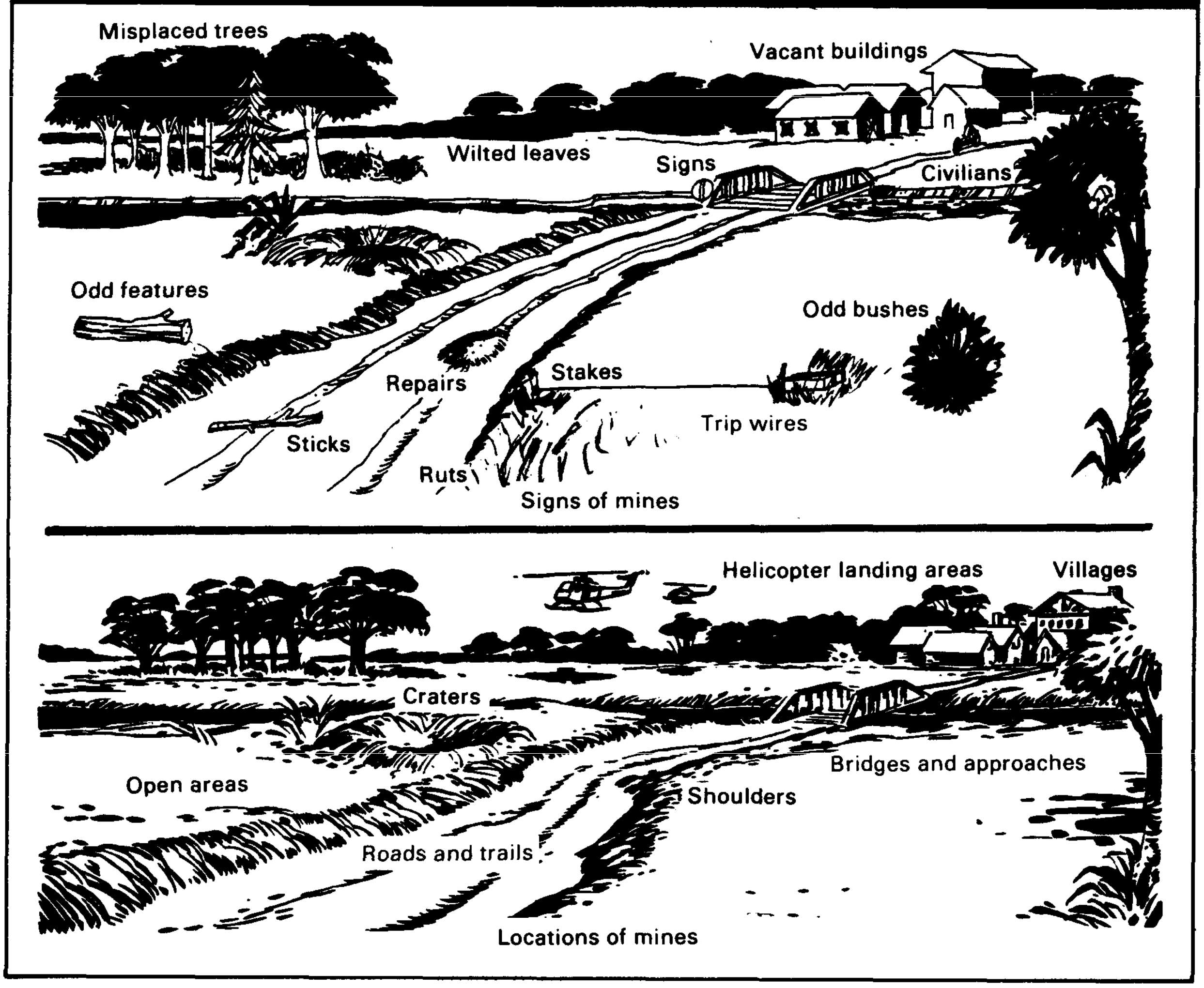
- Use electronic detectors to signal possible mine locations by changes in tones heard in the operator's headset. Probing is often used with electronic mine detectors to determine the exact location of mines.

MINEFIELD RECONNAISSANCE

Once an enemy minefield is detected, its limits are defined. There are two ways in which this is done, either by stand-off means or ground reconnaissance. In most cases, ground reconnaissance is the most dependable method.

Stand-off means. Studying remote imagery by trained interpreters is the most effective stand-off means of defining these limits. This option is restricted by terrain, weather conditions, and type of mine employed. Use of captured documents and prisoners to pinpoint mined areas is a less reliable method. Artillery, mortar, rockets, and aircraft munitions

FIGURE 4-3. SIGNS AND POSSIBLE LOCATIONS OF MINES



can be used to reconnoiter mine locations by fire. However, this often makes minefield breaching more difficult. The reconnaissance fire can disrupt mine patterns, spread shell fragments which will be picked up by electronic detectors, damage mines, or sensitize firing devices and detonators.

Ground reconnaissance. In most cases, ground reconnaissance is conducted by dismounted patrols. A minefield reconnaissance patrol consists of experienced and trained soldiers, organized into a security element and a search element. Equipment carried on the patrol depends on the mission of the patrol and type of mines it might encounter. Where chemical mines are suspected, protective clothing, chemical agent first aid supplies, and detection equipment are carried.

When the minefield reconnaissance precedes a bypass or breach, time is critical. To save time, several patrols are used. Each patrol is assigned a single route, with instructions to report when they first contact mines. Mine contacts or lack thereof can be translated into an outline of the field as the reports are charted.

BYPASSING AND BREACHING

BYPASSING MINED AREAS

Mined areas which impede friendly maneuver must be overcome quickly and effectively. Units encountering minefield will either bypass or breach. Early detection and minefield reconnaissance allow the force commander to analyze possible options. Whenever possible, mined areas should be bypassed to maintain momentum and conserve scarce breaching assets. Bypassing is done by maneuvering around or, when helicopter support is available, over minefield. In many cases, however, mined areas cannot be avoided. The terrain, mission, or possibility of being channelized into an enemy kill zone may make bypass impractical. In this case, the minefield must be breached.

MINEFIELD BREACHING

The objective of a minefield breach is to clear a path or lane through a mined area for friendly forces to continue their mission. The selection of lane locations should take advantage of cover and concealment, overmatching fires, and the commander's scheme of maneuver, Breaching a minefield where it is first encountered before considering other possible sites is not recommended.

LANE CHARACTERISTICS

A lane is a clear route through a minefield. Lane types or their function, usually indicated or designated by width, follows.

- A foot assault lane, 1 meter (3.3 feet) in width, may be breached to pass dismounted troops so they may continue the attack. It may also be necessary to breach afoot lane to allow the force to cross and secure the far side of the minefield while lanes are breached for vehicles.

- A 4-meter-wide (13-feet) initial lane will be breached initially to pass vehicles and equipment conducting the attack. Due to the narrowness of the lane (little more than the outside edge to outside edge of a main battle tank's tracks) this lane must be widened as soon as the tactical situation permits.

- A single lane of 8 meters (25 feet) is the desired width. This lane permits one-way traffic to pass through it with relatively little impact on vehicle speed and safety. Normally, this lane will be developed from the 4-meter-wide (13-feet) initial lane.

- A double lane of 15 meters (approximately 49 feet) allows two-way traffic. Single lanes should be developed into double lanes as soon as the tactical situation permits. Lanes require little if any work or upgrading for tracked vehicle traffic. Lanes which will be used by wheeled vehicles may require engineer effort to fill or level the lane's traveled way. Lanes which pass wheeled traffic require that mines, which may have been missed by detection or proofing hardware, be removed from the area covered by the wheelbase of these vehicles.

THE HASTY BREACH

The hasty breach is used to maintain the momentum of the attack by attempting to breach in stride as the minefield or obstacle is encountered. The hasty breach can be conducted under both conditions of awareness; the force is aware of the mined area through early detection or encounters it unintentionally. A hasty breach is conducted independently by a force with its available assets and sometimes without combat engineer participation. Breaching elements are located with the lead elements of maneuver units. Effective hasty breaches are the result of well-rehearsed mobility drills. Team members must know and take appropriate actions to suppress enemy fires, obscure the breach sites, create breaches, mark, report, and continue attacks through the minefield or mined area with as little pause as possible. Speed is extremely important because there is no time for the coordination and collection of resources from other units.

THE DELIBERATE BREACH

When it is not possible or necessary to take the minefield in stride or after a hasty breach has failed, a deliberate breach is conducted. This requires additional combat assets, support, or mobility equipment from other units. Combat engineer support is essential. More time is required for reconnaissance, planning, and buildup of necessary resources than is possible for a hasty breach. However, this time allows the enemy a chance to strengthen its defense. Generally, a deliberate breach requires that combat power be projected across the minefield to deny the enemy direct covering fire.

METHODS OF BREACHING

There are three methods of breaching conventional mined areas. These methods involve either mechanical means, explosive means, or manual neutralization of mines. Expedient means should be used when no other methods are available.

Mechanical breaching. Mechanical devices, attached to the front of an armored vehicle, remove the mines from the area in front of the vehicle or explode them. These devices include rollers, full-width plows, and track-width plows. Mechanical devices permit units to quickly clear vehicle lanes in minefield. However, the devices can impair the vehicle's mobility and make it an inviting target for enemy fires covering the minefield. Mechanical devices should be employed in combination to defeat the variety of fuzes which may be encountered.

Explosive breaching. Explosive devices are placed in the minefield and detonated, setting off nearby mines by sympathetic detonation or Mowing them away from the breach lane. A lane may thus be cleared for traffic through the minefield. Several techniques are used in explosive neutralization:

- Charges placed by hand. A one-pound explosive charge is placed six inches to the side of detected mines and detonated. This method exposes soldiers to enemy fire.
- Linear charges, Linear demolition charges are pushed or projected by rocket into the minefield. The charges must be brought forward by personnel or armored vehicles which may be vulnerable to enemy fires covering the minefield. The charges are exploded and a lane is formed.

Manual breaching. In this method, personnel move into the minefield to detect and mark mines. The mines are then removed by using a grappling hook in order to clear a lane. They may then be destroyed or removed. Since personnel are exposed and vulnerable to enemy fire, this method should be reserved for clearing activities.

Expedient means of breaching. When other breaching methods are not available, expedient means, such as pushing disabled vehicles through a minefield or using earth-moving blades to clear mines, should be used. The unit must apply the countermine resources available to continue its mission.

BREACHING OF SCATTERABLE MINES

Scatterable mines can be detected by visual observation, accidental encounter, close range detection or counterbattery and countermortar radar, Take the following steps when breaching scatterable mines emplaced on a unit's position or formation:

- Take the enemy delivery system under fire.
- Use obscurants to counter enemy target acquisition, if required.
- Use reports from unit personnel to determine minefield boundaries and density and best paths to exit the minefield. Actual techniques for breaching the minefield depend on vegetation, type of unit, types of mines, and the nature of covering fire. When mines and trip wires can be seen, personnel and equipment operators visually determine mine locations and negotiate a path to the edge of the minefield. When visual detection is difficult, moving mechanized formations immediately deploy personnel and equipment to clear paths from each vehicle to the edge of the minefield. These paths may be cleared by blades, rollers, plows, or dismounted individuals. Also, moving dismounted and wheel-mounted formations use manual neutralization methods to clear paths from individuals and vehicles to the edge of the minefield. Explosive breaching methods and other mine detonation measures are used only after safe operating distances have been reached.
- United States forces exploiting a breached lane are organized to react to remotely delivered mines emplaced in these lanes.
- Minefield breaching procedures used to breach into a unit position are designed to reduce the danger to either the breaching force or the entrapped unit.

MINEFIELD PROOFING

Proofing a vehicle breach lane involves a test of the lane to insure that all mines were removed. The safest and quickest way to proof a vehicle-width lane is to use mechanical means, if available. Countermine equipment will detect mines that were not initially located or detonated, including those fitted with multiple-impulse type fuzes. Proofing may have to occur once the forces necessary to eliminate enemy direct fire on the lane have been passed through. It should be initiated and completed prior to moving through the remainder of the force.

MARKING, REPORTING, AND RECORDING

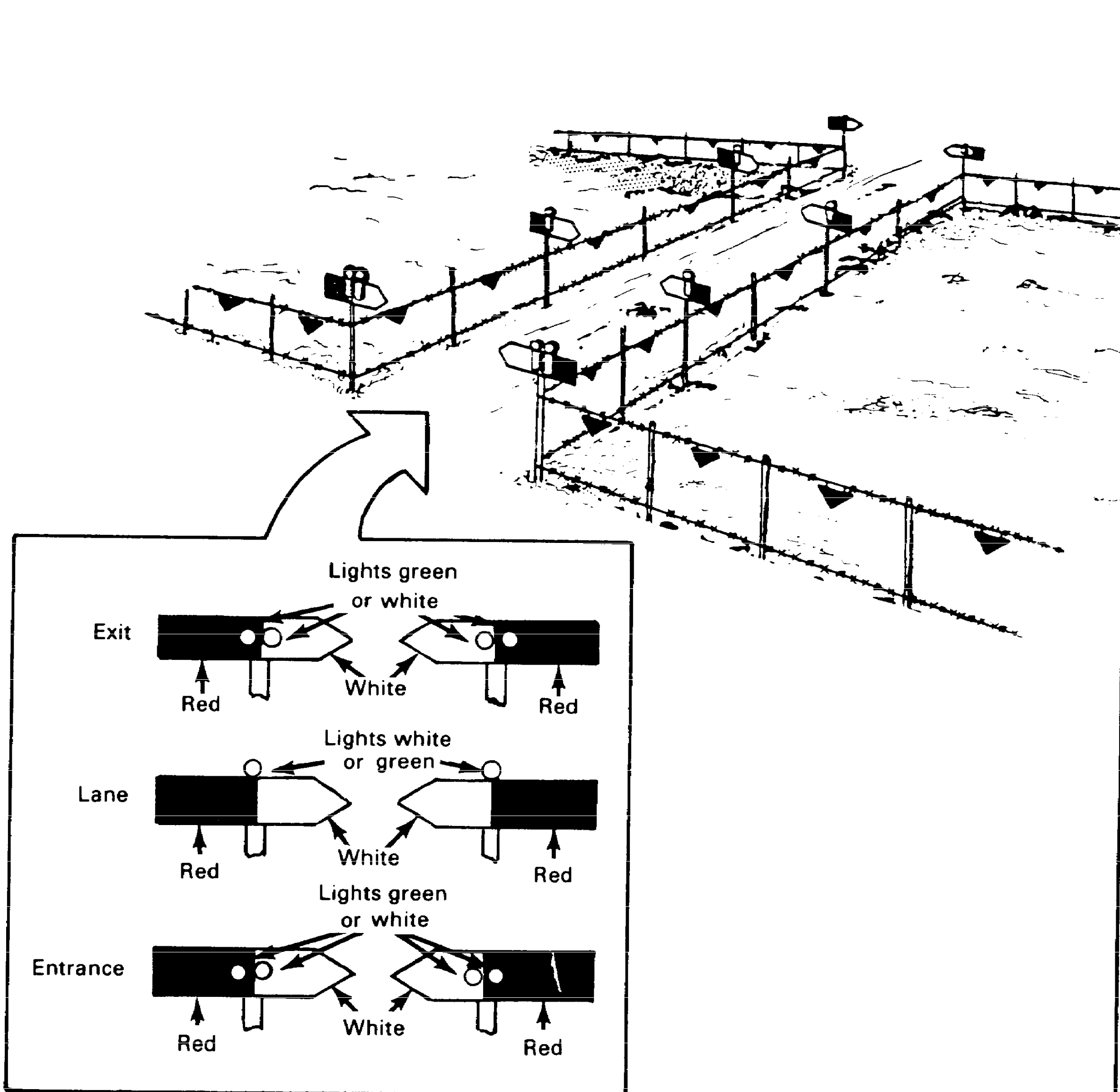
MARKING MINEFIELDS

Marking is necessary to define the limits of the breached path, lane, or gap, as well as the boundaries of the mined area. This activity is critical to the safe and swift movement of the remainder of the leading and follow-on forces. The limits of the minefield must be clearly identified to avoid detonating a mine. Since standard marking kits are not always available, a unit encountering an enemy minefield will mark it with available resources. These resources and techniques will be made known to follow-on forces via standing operating procedures (SOP) or operations/fragmentary order. Temporary marking is replaced by standard marking materials as soon as the tactical situation permits.

MARKING LANES

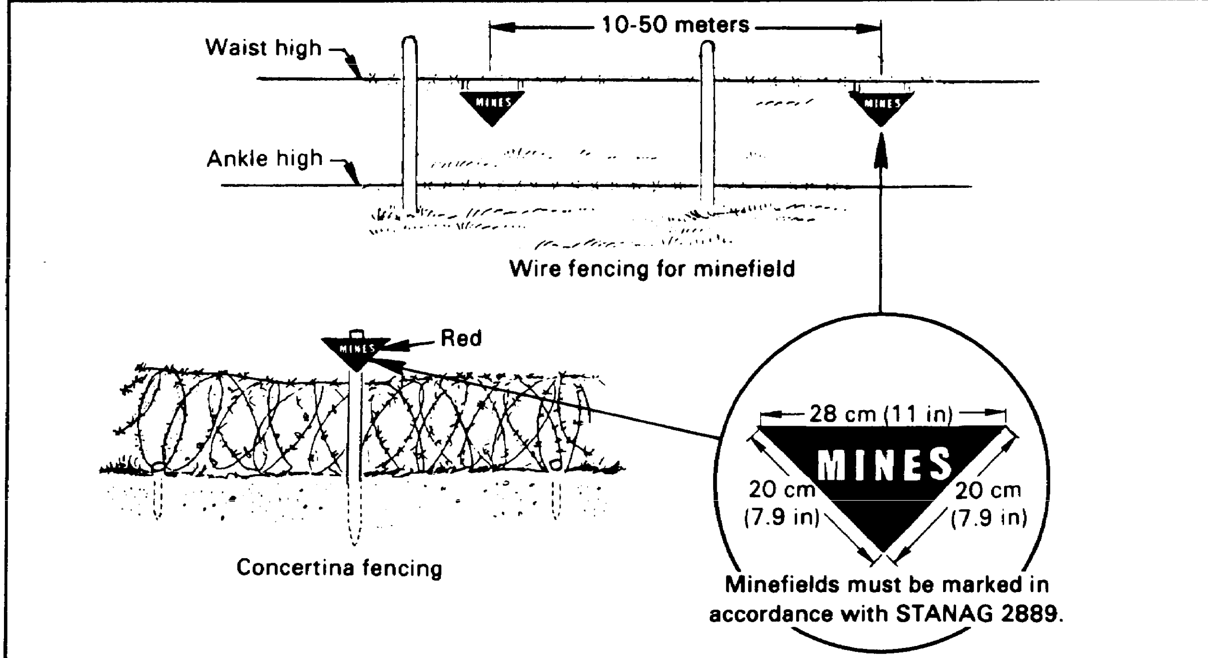
Distinctive markers must show where the lane begins and ends. There is a tendency for most drivers to start maneuvering before they are out of the minefield. The side limits of the breach are marked to prevent vehicles or personnel from traveling in areas that are not cleared and proofed. Side-marking systems, standard marking kits, or expedient devices are placed at least one foot inside the width of the mine-free lane to provide a safety margin. The width of the lane will be determined by the breaching method. Figure 4-4 shows a standard method of marking the limits of the lane, Figure 4-5 shows the individual markers that are hung on fences surrounding mined areas. All minefield are to be marked. Engineers supporting follow-on forces improve breach lanes and fence in

FIGURE 4-4. STANDARD LANE MARKINGS



Note: During daylight the lights are not required.

FIGURE 4-5. MARKING MINED TERRAIN



the remainder of the mined areas, placing warning signs on the fences. Fences and warning signs will normally be removed, if possible, if the minefield must be given up to the enemy in future operations.

REPORTING AND RECORDING MINEFIELDS

Any knowledge, detection, or encounter of enemy minefield is reported to the next higher commander by the fastest reliable means. Reports are normally transmitted through operational channels and must be as complete as possible. These reports (figure 4-6) are then integrated into intelligence data at the lowest possible level and are disseminated to higher, lower, and adjacent headquarters. The record is then forwarded to the senior Army engineer in the theater responsible for minefield reports. The report includes all known information concerning the minefield. The specific types of information and format required for enemy minefield reports (in accordance with STANAG 2096) are found in figure 4-6.

FIGURE 4-6. MINEFIELD REPORT

ALFA	Map sheet designation.
BRAVO	Date and time of collection of information.
CHARLIE	Type of minefield
DELTA	Coordinates of minefield extremities.
ECHO	Depth of minefield.
FOXTROT	Enemy weapons or surveillance.
GOLF	Estimated time to breach minefield.
HOTEL	Estimated material and equipment needed to breach minefield.
INDIA	Routes for bypassing minefield
JULIETT	Coordinates of lane entry
KILO	Coordinates of lane exit
LIMA	Width of lanes, in meters
ZULU	Other: Types of mines, new mines, booby traps.

COMMAND AND CONTROL

COUNTERMINE MEASURES

The maneuver force staff, including the supporting engineer representative, continues to revise countermine plans during the execution of countermine tasks. They must anticipate changes in the locations of mined areas. Patrols reconnoiter planned areas of operations to determine exact minefield locations. Aerial surveillance can detect some minefield and minelaying operations. As it is collected, enemy mine data is consolidated with friendly minefield records and provided to tactical commanders and staffs for operational planning.

TASK ORGANIZATION

In developing their task organizations, commanders should include countermine measures. The task organization should include special purpose equipment and units, such as combat engineers, located well forward. Bypass construction and breaching activities, if needed, can be started immediately. Whenever possible, task-organized forces should rehearse measures to be taken when encountering mines. The maneuver commander controls all breaching operations, coordinating artillery, Air Force and Army aviation support, smoke units, and engineer assets to insure the success of the operation. The commander organizes breaching assets into three elements, as described in chapter 2.

BREACHING AUTHORITY

The entire breaching operation must be under the control of a single responsible commander. Every element establishes direct communication with the commander who constantly reassesses the situation and controls the employment of maneuver and support forces. The commander must assume responsibility for traffic control for the countermine task. This includes establishment of movement orders, consolidation areas, and staging areas. If necessary, guides should be assigned to lead units through the lanes and remain to guard the lanes until relieved by follow-on forces. After the breach has been completed and the breaching unit has passed through the minefield, control of the area is passed to follow-on forces.

DEFENSIVE COUNTERMEASURES

Unit commanders must consider any combat area in which the enemy is operating or has operated as possibly containing mines or booby traps. Defensive countermeasures and countermine activities can be found in FM 20-32, TM 5-280, FM 71-2, and STANAG 2889. This information, summarized below, must be common knowledge to all soldiers. Also, command and control of forces should include use of the following measures to prevent contact with minefield, mines, or booby traps and resultant casualties.

Troop interval and dispersion. Troops should maintain safe intervals between units to prevent excessive casualties from a single device.

Operation of vehicles. Old vehicle tracks should be avoided, when possible, because they are often deliberately mined. However, within a breach lane, vehicle operators should follow in the tracks of the vehicle ahead to reduce the possibility of detonating mines missed by the first vehicle. The speed and spacing of individual vehicles can be varied to make the timing of command-detonated mines more difficult. Key personnel are prime targets for command-detonated mines and must not congregate in one vehicle. Whenever possible, vehicles should avoid traveling alone. Single vehicles may be prime targets for mines command-detonated by enemy patrols seeking weapons or intelligence information.

Point men. Alert and well-trained point men are the best mine and booby trap detectors. They must be rotated frequently or they may become ineffective under the job stress. This also applies to lead vehicles in columns.

Behavior patterns. Units and soldiers should avoid establishing predictable patterns of tactical behavior. Patrols should follow different routes out and back from their base. Patrol times or other movements should be random.

Reaction to mine casualties. Soldiers are understandably eager to assist fellow soldiers who have become mine casualties. They should be warned to do so with extreme caution, as secondary mines often inflict casualties on personnel grouped around the wounded. The soldier nearest each casualty should carefully clear a way to the individual and give first aid. Under no circumstances should soldiers crowd around the wounded and present a larger target for enemy covering fire.

MINEFIELD CLEARING OPERATIONS

CONSIDERATIONS

Minefield clearing is the elimination of all mines in a minefield or mined area. It is conducted after enemy fires have been eliminated from the mined area. Thoroughness and safety, not speed, are the most important considerations. Clearance is conducted by engineer units which generally use manual mine detection methods and hand-emplaced explosives to detonate all mines in place. The procedures necessary to clear minefield are described in FM 20-32.

PREPARATION AND PRECAUTIONS

Successful mine clearance is directly dependent upon the discipline and skill of personnel in the clearing unit. Leaders must exercise complete and positive control over all soldiers engaged in the clearing operation. They must guard against overconfidence and rotate personnel involved in the more critical tasks such as operating mine detectors. When clearing mines from an area contaminated by chemical agents, commanders insure that adequate protective clothing and equipment (TM 5-220) is provided and used. Detonation of chemical mines within areas already controlled by US forces should be avoided. Minefields suspected of containing chemical mines are bypassed and referred through channels to specially trained personnel. Before entering an area to conduct deliberate clearance, take the following precautions:

- Check division, corps, and theater minefield records files for all records of minefield (friendly or captured enemy) installed in the area.
- Check aerial photographs of the area.
- Cross-check POW interrogation reports and the All-Source Intelligence Center for indications or reports of enemy mining or booby traps.
- Perform ground minefield reconnaissance in the suspected area.
- Establish and mark minefield boundaries if the field is not already fenced.

CHAPTER 5
Counterobstacle Tasks

USE OF OBSTACLES

THREAT DOCTRINE

While Threat forces have the military expertise and capability to constructor develop obstacles other than minefields, their doctrine limits this effort due to the offensive nature of their operations and the expected tempo of the AirLand battle. Simple obstacles include demolished overpasses, road craters, wire obstacles, and urban rubble. Obstacle systems can include such combinations as road craters/mines/rubble, and rubble/fire/timber obstacles. United States forces must also cope with large obstacles created by nuclear weapons. The clearing of blown-down trees and extensive rubble from nuclear blasts, for example, is a huge mobility task. Also, the task may have to be done in a contaminated environment. Although obstacles themselves may not be destructive, as are mines, many will be booby trapped. The objective of enemy-installed obstacles is to delay moving forces, channelize them, and create time for concentration of destructive fires. Threat obstacles must be rapidly overcome to prevent excessive casualties to friendly forces. Thus, the combined arms team should be prepared to overcome all types of obstacles.

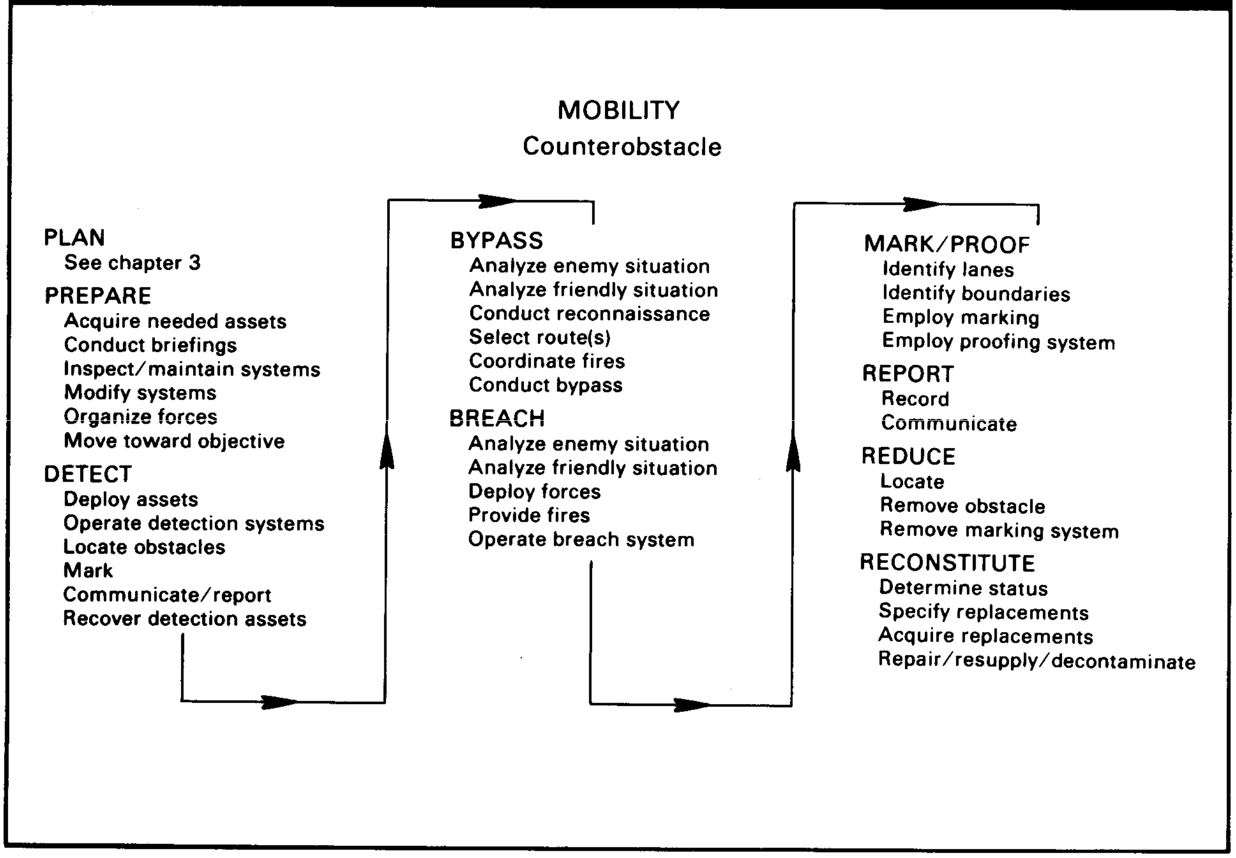
COUNTEROBSTACLE ACTIVITIES

Counterobstacle tasks are divided into nine distinct steps. Each step is separated into several subtasks. The counterobstacle function differs from the countermine function in only two steps. The requirement to proof breached lanes is unnecessary unless the obstacle includes mines (complex). Secondly, the complete removal of mines is termed clearance, whereas the total removal of an obstacle system is termed reduction. Figure 5-1 shows the activities and steps associated with a counterobstacle task. During a single obstacle encounter, however, not all of the subtasks may be required. For example, the removal of a timber obstacle through breaching might eliminate the need for marking or reduction. The remainder of this chapter will discuss the unique considerations of counterobstacle subtasks.

PLANS AND PREPARATIONS

The planning phase for counterobstacle tasks is similar to that of other mobility tasks (chapter 3). Knowledge of existing enemy obstacles or their likely location helps the commander formulate mobility plans. If avoiding the obstacle is not possible, the commander selects and prepares the method of breaching that will allow the force to overcome the obstacle in stride. Because it is not always possible to obtain reconnaissance data fast enough or in detail, the maneuver commander should equip lead elements with the best available means for breaching any type of obstacle. Organic means are supplemented with engineer elements whenever possible. Engineers providing counterobstacle support have special engineer equipment, pioneer tools, and demolitions to breach all types of obstacles.

FIGURE 5-1. POSSIBLE SUBTASKS IN THE COUNTEROBSTACLE PROCESS



OBSTACLE DETECTION

The success of counterobstacle activities is in reaching the objective beyond the obstacle. Enemy forces around and beyond the obstacle are the object of attack, not the obstacle itself. Overcoming an obstacle without a significant loss of time, personnel, and equipment is the goal of maneuver forces. To achieve this goal, early detection and warning of obstacles is necessary. The obstacle may either be avoided or overcome, but early warning will allow for swift concentration of effort in order to accomplish the task.

Enemy forces around the obstacle are the object of attack, not the obstacle itself.

MEANS OF DETECTION

Currently, counterobstacle detection is primarily limited to visual inspection and reconnaissance. As maneuver forces prepare to move on the battlefield, means of detecting and identifying obstacles in their path are executed. The mobility planner (the operations officer or staff engineer) forecasts the most likely locations where obstacles could delay, disrupt, or stop tactical movement. Tactics of detection are based upon the methods and equipment available. For example, the leading force in an attack employs its organic reconnaissance elements forward of the main body. The reconnaissance personnel from divisional and corps engineer battalion S-2 sections may be task organized to move with the scouts. In this manner, tactical route reconnaissance and mobility technical data can be collected at the same time. Engineers may require vehicles similar to those used by reconnaissance elements or at least space for the engineers and their equipment if this is possible.

Aerial reconnaissance. Aerial reconnaissance and remote imagery are other methods of early obstacle detection, Unlike mines and minefield, most obstacles are easily detected from the air. Limited only by adverse weather conditions and enemy antiaircraft systems, aerial reconnaissance can provide the quickest detection of obstacles.

Role of commander. Counterobstacle reconnaissance information must be swiftly dispatched to the maneuver force commander.

Early detection allows the commander time to plan, prepare, and adjust forces for bypassing or breaching the obstacle. Avoiding physical encounter with the obstacle is the ultimate goal because it saves time and resources.

DETECTION REPORTS

Units of all arms and services use simple and concise report formats to quickly report obstacle information. The four different reports explained in this section implement STANAG 2096. They are the terrain, obstacle, bridge, and tunnel reports. Much of the detail required in the bridge and tunnel reports can only be provided by qualified engineer personnel. Personnel of other arms or services provide only the detail they are qualified to collect and report. The discussion of these reports includes expedient techniques for gathering the required technical data. Although these report formats are designed primarily for radio transmission, they can be used for written reports and supplemented by drawings, maps, traces, or overlays. If not transmitted by radio, they should be relayed by the fastest possible means. The originator completes only those parts of the format which apply to the detected obstacle. These reports are forwarded through operational channels and monitored by the staff intelligence, logistics, and engineer sections. Also, at division level, the reports are provided to the terrain analysis detachments in order to update their data base.

Terrain reports. The purpose of this report is to provide general terrain information not available through terrain analysis. It can provide the assessment for cross-country movement, routes of concealment, and area trafficability. A sample terrain report is shown in figure 5-2.

Obstacle reports. The format for reporting enemy or unidentified minefield is provided in chapter 4. This report is used for initial observation of all other obstacles. The inclusion of incomplete data concerning enemy activity or the existence of mines, although no details are known, is often of great value. An example is that mine-like objects appear near a road crater, but an enemy force of unknown size prevents closer reconnaissance. A sample obstacle report is shown in figure 5-3.

Bridge reports. An army must make maximum use of existing bridges. The existence and condition of bridges is essential information for tactical movement and maneuver. The bridge report confirms or denies the existence of specific bridges and provides information on their condition and capability to sustain crossings. A sample bridge report is illustrated in figure 5-4.

FIGURE 5-2. TERRAIN REPORT

ALFA	Map sheet and grid references (four grid points to outline area reconnoitered).
BRAVO	Shape of the ground, for example, flat, rolling, hilly, swampland, or mountainous.
CHARLIE	Cross-country movement (GO, SLOW-GO, or NO GO).
DELTA	Vegetation (type and restrictions, if any).
ECHO	Concealment available.
FOXTROT	Land use (rice paddies, plowed but unplanted, wheat fields, and so forth).
GOLF	Suitability of soil for digging, for example, good (no rocks), poor (rocky), and difficult (rock) given existing weather conditions.
HOTEL	Weather conditions at time of report (dry, wet, frozen, and so forth).

Bridge military load classification. Before any existing bridge can be used to capacity, it must be classified according to the bridge military load classification system. The military load class of each bridge is posted to prevent damage from overloading which may cause failure.

Classification factor. Bridge classification is basically the reverse of design procedure. Since the individual bridge members are already present, you need only to record their dimensions and strength characteristics to compute the load capacity. To determine the class of a bridge, use the following data:

- The number of members (where applicable). For example, while classifying stringer bridges and concrete T-beam bridges, note the number of stringers in each span.
- Size of members. Take exact and complete dimensions of specific bridge members.
- The span length. Measure span length from center to center of supports. The classification of the bridge is usually based on the weakest span. If the weakest span is easy to see, you don't need to investigate further. However, if the weakest span is difficult or impossible to locate by sight, you must classify all spans. Even if several spans appear identical, you must take actual measurements to prevent error.
- The width of the traveled way. Measure the distance between the inside faces of the curb (figure 5-5 on page 5-6) to get the traveled way width.
- General condition. You must note the general condition of the bridge, especially damage from natural causes like rot and

FIGURE 5-3. OBSTACLE REPORT

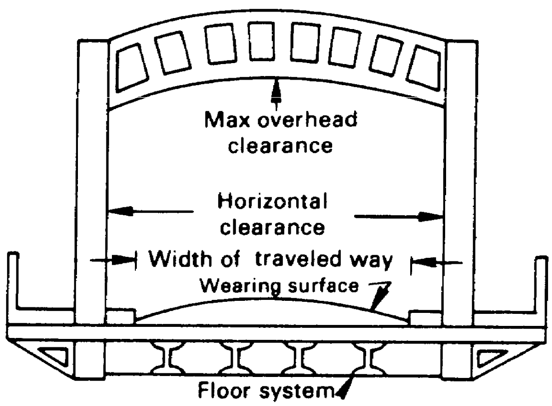
ALFA	Map sheet(s).
BRAVO	Date-time group of observation.
CHARLIE	Location (grid reference).
DELTA	Type of obstacle.
ECHO	Enemy weapons having coverage on the obstacle, if any.
FOXTROT	Any other information which could impact on breaching or bypass, for example, terrain restricts bypass, work required (in personnel-hours) to breach obstacle.

FIGURE 5-4. BRIDGE REPORT

ALFA	Map sheet(s).
BRAVO	Date-time group of observation.
CHARLIE	Location (grid reference).
DELTA	Type of bridge (number of spans, length, and type of material).
ECHO	Military load classification (one-way traffic).
FOXTROT	Military load classification (two-way traffic).
GOLF	Condition of bridge.
HOTEL	Clearance width of vehicle passage.
INDIA	Clearance height for vehicle passage.
JULIETT	Possible bypass route(s) and condition of bypass (difficult/easy).
KILO	Any other information which could impact on trafficability, for example, bridge is wired for demolition.

rust, or combat action. Classification procedures presume that a bridge is in good condition. If the bridge is in poor condition, the class obtained from mathematical computations must be reduced according to the classifier's judgment.

FIGURE 5-5. WIDTH OF ROADWAY AND CLEARANCES



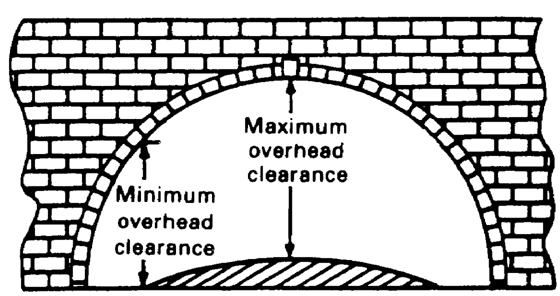
Bridge classification card. This manual lists only one bridge classification method, the Bridge Classification Card (GTA 5-7-7) found in appendix D. This card provides a rapid means of classifying bridges. Using a graphic method with several approximations, the card outlines procedures for determining the class of simple steel and timber stringer, masonry arch, concrete T-beam, and concrete slab bridges. Bridge classification with this card is based on the class of the superstructure only, since this is the controlling feature. A balanced design in the substructure is assumed.

Tunnel reports. A sample tunnel report is shown in figure 5-6 and tunnel clearance measurement in figure 5-7. Tunnel reconnaissance determines essential information about underground roadways or sections of a road which have been artificially covered.

FIGURE 5-6. TUNNEL REPORT

ALFA	Map sheet(s).
BRAVO	Date-time group information was collected.
CHARLIE	Location (grid reference).
DELTA	Length.
ECHO	Width at most constricted diameter (figure 5-7).
FOXTROT	Height at minimum height location (figure 5-7).
GOLF	Gradient.
HOTEL	Type of tunnel (railroad, vehicle, or footpath).
INDIA	Condition.
JULIETT	Bypass routes available.
KILO	Any other information which could affect trafficability including shape of tunnel bore.

FIGURE 5-7. TUNNEL CLEARANCES



Such information includes locating type, length, width, and gradient inside the tunnel. Information on obstructions in the tunnel's liner or portals which would limit the dimensions of vehicles using the route is especially important.

BYPASSING AND BREACHING

OPTIONS

Once the obstacle is detected and reported, several counterobstacle options are available to the maneuver commander. The method of choice depends on availability of counter-obstacle equipment and the tactical situation. The deciding factor is usually the urgency of the mission. The methods for passage of simple and complex obstacles include—

- Bypassing.
- Forcing through.
- Hasty breaching or reduction.
- Deliberate breaching or reduction.

Bypass. To save time and labor, obstacles are bypassed where possible. This should be done with caution, however. A bypass route that appears desirable at first may be a kill zone. Also, time spent looking for a bypass (without benefit of standoff detection means) may cause unnecessary delay. Therefore, the commander should quickly determine if a bypass would produce additional risks. If the bypass route leads forces into an ambush or kill zone situation, the bypass should not be executed.

Forcing through. Where bypass is not possible or breaching means not available, forcing through is used under special tactical situations. All obstacles can eventually be forced through, but some are more difficult than others. The latter include concrete and steel obstacles or complex fortifications. Others, such as wire obstacles, abatis, and log cribs can be overcome by forcing through. However, the possible equipment damage and casualties caused by forcing through must be weighed against the desired tactical advantage.

Hasty breaching. This method is used when the obstacle is covered by enemy direct or observed fire. Bypass is not possible and speed is the critical factor. The objective is to create a clear path through the obstacle without loss of momentum. In some cases, the obstacle can be breached in a way that completely negates the obstacle's value. This is called obstacle reduction. In all cases, the counterobstacle task is undertaken with assets organic to the maneuver force and engineer equipment traveling with the force. When engineer forces are available, they are organized to assist in the actual breach.

Deliberate breaching. This method is preferable to hasty methods whenever time and the tactical situation allow detailed reconnaissance and additional support deployed at the obstacle. A deliberate breach is also undertaken when hasty methods have failed. The disadvantages of this method, however, are movement delay and possible enemy response.

MEANS OF BREACHING

Breaching is accomplished by using manual, mechanical, or explosive force against the obstacle. These three means of breaching or reduction can be used together or separately. There are advantages and disadvantages of each means.

Manual reduction or breaching. This is the removal or breaching by troops and is the slowest and most dangerous method. It is rarely desired because the working party is exposed to enemy direct or observed indirect fire. Assaulting foot troops use mats, planks, assault ladders, or other available equipment to surmount wire obstacles and barriers. This is a rapid means for light forces to secure the far side of an obstacle. Antipersonnel mines will significantly reduce the speed and effectiveness of this tactic.

Mechanical reduction or breaching. Most obstacles, except extensive concrete or steel barriers, can be breached by mechanical means. Tanks or engineer equipment can destroy obstacles by force. Heavy equipment can be used to develop vehicular passage lanes. Equipment suitable for reducing timber obstacles, steel rail obstacles, and small concrete or rock obstacles is organic to combat engineer units. The M9 armored combat earthmover (ACE) and combat engineer vehicle (CEV) can destroy by impact or push aside such obstacles. Obstacles which are too heavy to be pushed aside can be breached by building earthen ramps over them or shattering them with explosives. Obstacles must be checked for mines and booby traps as these are often used by the enemy to reinforce obstacles. Radiation presents the following special situations:

- Some obstacles may consist only of radioactive contaminated areas. In some cases, foot troops or vehicles can be quickly passed through without resorting to other measures. Where contamination is too great to allow safe passage of foot troops, paths are cleared quickly by bulldozing with a combat engineer vehicle or tank bulldozer. Radioactive fallout contamination from even the largest atomic weapons is not more than a quarter of an inch deep. The contaminated earth should be removed to this depth and covered or pushed well clear of the lane or area. Scraping away fallout does not entirely eliminate radiation within the lane, but reduces it to a degree which allows swift passage of forces.

- This method should not be used in areas affected by induced radiation as this type of contamination penetrates deeper into the ground than fallout. The amount and intensity of induced radiation depends on the location of ground zero, the yield of the nuclear weapon, height of burst, whether the device was an enhanced nuclear weapon, and time elapsed since detonation. Chemical reconnaissance personnel should advise commanders as to the locations of these areas. Terrain contaminated by induced radiation should be bypassed.

Explosive reduction or breaching. This is the quickest and most efficient means of obstacle removal or reduction and is the most common method used during hasty or deliberate breaches. It not only includes hand-placed demolition charges, but direct and indirect weapons fire, linear explosive devices, fuel-air explosive charges, and nuclear detonations as well. The successful use of demolitions depends on two factors, the type of obstacle being breached and the physical characteristics of the obstacle. Certain types of charges are more effective against certain types of obstacles, The type, width, depth, and composition of an individual obstacle system will dictate the amount and placement of the explosives. Extreme caution should be used to avoid casualties to friendly personnel from falling debris. Troops in the vicinity must be forewarned through visual signals, radio, or by firing at a prearranged time. Destruction of obstacles by direct fire or artillery fire generally requires a high expenditure of ammunition. Tanks firing high-explosive plastic ammunition or the CEV 165-millimeter demolition gun are more effective than artillery fire.

SITUATIONAL TECHNIQUES

A discussion of the methods and situational techniques in breaching nonexplosive obstacles follows. Nonexplosive obstacles that Threat forces can include in their defensive or flank protective measures include—

- Timber obstacles.
- Wire obstacles.
- Nuclear weapons effects.

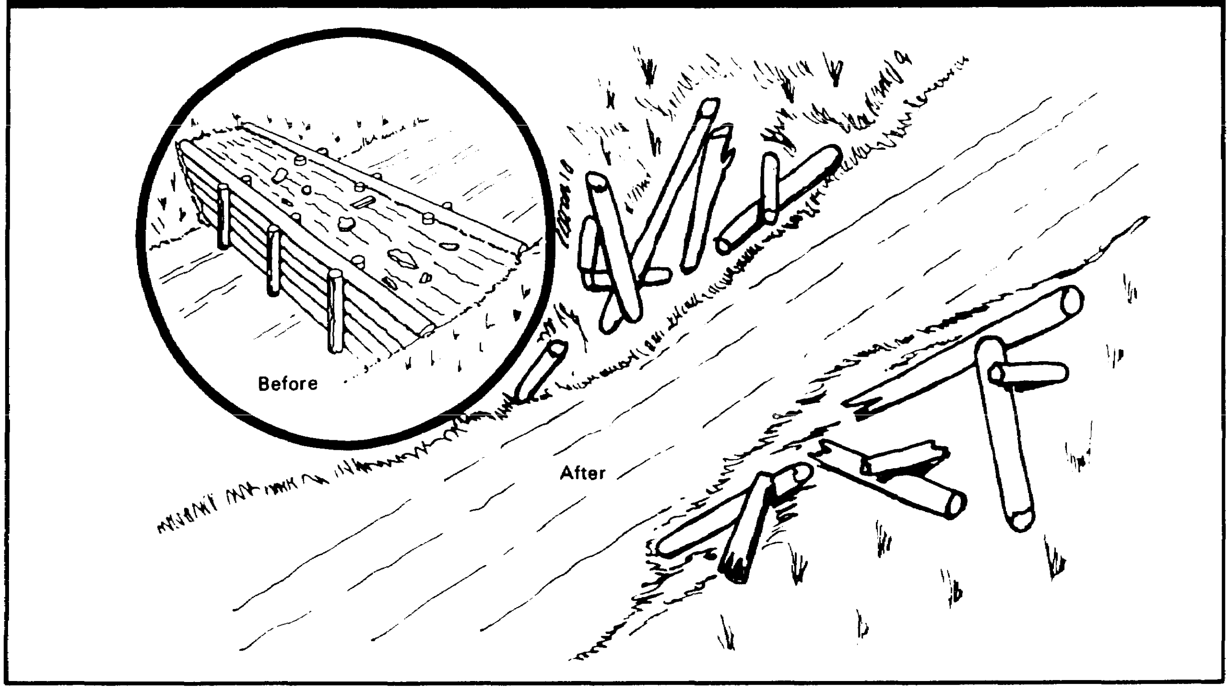
- Antiairborne obstacles.
- Water and beach obstacles.
- Strongpoints and urban rubble.
- Snow obstacles.
- Icing obstacles.

Timber obstacles. Heavily wooded areas provide an effective obstacle to vehicular movement. Log obstacles, such as abatis across roads and trails and earth-filled cribs can further decrease trafficability. These obstacles can be mined and should be covered by fire. Engineers should be positioned well forward in maneuver columns to breach or reduce such obstacles. Preferred breaching techniques are mechanical removal, destruction with demolitions, or a combination of both.

Use of demolition gun. The CEV is equipped with a 165-millimeter demolition gun. The maximum effective range of this weapons system is 950 meters. When brought forward for breaching log cribs or abatis, the CEV crew fires its gun low at the center of mass on the target (figure 5-8). The CEV or heavy equipment with a dozer blade then mechanically pushes the remaining debris from the breach lane.

Clearance of abatis. The removal and clearance of log abatis depends on the characteristics of the fallen trees and the total depth of the timber obstacle. An abatis consisting of only several trees or trees of small diameter can generally be forced through with mechanical pushing effort. Where this is not possible, a combination of manual or explosive breaching and mechanical force is recommended. First, the fallen trunk of the tree should be separated from its base with saws or explosive charges. The remaining timber is then pushed or winched from the roadway. Figure 5-9 on page 5-10 shows the placement of concentrated external cutting charges on tree or timber obstacles.

FIGURE 5-8. DEMOLITION GUN DESTRUCTION OF LOG CRIB



Cutting timber with explosives. The following formula is used for cutting trees, piles, posts, beams or other timber with explosives as an untamped external charge:

$$P = \frac{D^2}{40} \text{ or } P = .025\,D^2 \text{ where,}$$

P = pounds of TNT required.

D = diameter of round timber, or least dimension of dressed timber, in inches, and

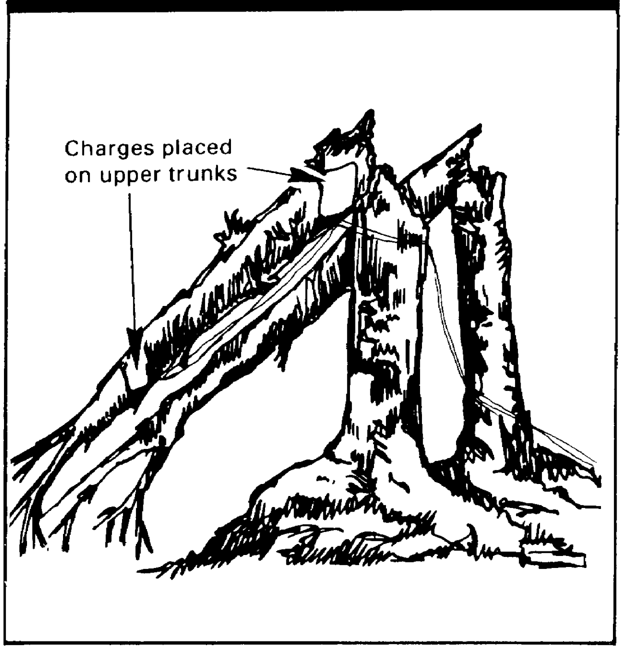
$\frac{1}{40} = .025 = \text{constant.}$

The amount of explosive required to cut a round timber 30 inches in diameter using **an** untamped external charge is determined as follows:

$$P = \frac{D^2}{40}$$

$$P = \frac{(30)^2}{40} = \frac{900}{40} = 22.50 \text{ pounds of TNT.}$$

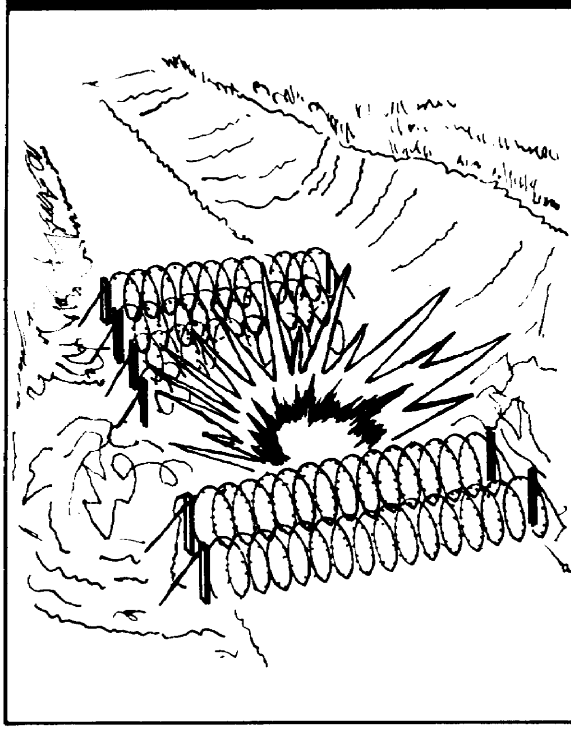
FIGURE 5-9. ABATIS CLEARANCE



Concentrated charges should be rectangular, 1 to 2 inches thick and approximately twice as wide as they are high. Charges are placed as close as possible to the surface of the timber. Notching the tree to hold the explosive in place is often helpful. If the tree or timber is not round and the direction of fall is of no concern, the explosive is placed on the widest face so that the cut will be through the least thickness.

Wire obstacles. Wire obstacles are used mainly to hinder movement of dismounted troops and usually supplement other obstacles. The preferred breaching technique is through use of the CEV demolition gun (figure 5-10) or the bangalore torpedo (figure 5-11). By themselves they are generally not effective against motorized forces, although wire can stop wheeled or tracked vehicles if entangled in running gear or sprockets. Although the use of manual techniques, such as personnel ramps of wood or fencing, can be used, the

FIGURE 5-10. WIRE OBSTACLE BREACHED WITH CEV



possibility of hidden antipersonnel mines or booby traps in the wire obstacle adds additional risk. Also, mechanical breaching using the track-width mine plow is capable of swiftly breaching concertina while clearing mines in the breach lane.

Nuclear weapons effects. Large amounts of rubble in built-up areas will produce an effective obstacle that is difficult to breach. Other obstacles, such as tree blowdown will be created by nuclear weapons. Rubble and debris can be breached by mechanical or explosive means. Some rubble may require removal with a winch or tow chain. Only the minimum amount of rubble that will allow vehicles to pass should be removed. Trees blown down by nuclear weapons are often parallel-laying. The difficulty of reducing or breaching will depend on the extent of blowdown and the breast-high diameter (BHD) of the toppled trees. Coniferous trees will form a barrier of long, straight trunks with little foliage. Deciduous trees, on the other hand, will be more difficult to clear because of dense foliage and many branches low on the trunks. Breaching over existing trafficways is emphasized to avoid clearing tree bases and stumps. Work crews and equipment operators must be suited in protective clothing when breaching contaminated rubble and debris.

Antiairborne obstacles. Antiairborne obstacles are used to deny forces the use of landing strips or zones for airborne or air assault. These could consist of obstacles previously discussed. Such combinations include abatis, wire entanglements, steel or wood posts, concrete or steel obstacles and mines. Advance reconnaissance must provide information on these obstacles. Within the context of an operation, demolition parties should be brought in as early as tactically possible to begin reduction of such obstacles. Although speed is urgent in removal operations, these mobile teams provide the only means of breaching the obstacles until mechanical and heavier demolition equipment can be landed and used.

FIGURE 5-11. WIRE OBSTACLE BREACHED BY BANGALORE TORPEDO

Water and beach obstacles. Water and beach obstacles generally consist of wire entanglements, constructed beach obstacles, mines, floating obstacles, or natural sandbars. Figures 5-12 and 5-13 show how linear breaching charges are used to destroy submerged obstacles and sandbars. Underwater wire entanglements and natural obstacles can be breached with mechanical or explosive means. The placement of explosive charges on constructed beach obstacles is shown in figure 5-14. Floating obstacles should be reduced by destroying the anchorage only, allowing the obstacle to float or be hauled downstream. When possible, the obstacle may be removed by sinking it in place. Breaching water and beach obstacles often requires special personnel with special skills such as divers.

FIGURE 5-12. LOG SCAFFOLDING BLOWN BY BANGALORE TORPEDO

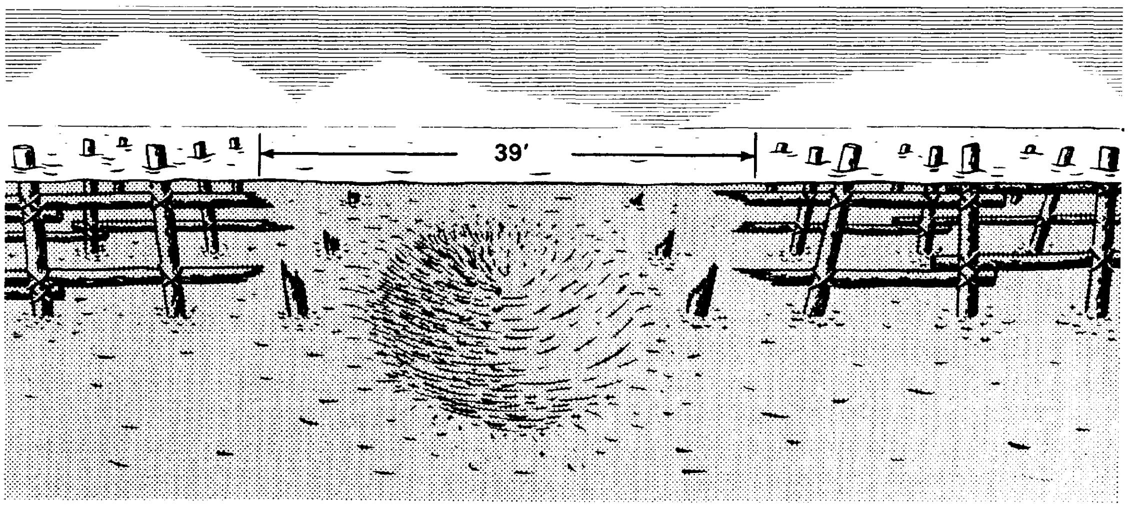
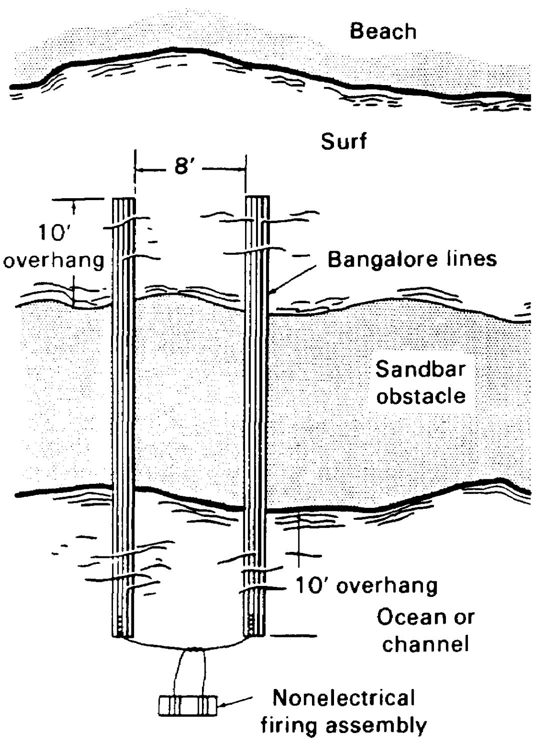
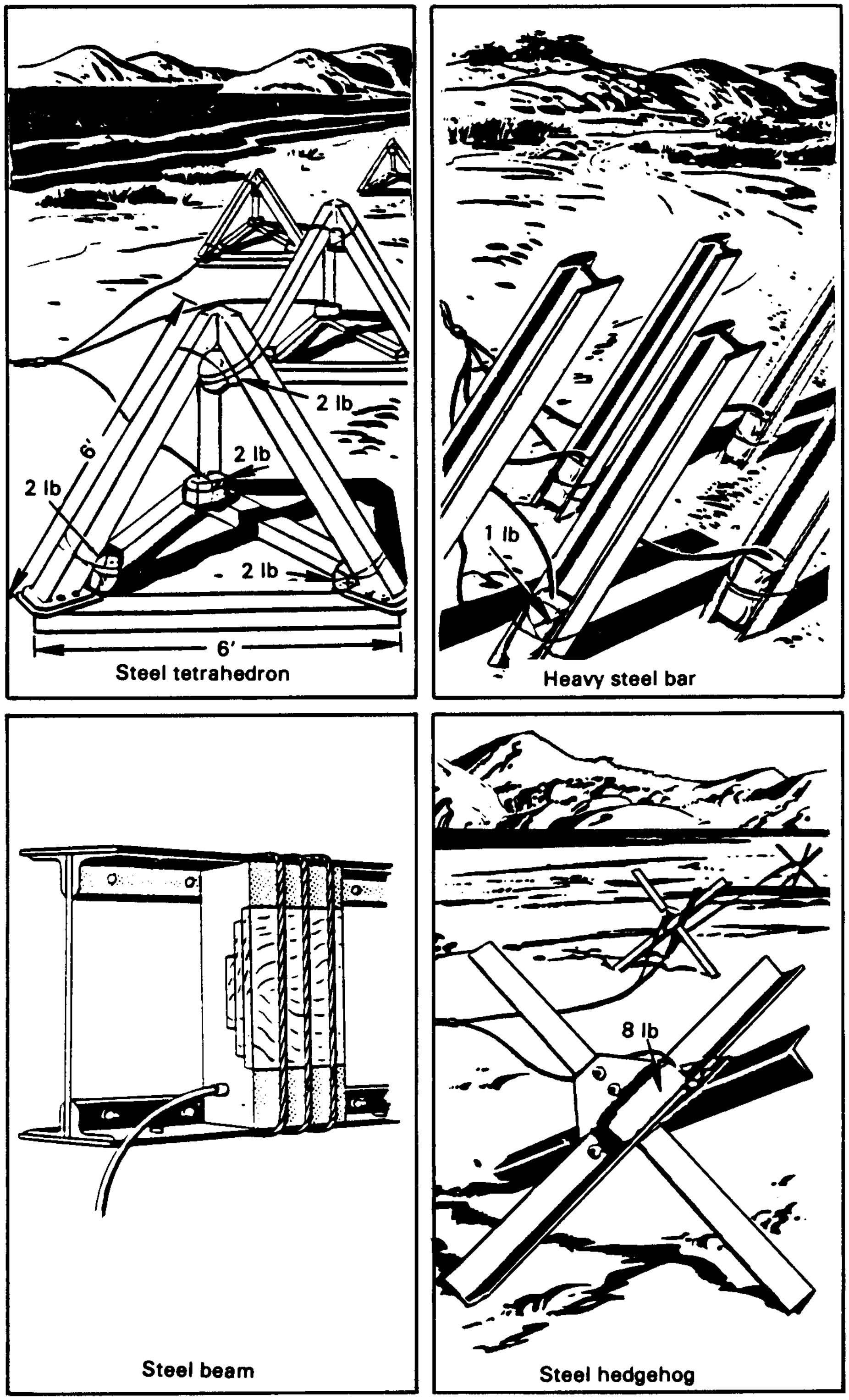


FIGURE 5-13. BLASTING SANDBAR



Strongpoints and urban rubble. A strongpoint is a well-fortified position designed to defend against an attack. Strongpoints may be encountered in all terrain environments, particularly urban, because buildings can be easily converted to hardened positions. When a strongpoint is assaulted, the area selected for penetration must be isolated from the remainder of the mutually supporting defensive system. The assault elements are organized in a manner similar to a force breaching an obstacle or minefield.

FIGURE 5-14. CHARGES PLACED ON BEACH OBSTACLES



Steel tetrahedron

Heavy steel bar

Steel beam

Steel hedgehog

The CEV is ideal for fighting through fortifications.

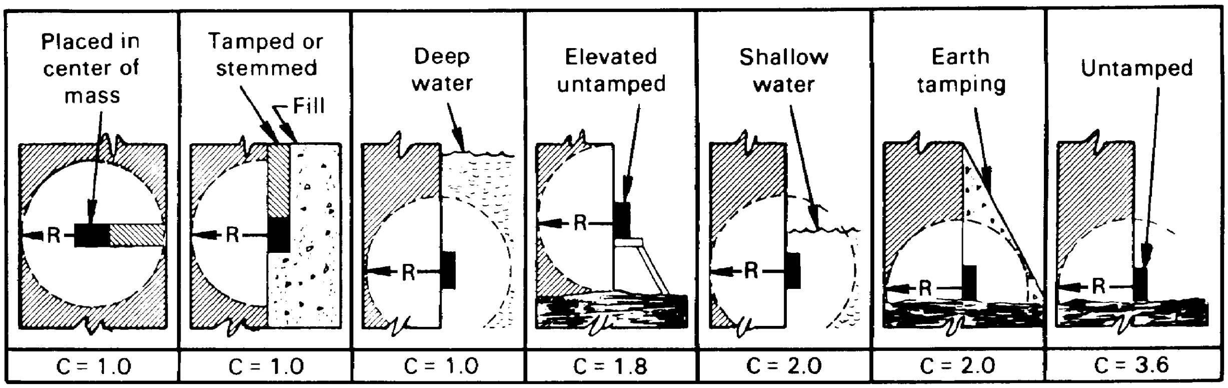
Breaching techniques. Engineers use the same techniques to breach strongpoints as they use to breach any other large obstacle system. Before the assault, forces conduct ground reconnaissance to determine breaching resources needed. Normally, those personnel conducting the breach will make the reconnaissance. After the fortified line has been breached, the route to and through the gaps must be maintained. Secondly, the captured fortifications should be destroyed by demolition or with heavy equipment. The CEV, with its 165-millimeter demolition gun, boom, winch, and blade, make it well suited for fighting through fortifications.

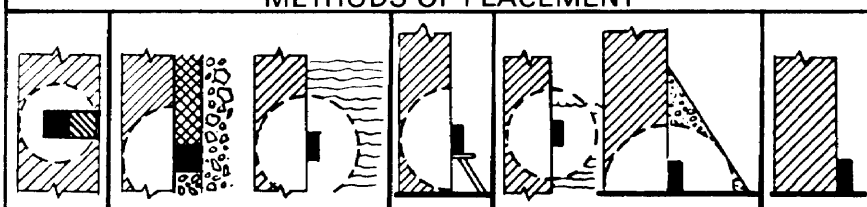
Use of mechanized equipment. Mechanized engineer equipment is essential for obstacle breaching missions in urban areas. The armored combat earthmover (ACE) and CEV are well suited to breaching force tasks in these environments. The ACE can remove rubble and destroyed equipment, rapidly fill craters, and clear the traveled way of roads.

The CEV can remove obstacles and rubble with its blade, winch, and boom. Its 165-millimeter demolition gun is effective against hardened obstacles. Both of these engineer systems afford limited protection against small arms fire, chemical contamination, and nuclear radiation.

Use of demolitions. Concrete obstacles, such as building rubble or bunker fortifications, can be breached using demolitions. Figure 5-15 shows the methods of placement for concrete demolition and an expedient calculation chart for determining the amount of explosives required. The disadvantage of this method is that personnel installing demolition charges are exposed to enemy covering fire. The combined arms team organizes for

FIGURE 5-15. CALCULATION OF TNT CHARGES FOR CONCRETE



THICKNESS OF CONCRETE (FEET)	METHODS OF PLACEMENT 					DISTANCE BETWEEN CHARGES (FEET)	
	POUNDS OF TNT					INTERNAL	EXTERNAL
2	2	8	14	16	28	2	4
2½	2	15	27	30	54	2½	5
3	4	22	39	44	78	3	6
3½	6	35	62	69	124	3½	7
4	8	52	93	103	185	4	8
4½	11	73	132	146	263	4½	9
5	15	79	142	158	284	5	10
5½	20	105	189	210	378	5½	11
6	22	136	245	273	490	6	12
6½	28	173	312	346	623	6½	13
7	35	186	334	371	667	7	14
7½	43	228	410	456	821	7½	15
8	52	277	488	553	996	8	16

C = Calculation factor   R = Radius of concrete breaching in the same manner as for countermine or other counterobstacle activities. If possible, the assault force secures the far side of the obstacle before the breaching force employs explosive charges.

Snow and icing obstacles. Obstacles created by mounds of snow in traveled ways delay or trap vehicles attempting to negotiate them. These obstacles may be deep snow or compacted ice over snow. Obstacles created by icing roads, slopes, and so forth create a temporary NO GO situation.

COMMAND AND CONTROL

PLANNING

The commander must maintain positive control regardless of the method used to overcome obstacles. Coordination and timing of the separate counterobstacle activities can only occur with good communications and a well-thought-out plan. To sustain movement momentum, counterobstacle activities must be executed violently and rapidly.

RESPONSIBILITIES

Counterobstacle activities and responsibilities are a necessary part of combined arms team operational plans. Responsibilities are divided as follows:

- Engineers (or specially-trained personnel if sufficient engineers are not available) should be organized with one squad per lead maneuver platoon. Breaching equipment should accompany these forward platoons. When necessary, additional engineers should accompany the main body to breach additional foot or vehicle lanes.

- Although infantry provides part of the assault force, they must also be trained in breaching foot lanes.

- Armor provides part of the assault force. They must also be prepared to use their tank dozers or rollers and to tow or push explosive charges.

- Supporting artillery provides counterbattery fire required to eliminate Threat artillery fires directed on breaching forces. Artillery or mortar-delivered smoke is essential to obscure the breaching effort.

- Combat service support is coordinated to allow rapid resupply and distribution during consolidation on objectives.

GROUPING OF FORCES

These forces are organized into the following three groupings:

- Support force provides the direct and indirect fire power assets required to assist the assault force.

- Assault force, consisting of infantry, armor, and engineers, is capable of accomplishing hasty attacks on the defending enemy.

- Breaching force, organized as required, provides vehicle lanes during hasty or deliberate breaches.

LANE CHARACTERISTICS AND MARKING

Breaching by mechanical methods is preferred over hand breaching. If possible, one breach per assaulting platoon should be made. The minimum number of lanes required is one per maneuver company. Surprise and limited observation by the enemy are necessary in the latter case. Breach lanes for obstacles will have the same characteristics as minefield breach lanes. These characteristics are explained in chapter 4. The unit that breaches an obstacle is responsible for marking the resulting defile or constricted route. Defiles may exist through an obstacle area, or a gap may be cleared through them. All routes or defiles are marked with standard marking systems or with expedient material by the breaching element.

Such routes may be suitable for both tracked and wheeled vehicles. Marking should allow for separation of these vehicles onto different lanes, if necessary. When it is necessary to give advance warning of a defile or obstacle breach lane, approach and exit markings are also required. Figure 4-4 on page 4-10 shows how these areas are marked. Some obstacles require the establishment of safety area markings, such as contaminated areas. As soon as possible, fences or markers are deployed to mark the perimeter of the hazard.

OBSTACLE HAND-OFF

The flow of traffic through a breached lane is an important consideration in maintaining or regaining the momentum of movement. While developing counterobstacle plans and orders, a technique for handing-off control of the breached lane is required. This step allows follow-on forces to quickly find the defile or lane and negotiate it. The tactical commander of the leading force can designate a guard team to remain behind in order to assure safe transfer of the site. If obstacles are detected early, guide detachments are provided by the follow-on force to remain at the breached lane or bypass and guide traffic safely to and through the obstacle.

OBSTACLE REDUCTION

Obstacle reduction is the complete destruction or removal of an obstacle and generally requires engineer support. It is undertaken to regain full use of routes and maneuverable terrain, or eliminate danger to personnel. Obstacle reduction is not generally conducted in conjunction with breaching as thoroughness and safety are the major considerations. Obstacle reduction is done with mechanical means or demolitions.

CHAPTER 6
Gap Crossing

HISTORY

HISTORICAL PERSPECTIVES

Ever since armies have marched and fought, leaders have faced the problem of crossing gaps. The natural difficulty of this task has persuaded them to use gaps as part of their defensive tactics. These crossings have frequently been defended by opposing forces. Since World War II, 29 significant battles have been fought at gap-crossing sites. Of these attempts, 21 were successful for the attacker. The eight unsuccessful crossings were not at rivers, but at streams ranging in width from 15 to 150 meters.

The armed forces of larger nations plan and train for mobile warfare with emphasis on mechanized combat forces. This creates a high degree of mobility both in nuclear and conventional warfare. However, most vehicles will still depend on roads for extended marches and must cross gaps, wet or dry, using special equipment or techniques. Gap-crossing equipment capabilities and Army vehicle mobility characteristics are given in appendix B.

Breaching in stride. Although gaps can be overcome by airborne, airmobile or AirLand operations, the ability to sustain combat depends on linkup with combat trains which are vulnerable to natural and constructed gaps and which may require assistance in crossing them. Therefore, even undefended, gaps produce delay that must be minimized. The speed of movement depends on the force's ability to breach gaps in stride.

Tactical advantage. The force conducting a gap crossing has several tactical advantages such as time, method, and location. This is particularly true for linear gaps such as lengthy tank ditches, streams, canals, or rivers. The defending force loses the initiative for choosing the time and location of the crossing and must usually hold the obstacle line with minimal forces. The defending force must also maintain reserves ready to move quickly to any threatened crossing site.

Role of attaching force. The attacker plans and executes gap-crossing tasks to exploit the defender's situation. It must surprise the enemy and swiftly pass through the gap before the defenders can mass forces and firepower. The defender generally cannot hold extended gaps in strength, however, crossings at any point maybe opposed. Before deploying gap-crossing assets, the attacker must eliminate enemy direct fire from the far side of the gap and when possible, eliminate observed indirect fires. It must then quickly establish a tactical foothold on the far side to prevent the defender from indirect fire observation. This creates a base from which moving units can defeat counterattacks and then continue movement.

CROSSING EQUIPMENT

Improvements in weapons systems have affected both gap-crossing techniques and equipment. The development of the armored fighting vehicle has dramatically influenced this process. There has also been a large increase in the size and weight of vehicles and equipment to be crossed. The speed and mobility of motorized vehicles has also increased significantly. As a result, an advancing force will encounter gaps requiring engineer effort more frequently than ever before. Table 6-1 provides a comparison of battlefield movement rates from 1940 to the present.

GAP-CROSSING LESSONS

The significant historical lessons of military gap-crossing operations are still applicable on the AirLand battlefield and focus on the attacker's ability to provide the following:

- Assets to quickly project combat power across the gap.
- Means to accomplish swift crossing of heavier combat equipment and supplies.
- Assets to replace initial bridging, rafting, or ferry equipment with more permanent structures so that the gap is not an obstacle on the line of communications and supply when assault bridging is recovered and returned for use by maneuver elements.

Military gaps. The term military gap is defined as any battlefield terrain feature, wet or dry, that is too wide to be overcome by self-bridging. In this manual, they are called gaps. Self-bridging means the ability of a

TABLE 6-1. BATTLEFIELD MOVEMENT RATES

	MODE	RATE (SUSTAINED)
1940	Infantry (dismounted)	4-5 km/h
1968	Infantry (M113 mounted)	20 km/h
1984	Armored/infantry (M1/M2 mounted)	30-40 km/h

vehicle to cross a gap using only its length, weight, and suspesion system. For example, US ‘Army main battle tanks can self-bridge over channels, streams, or ditches up to 2.7 meters (9 feet) wide (figure 6-1). Other tracked vehicles vary in their ability to self-bridge gaps. However, wheeled vehicles, with the exception of multi-axel configuration, do not have this capability. Table B-7 in appendix B lists combat vehicle self-bridging capabilities.

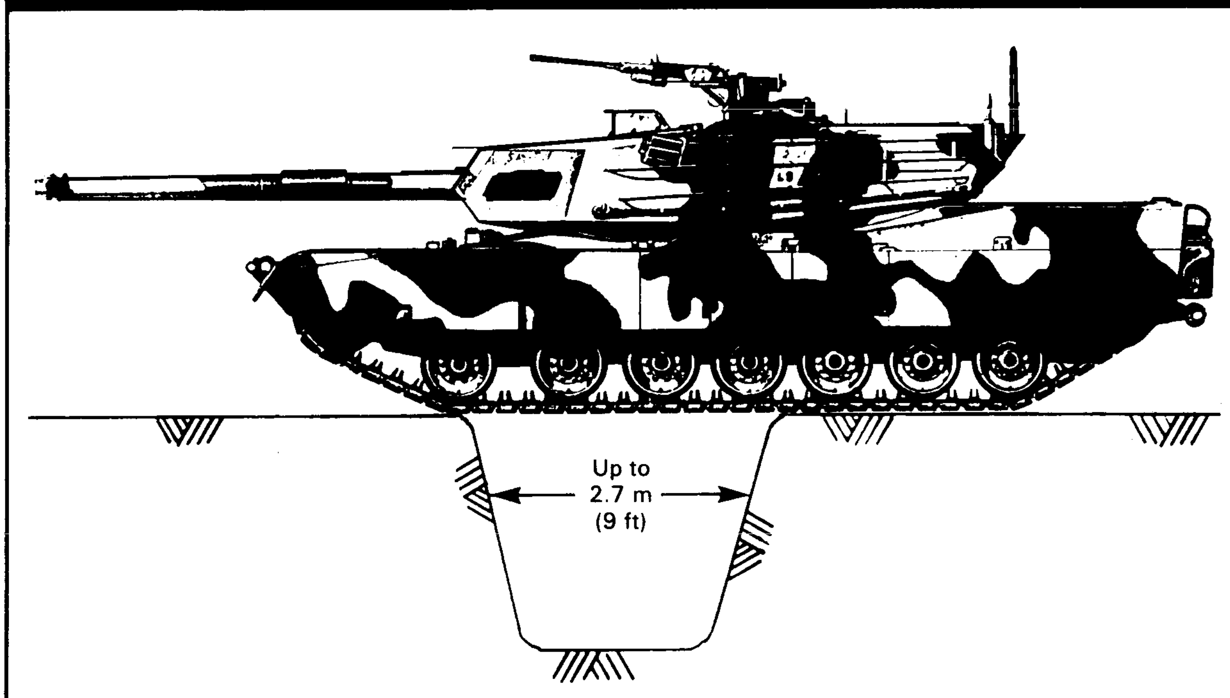
Fording. Fordability of a wet gap means. how easily it can be crossed without the use of special equipment. Fordability depends on both the physical characteristics of the gap and the crossing capabilities of the vehicle. Tanks are able to ford water depths up to 1.2 meters (4 feet). Trucks larger than the M151 utility series vehicle can ford water depths up to 0.9 meters (3 feet). Some vehicles can be equipped with devices that enable fording in water as deep as 6 meters (20 feet).

River-crossing operations. Even with sophisticated equipment, rivers remain major obstacles. A river crossing is one of the most complex combined arms operations. It differs from other gap-crossing activities in the size of the forces deployed. Generally, river crossings are conducted at division level. River-crossing doctrine is discussed in FM 90-13.

MOBILITY SYSTEMS APPROACH

As a mobility task, gap crossing involves those activities which will allow a force to maintain movement over or through gaps. Like other mobility tasks, bypass should be the first option considered. This is often not possible, however, as large linear gaps and reinforcing obstacles lessen the possibility of local bypass. Extensive movement of forces will be required to avoid crossings. Crossing sites must be carefully chosen. For linear gaps, a broad crossing front is best as it reduces congestion and vulnerability of troops to enemy fires. The characteristics of the obstacle and the types of equipment to be

FIGURE 6-1. SELF-BRIDGING CAPABILITY OF TANK



crossed will dictate the necessary equipment and techniques. Light forces, such as infantry, require minimal support in crossing most gaps. However, coordination for aerial resupply or follow-on crossing efforts are critical to the ability to sustain operations. Planners and commanders must determine specific characteristics of the obstacle when attempting to pass mechanized forces or wheeled traffic over dry and wet gaps. Also, the mobility scheme approach to planning and executing activities is critical. Planning, reconnaissance, consolidation, and reconstitution assume added significance to limit movement delay and the separation of forces at crossing sites.

TYPES OF CROSSING

There are two types of offensive gap crossings, hasty and deliberate. Both types imply that the crossing will likely be opposed. The movement of forces across the gap is conducted in a similar manner in both cases. Tactics can be based upon those specified for the breach of obstacles and mined areas.

Hasty crossing. In the hasty crossing, the attacking force uses organic, existing, or expedient crossing means with little or no loss of momentum. It must be anticipated and plans made in advance before the leading elements reach the near shore or bank. Routine procedures, such as positioning hasty crossing equipment well forward in march columns, will assist. Since time is the most important element, the commander and engineer select the quickest method. The following options are listed in order of increased time requirement:

- Drive across (self-bridge or ford).
- Swim amphibious vehicles.
- Employ the armored vehicle launched bridge (AVLB).
- Cut down banks and drive across.
- Use other expedient techniques.
- Raft/ferry force across gap.
- Use float bridging.
- Wait for follow-on bridging or bypass.

Deliberate crossing. A deliberate crossing is executed if a hasty gap crossing is not possible or has failed. A deliberate crossing is a centrally planned and coordinated activity. In most cases before crossing the gap, a build-up of forces and equipment is needed on both the near and far sides. Enemy forces must first be cleared from the near side. Next, a secure foothold must be established on the far side. Integrated with close air support and air defense weapons fire, this foothold lessens the chances of losing vulnerable crossing assets to enemy direct or observed indirect fires.

GAP-CROSSING STEPS

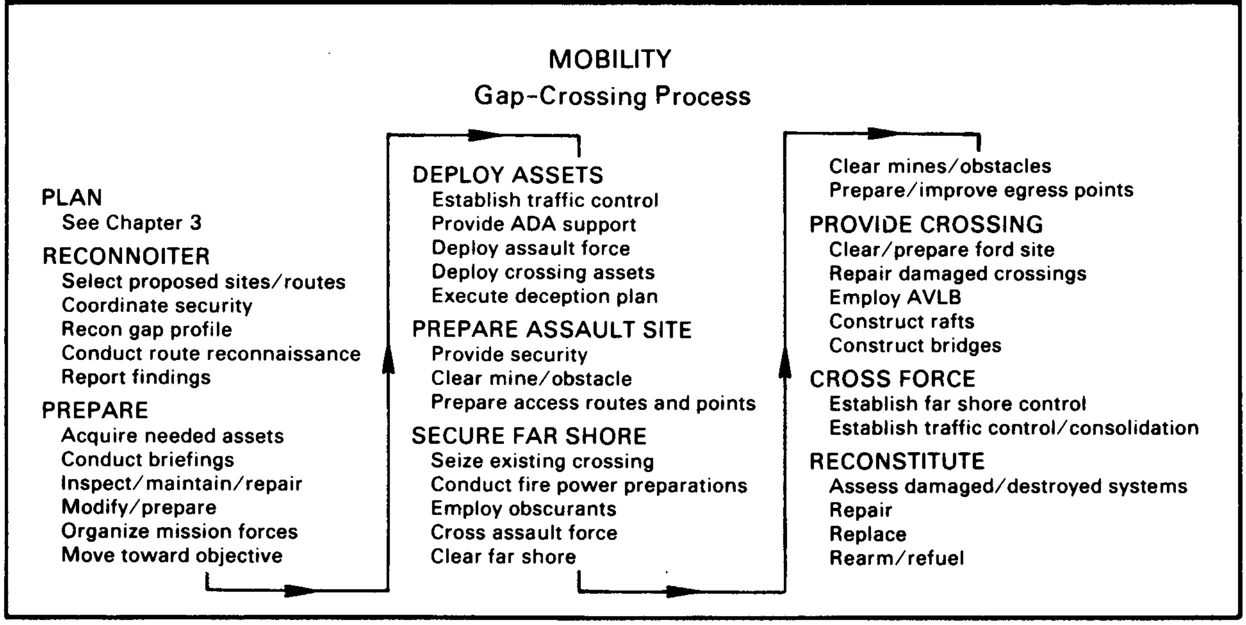
The gap-crossing functional area is made up of nine distinct steps (figure 6-2). Within each category, not all of the tasks maybe required. For example, crossing sites with suitable banks and entrance/exit points will not require extensive engineer preparation. The fundamentals of planning are described in chapter 3. The remainder of this chapter offers specific guidance and techniques which apply to the gap-crossing mobility function.

PLANS AND PREPARATIONS

Successful planning and preparation for gap crossing depends on early detection and investigation of gap obstacles. Timely and accurate intelligence data allows the commander to develop methods and tactics for overcoming the two greatest disadvantages of gap crossing, namely limited crossing assets available and the frequency rate at which gaps are encountered.

Organic crossing means. Since small gaps are encountered frequently, each maneuver force must have mobile crossing means of its own and be able to install them quickly. Follow-on bridging, such as the medium girder bridge, will have to be positioned after assault bridges are removed at each of these minor gaps. Also, the rate of encounter for

FIGURE 6-2. POSSIBLE SUBTASKS IN THE GAP-CROSSING PROCESS



wide gaps will require bridge systems capable of spanning these gaps to always be well forward.

Commander's decision. The rate of encountering gaps and scarcity of crossing assets present problems similar to those in other combat situations. The solution to these difficulties must be based on a sound tactical plan. The engineer or mobility planner must inform the commander of the engineering considerations for successful crossing with the assets and labor available and should state the most satisfactory plan from a technical point of view. The commander must then weigh the factors, risks, and limitations involved and decide on the best course of action.

RECONNAISSANCE AND SITE PREPARATION

DETECTION AND VERIFICATION

Generally, the existence and locations of gaps will be obtained in the planning phase. The staff mobility planner is able to pinpoint existing gaps along the proposed avenues of approach. In most cases, the physical characteristics of the feature, such as width, bank conditions, approaches, and water velocity (if applicable) can be obtained from divisional, corps, or theater Army terrain teams. The reconnaissance effort centers on verifying this data. Intelligence information provides the main source for detecting unknown reinforcing gaps. Such obstacles include antitank ditches and demolition craters. Tactical reconnaissance parties, such as scouts, or aerial observers, provide early warning of enemy-emplaced gaps. Reinforcing gap obstacles will likely be integrated with mines. Whether the gap is an existing or reinforcing obstacle, reconnaissance is essential to the maneuver commander. The commander must have timely information or verification of the gap, including mobility data on the routes to and from the gap. Thus, the commander is able to select the most tactically sound crossing site(s), routes, and method of deception. This information is provided by both ground and air reconnaissance means.

CROSSING AREA RECONNAISSANCE

Physical ground reconnaissance of possible crossing areas is preferred. This enables the crossing unit to "see" and plan support requirements and traffic control needs. Keeping in mind that the unit must attack the enemy and physically cross the gap concurrently, the reconnaissance of possible crossing areas focuses on the following features:

- Trafficable routes to the site and routes from the far side exit leading toward the objective.
- Fighting positions for supporting weapons on the near side of the gap.
- Fighting positions on the far side once a foothold is established.
- Covered, concealed, and dispersed assembly areas near the entry bank.
- Work areas for support forces and the collection of crossing assets.
- positions on both sides of the gap that could provide enemy observation on the crossing site.
- Effects of weather on soil trafficability, visibility, the use of smoke, and the current velocity (for wet gaps).

GAP PROFILE RECONNAISSANCE

The collection of data on the physical characteristics of the gap at each possible crossing site is a critical task. However, it may not be possible to obtain all of the desired information. The time available, accessibility of the site, and enemy situation may not allow detailed engineer reconnaissance. If possible, the minimum collection of reconnaissance data should include—

- Condition of access/egress points.
- Location and condition of existing crossing sites.
- Indication or sighting of reinforcing obstacles (mines, underwater obstacles, or obstacles constructed along the banks).
- Width, depth, and bottom conditions of dry gaps.
- Width, depth, bottom conditions, and water velocity of wet gaps.
- Bank height, slope, and soil stability of both wet and dry gaps.

Engineers use this information to determine specific site-crossing requirements. The entry and exit banks may require grading or other measures to stabilize the soil. The obstacle's depth and width will determine which crossing technique, such as fording, swimming, rafting, bridging, or driving across, is best suited to the needs of the maneuver unit. The water velocity in a wet gap will determine vehicle swimming capabilities and bridge anchorage requirements. The reconnaissance of existing bridges is necessary to enable engineers to plan for their repair or reconstruction along key routes. Figure 6-3 shows the physical characteristics contributing to wet gap-crossing abilities. Figure 6-4 shows the similar type of constraints for dry gaps.

CROSSING SITE SELECTION

The location and nature of crossing sites is determined by the tactical requirements of the unit, as well as the mission and objective beyond the gap. Characteristics of the obstacle and the amount of crossing equipment available will affect the number of crossing sites. If there are no fording sites across a wet gap, vehicles cross by swimming, rafting, or bridging. The routes of access and egress, the slope, stability of the banks, and the depth and velocity of the water for wet gaps all influence the selection of possible crossing points. Reconnaissance elements investigating possible sites must always be alert for

FIGURE 6-3. WET GAP SITE CRITICAL FACTORS

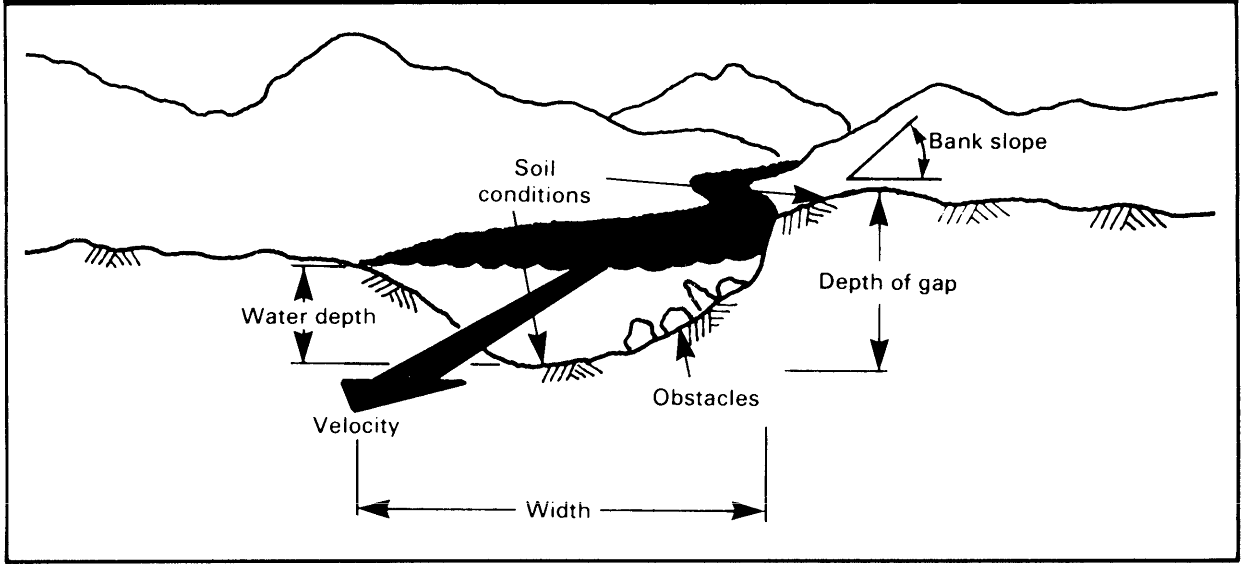
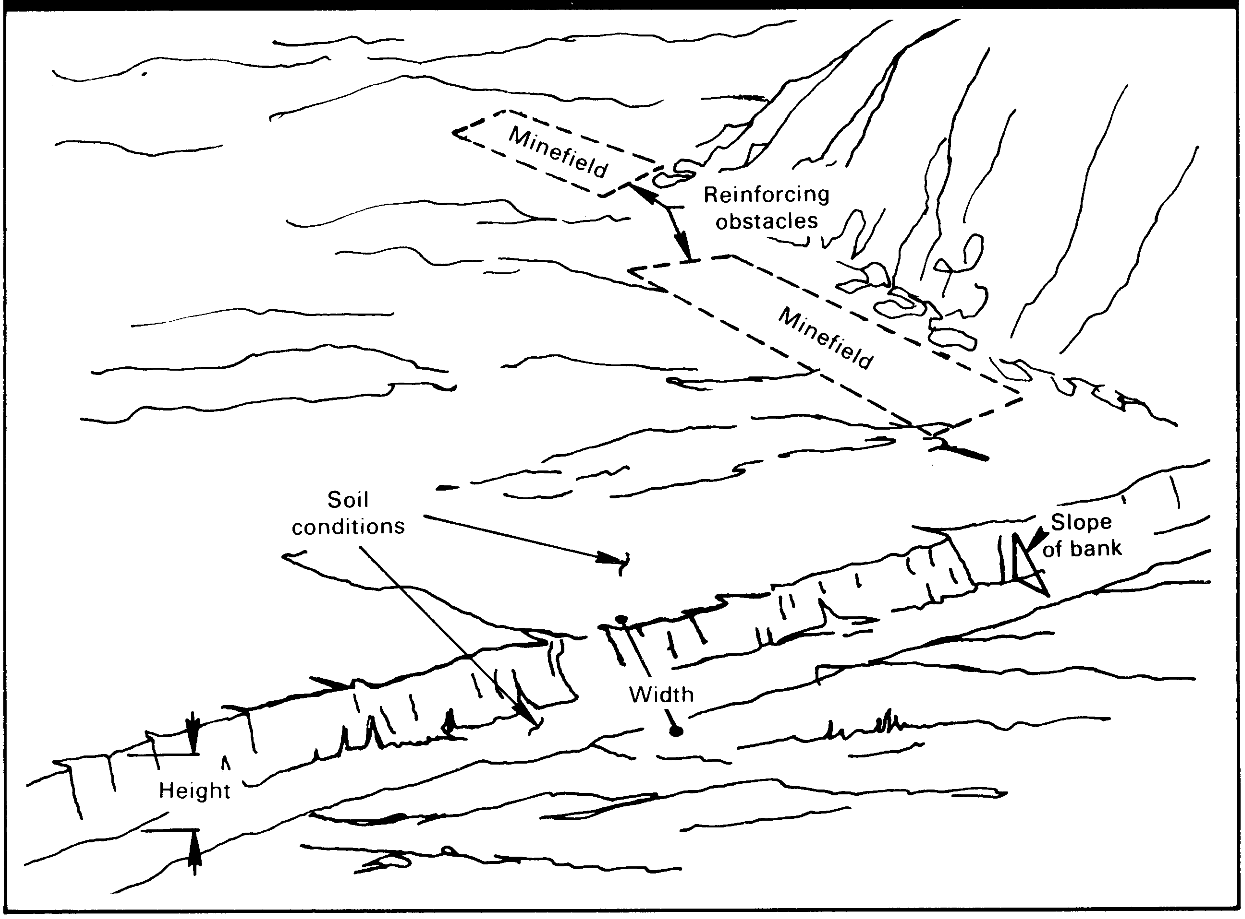


FIGURE 6-4. DRY GAP SITE CRITICAL FACTORS



signs of enemy mines or booby traps. These include obstacles and mines installed in the bottom of a dry gap or along both shores and underwater for wet crossings. Experience has shown that old crossing sites will be mined or obstructed more often than areas not previously used. A description of how the characteristics of a site influence each technique for crossing is necessary. Crossings can be accomplished either by using existing civilian bridges, swimming vehicles, fording, use of expedient means, or a military raft or bridge.

Civilian bridges. The securing of intact bridges should not be part of a site-crossing plan. If US forces or their allies gain military control, this action should be considered a bonus. Civilian bridges will normally be under enemy control and therefore destroyed by the defender before they are surrendered. Targeting of such bridges for director indirect fire is relatively simple as the locations are known by both sides. In many cases, the load classification of civilian bridges is not enough for heavy vehicles such as tanks. If used in defensive or retrograde crossings, civilian bridges should supplement other crossing techniques.

Vehicle swimming. Two factors should be considered in swimming amphibious vehicles through wet gaps—the velocity of the water and condition of the banks. In general, as stream velocity increases, most amphibious vehicles become less maneuverable, take longer to cross a given gap, and have more trouble in exiting. Also, because these vehicles drain rapidly when exiting, initially firm banks tend to deteriorate rapidly from multiple uses of the same exit point. Therefore, numerous exit points should be planned. This is true even when stream velocities are low and the bank's trafficability is good. The existence of mud or surface irregularities further degrades the percent of slope an amphibian can overcome.

Vehicle fording. When selecting a fording site in a wet gap crossing, the depth of the water is the most significant factor. The ability to ford varying depths depends on the vehicle. The depth of the water in one crossing area may change due to bottom surface mud or irregularities (boulders or pot holes).

Expedient crossing means. When evaluating a potential crossing site, the reconnaissance party should note material or existing features that could be used as expedient crossing devices. These include culvert pipe, lumber or cut timber, or war-damaged equipment. Sections of culvert pipe, for example, laid side by side in the gap, form the basis of a culvert bridge. The culverts are laid parallel to the current in a wet gap. Any available fill material is placed over the culverts, thus dissipating the pressure of vehicles over the surface of the pipes. Disabled or destroyed vehicles pushed into the gap can also become an expedient crossing surface.

Military rafting/bridging. The first criteria in selecting crossing sites is whether crossing without bridging or rafting would cause significant delay. Steep banks, water velocity, and depth of the gap are the critical factors. Steep bank angles are normally enough to prevent the exiting of swimming or fording vehicles. Water velocity determines equipment requirements. When a wet gap is too deep for fording, bridging and rafting equipment should be used. Float bridge equipment is organic at separate brigade, division, and corps levels. FM 90-13 provides additional information on the deployment of these assets to support major combined arms operations.

RECONNAISSANCE REPORTS

Reports of a gap's initial detection or supplemental intelligence data is essential to gap-crossing plans. Swift, accurate reports allow the commander and staff to adjust tactical plans.

Four different report formats are provided in this section. These are the amphibious crossing site report, ford report, ferry site report, and bridge site report. A sample obstacle report format is given in chapter **5.** Much of the detail for these reports can only be provided by qualified engineer personnel. Nonspecialist personnel include only the detail they are qualified to collect and report. The discussion of these reports and the reconnaissance include expedient techniques for gathering the required technical data. All of the reports implement Standardization Agreement (STANAG) 2096.

Although these reporting formats were devised for radio transmission, the most secure means of communication, usually written, should be used to lessen the vulnerability of the force and for tactical surprise. Radio transmission should be the last choice. Supplemented with drawings, maps, traces, or overlays, these written reports are forwarded through operational channels and monitored by the staff intelligence, logistics, and engineer sections (if provided). Also, the reports are provided to the terrain analysis detachments in order to update their data base. The originator completes only those parts of the report which apply to the results of the reconnaissance.

These reports, usually written, should be forwarded by the most secure means available.

Obstacle reports. Most gaps are detectable during the mobility planning sequence. Reinforcing gaps, such as craters created by demolition just prior to encounter, will not be detected early. The obstacle report is used to report initial detection of such gaps. Subsequent reconnaissance, if required, provides additional detail.

Amphibious crossing site reports. The amphibious crossing reconnaissance provides information concerning the difficulty of swimming vehicles across a wet gap. This report requires that the observer make a military judgment appraisal on the combined physical characteristic effects of the gap. A sample amphibious crossing site report is shown in figure 6-5 on page 6-10.

Ford reports. The object of this report is to determine if vehicles can negotiate a wet or dry gap without swimming. Measurements, such as water depth, slope of banks, and stream velocity, are made physically. A sample ford report is shown in figure 6-6.

Determining depth of gaps. Field expedients, such as measured poles or weighted ropes, are usually required. Depth readings are normally taken every 3 meters. Depths and currents must be checked at frequent intervals to warn against changes due to environmental factors such as rain, snowfall, or the opening of dams or locks upstream.

FIGURE 6-5. SAMPLE AMPHIBIOUS CROSSING SITE REPORT

ALFA	Map sheet(s).
BRAVO	Location (grid reference) and date-time group of observation.
CHARLIE	Types of amphibious vehicles considered (wheeled, tracked, and so forth).
DELTA	Classification and frontage, in meters, of complete site, for example, WHITE-400 meters. ● White. A site where vehicles can be expected to make a passage with such ease that few, if any, will require assistance. ● Gray. A site where the majority of vehicles will require assistance to make a passage. ● Black. An impractical site owing to the excessive amount of assistance required.
ECHO	General information to include other limitations, for example, mines, debris, ice flows, ice thickness, enemy observation, enemy fire, and explanation of restrictive factors.

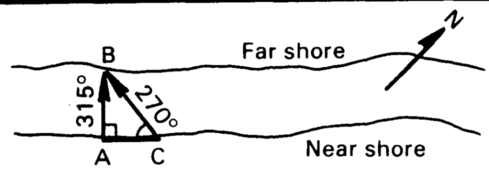
Determining gap width. For wet gaps or gaps with restrictive terrain, a compass can be used to measure the distance from bank to bank. From a point on the near shore and close to the water's edge, the azimuth to a point on the opposite shore is taken and recorded. Another point on line at a right angle to the azimuth selected is established on the near shore from which the azimuth to the same point on the far shore is 45 degrees (800 roils) at variance with the previously recorded azimuth. The distance between the

FIGURE 6-6. SAMPLE FORD REPORT

ALFA	Map sheet.
BRAVO	Date-time group of information collection.
CHARLIE	Location (grid reference or trace).
DELTA	Minimum width.
ECHO	Maximum depth.
FOXTROT	Stream velocity.
GOLF	Type of bottom, for example, SOFT SANDY or FIRM ROCKY.
HOTEL	Maximum slope on banks and bank condition, for example, 9 percent-SLIPPERY CLAY.
INDIA	Trafficability of near and far shore routes (GO, SLOW GO, NO GO).
JULIETT	Rise and fall of water level.
KILO	Concealment/cover.
LIMA	Any other information which could be given, such as essential limiting factors or requirements for support.

two points on the near shore is measured, and this distance is equal to the distance across the stream (figure 6-7).

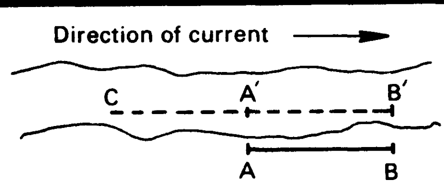
FIGURE 6-7. MEASURING GAP WIDTH WITH COMPASS



Key:
A is the point on the near shore.
B is the point on the far shore.
AB is the distance to be measured.
Azimuth of line AB is 315°.
Azimuth of line CB is 270°.
Difference between azimuth AB and azimuth CB = 45°.
Distance along AC equals distance along AB.

Determining stream velocity. Current velocities vary in different parts of a stream. In general, the current is usually slower near the shore and swifter in the main channel. Similarly, the current is slower as the stream widens. To determine the velocity of a stream, measure a distance along the river bank (figure 6-8). Throw a light object which floats into the stream, and record the time the object takes to float the measured distance. This procedure is then repeated several times. The average time of the tests is then used in the formula in the figure to determine stream velocity .

FIGURE 6-8. DETERMINING STREAM VELOCITY

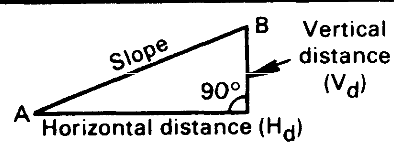


$$\text{Vel} = \frac{\text{Measured distance AB (meters or feet)}}{\text{Time to float from A' to B' (seconds)}}$$

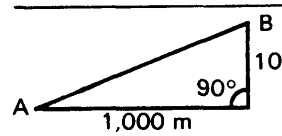
Note: The same method of measurement, feet or meters, is used throughout the process.

Determining slope on banks. The rise or fall of a ground form from a specific point is known as slope. Slope can be expressed as steep or gentle, but these terms are too general for gap-crossing reconnaissance purposes. A more exact slope description is needed to indicate the effect a given slope will have on traffic flow. To meet this requirement, reconnaissance personnel compute and report the percent of slope for bank gradients. Percent of slope is the ratio of the change in elevation (vertical distance) to horizontal ground distance, multiplied by 100 (figure 6-9). Percent of slope is used to describe slopes which rise or fall. If not shown by symbol, arising slope in the direction of travel is preceded by a plus (+) sign, and a falling slope by a minus (-) sign. In computing percent of slope, the vertical distance and the horizontal distance must always be expressed in the same unit of measure.

FIGURE 6-9. DETERMINING SLOPES ON GAP APPROACH BANKS

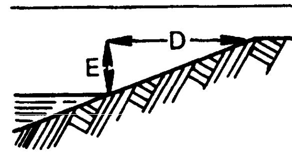


$$\text{Percent of slope from A to B} = \frac{\text{Vertical distance } (V_d)}{\text{Horizontal distance } (H_d)} \times 100$$



Example: From A to B

$$\text{Percent of slope} = \frac{V_d}{H_d} \times 100 = \frac{100\text{ m}}{1{,}000\text{ m}} \times 100 = +10\%$$



D = Approach distance
E = Approach elevation

$$\text{Slope in percent of approach} = \frac{E}{D} \times 100$$

This report confirms or denies the possibility of using military rafts.

Ferry site report. The object of reporting ferry or raft site information is to confirm or deny the possibility of using military rafting equipment. A sample ferry site report is shown in figure 6-10.

FIGURE 6-10. FERRY SITE REPORT

ALFA	Map sheet(s).
BRAVO	Date-time group of collection of information.
CHARLIE	Location (grid references or trace).
DELTA	Trafficability of near and far shore routes (GO, SLOW, GO, NO GO).
ECHO	Possibilities for concealment or cover.
FOXTROT	Width of the river.
GOLF	Depth of water along ferry path and at the banks, including tidal information.
HOTEL	Stream velocity.
INDIA	Maximum slope on bank approaches and bank conditions.
JULIETT	Parking areas for road and water transport.
KILO	Any other information which could be given, such as maximum number of rafts for which site is usable, work required in personnel-hours for preparation of approach routes, present water gage reading, if available, and obstructions or restrictions at the site.

Bridge site report. Unlike the bridge report format described in chapter 5, this report describes likely locations for emplacing gap-crossing bridges. It can be used for reporting employment sites for the armored vehicle launched bridge (AVLB) or for bridges capable of spanning large gaps. A sample bridge site report is given in figure 6-11.

SITE PREPARATION

Once a crossing site is selected, the force collects and prepares the soldiers and equipment required to successfully cross the gap. At this stage, the necessary command and control measures are initiated. These include the separation and control of assault forces, crossing means, and support forces. The organization, preparation, and rehearsals necessary for crossing tasks are similar to those for countermine and counterobstacle activities. These allow flexibility of control. If possible, a plan is initiated to deceive the enemy of crossing intentions. The crossing site selection should minimize discovery by the enemy. Crossings should start at night as a further measure of protection. Smoke generator detachments are employed when available. If possible, the site is secured from enemy air and underwater attack. Air Defense Artillery (ADA) units will be employed to protect the crossing site\ area. Also, alternative plans are available in case the site is destroyed. Once a crossing site has been detected, it will be extremely vulnerable. Arrangements should be made for the quick dispersal of crossing equipment or for alternative means of crossing. When possible, the frequent changing of crossing sites should be planned, rehearsed, and executed in the deployment of forces.

FIGURE 6-11. SAMPLE BRIDGE SITE REPORT

ALFA	Map sheet.
BRAVO	Date-time group of collection of information.
CHARLIE	Location (grid reference or trace).
DELTA	Width of gap between near and far bank edge of gap.
ECHO	Width at water level.
FOXTROT	Width at bottom of gap.
GOLF	Rise and fall of water level and change in wet gap width.
HOTEL	Velocity of current.
INDIA	Nature of bottom.
JULIETT	Height of near bank above water level.
KILO	Height of far bank above water level.
LIMA	Safe bearing pressure of soil.
MIKE	Description of work required on approaches, near and far banks.
NOVEMBER	Possible local areas for concealing bridging equipment.
OSCAR	Potential staging areas.
PAPA	Turnouts for oversize, overweight, or disabled vehicles.
QUEBEC	Trafficability.
ROMEO	Road nets.
SIERRA	Assembly areas.
TANGO	Engineer release point.

PREPARATION OF ASSAULT SITES

The first step in executing a gap crossing is the control of the near bank side of the gap. This includes moving to the selected site and establishing security. Adequate routes are important for the timely movement of the assault force and crossing assets. Combat trails may have to be developed under fire. The CEV and M9 armored combat earth-mover (ACE) should be deployed forward to assist in these tasks. Clearing and upgrading of approaches to crossing sites and the sites themselves is a priority task for engineers. Once the near side is secured, access and egress points must be prepared. These points, and the banks at crossing sites, will likely be reinforced by obstacles and/or mines. The techniques for breaching these additional restrictions are applied by the force making the initial crossing. They can be assisted by the assault force before their deployment to the far shore. Once these tasks are accomplished, the crossing is begun.

METHODS OF CROSSING

HASTY CROSSINGS

Hasty gap crossings are characterized by several factors, they are—

- Speed, surprise, and a minimum loss of momentum.
- Weak enemy defenses on both banks.
- Minimum **concentration** of forces.
- A quick continuation of the attack.

To maintain momentum and to get maximum combat power across quickly, the maneuver force negotiates the gap on a broad front. Air assets are ideally suited for this mission. Airborne or airmobile forces can be used to enhance surprise and establish forces on the enemy side of the obstacle. They can also speed up crossing tasks by carrying equipment quickly. Airmobile forces can be used to seize crossing sites before the enemy can destroy or damage them.

Dry gap hasty crossing. Antitank ditches and craters are examples of dry gap-crossing obstacles. They are used to block roads and trails at points where the terrain prevents bypassing. To hamper breaching operations, antitank and antipersonnel mines are often placed at the obstacle and covered by indirect and direct fire. Once the mines have been breached and direct fire suppressed as much as possible, the CEV or M9 ACE can be used to push down the sides of ditches or to fill in craters. The CEV demolition gun or hand-emplaced explosives can be used to cave in the sides of ditches sufficiently to allow passage of traffic. Substantial fill material placed in craters or ditches allows the passage of combat tracked vehicles. The crossing site can be improved and maintained for wheeled traffic use after the far side is secured. The AVLB is particularly suited for spanning streambeds, antitank ditches, craters, canals, partially blown bridges, and similar obstacles. It can be launched or recovered in less than 5 minutes. Normally, the engineer AVLB is attached to a forward engineer element for use in hasty crossings of short gaps. The AVLB should be left in place across the gap only so long as necessary, then replaced with other fixed bridging. If the hasty bridge is not required for follow-on forces, the last tactical element across is responsible for recovering the bridge. Otherwise, the launcher may be directed to move rearward or remain in place to meet up with a replacement bridge.

Wet gap hasty crossing. The divisional engineer battalions provide wet gap-crossing support to the tactical maneuver units. Major wet gap crossings usually require additional support from corps or theater army engineer units. Identifying wet gaps early and deploying the required resources allow hasty crossings of known or anticipated gaps to occur in stride. Bridges are rarely employed in the assault phase because of their vulnerability to enemy fires and the need to concentrate assets at the crossing site(s). The exception is the AVLB which is used in wet gap hasty crossings. If possible, an assault force is projected across the gap. However, the AVLB requires only the elimination of direct fire and security afforded by support forces, as the vehicle provides small arms and limited NBC protection.

Crossing means. When necessary, the leading force engineer unit constructs mobile assault, float bridges, or expedient bridges. These crossing means will be replaced by other floating or fixed bridging as soon as possible to permit the forward bridge company to retrieve its equipment and continue to support the leading force.

Engineer tasks. Engineer tasks in the wet gap hasty crossing include—

- Breaching or reducing obstacles and/or mines.
- Guiding the assault forces to the crossing site.
- Finding and upgrading ford and swim sites.
- Operating and controlling crossing equipment to include traffic flow.
- Constructing approach roads and exits.

FM 90-13 contains a detailed discussion on the planning and execution of river crossings, including the responsibilities of all elements involved.

DELIBERATE CROSSINGS

The deliberate breach of gaps is used when a hasty gap crossing is not feasible, has failed, or when renewing offensive operations at the gap. It may be forced by a large or complex gap obstacle. Such a gap could prevent effective use of organic or expedient crossing means. A strong enemy defense on one or both sides of the crossing site may also require a deliberate crossing. Deliberate gap crossings are characterized by—

- A deliberate pause to prepare, acquire additional equipment, and concentrate combat power.
- Clearance of enemy forces from the entry bank.
- Air superiority over the crossing site.
- Air defense protection within the crossing area.
- Detailed planning and centralized control.

Wet gap deliberate crossing. The deliberate gap crossing is divided into three phases. These phases are the assault phase, rafting phase, and the bridging phase. They may occur in sequence or concurrently. In each of these phases, the responsible engineer unit—

- Knows the availability of crossing equipment.
- Recommends crossing sites.
- Plans the use of fords,
- Plans for aiding amphibious vehicles to exit the far bank.

In planning the deliberate gap crossing, the engineer should plan for—

- Rehearsal of the crossing.
- Inspection of amphibious vehicles.
- Location of concealed crossing equipment assembly areas.
- Enforcement of noise and light discipline.
- Control at fords and amphibious crossing sites.

- Establishment of entry and exit bank recovery teams.

Objective. The objective in deliberate gap crossings is to project combat firepower to the exit bank at a rate faster than the enemy can concentrate forces for a counterattack. To do this, the commander may elect to first construct rafts for nonswimming vehicles while swimming vehicles make the crossing. Bridge construction is started when observed indirect fire has been eliminated. If the tactical situation allows elimination of the rafting phase, bridging efforts would begin immediately. This is a suitable option considering the high speed of employment of systems like the ribbon bridge. Factors in evaluating these alternatives include—

- Opposing force capability to fire on crossing sites.
- Types of crossing equipment.
- Crossing sites available (number, location, and quality).
- Characteristics of the obstacle.

Temporary means. Rafting is generally a temporary method of moving firepower to the far bank and should stop once this equipment has crossed. For planning purposes, bridges should be constructed to move the elements of the brigade trains and other follow-on units. If sufficient equipment is available, rafting operations may continue while replacement bridges are under construction. The rafts may later be incorporated into the bridges or removed.

Responsibilities. Plans for movement across a wide wet gap must be detailed and control of traffic must be positive. Initially, exit bank responsibilities will be assumed by divisional units until they can be relieved by nondivisional engineers. Communications planning is critical, continuous, and concurrent with tactical planning. Prior to contact with enemy forces, radio listening silence should be strictly enforced to deny the enemy knowledge of the crossing. Once friendly intentions are obvious, maximum use of wire communications with provisions for backup wire and messenger communications is essential. Standing operating procedures should include allocation of communications equipment for major wet gap crossings.

Dry gap deliberate crossing. Deliberate dry gap crossings are generally determined by the strength of enemy defenses or the magnitude of the gap. If possible, the use of the M9ACE, CEV, and blade tanks to reduce banks, or the AVLB are preferred. The Bailey bridge, medium girder bridge (MGB), and M4T6 dry span are used for spanning major dry gaps. These assets are labor-intensive and expose personnel to enemy fire during their construction. In all cases, the most important goal is to reduce enemy resistance. Maneuvering assault forces on the far bank is a crucial step of the deliberate crossing. Use of air assault assets is desired but will generally involve assault into the enemy's flanks or rear. This could be time restrictive and is dependent on local air superiority. Other means involve using rope or foot bridges for dismounted crossings. Support force concentration of suppressive fires and obscuring smoke on the enemy also contribute to successful dismounted maneuver.

RETROGRADE CROSSINGS

Obstacles and mines placed behind defending forces by the enemy must be expected in withdrawal operations. The enemy will attempt to isolate units and disrupt withdrawal routes. Gap-crossing sites will be prime targets. Proposed or operational sites will be damaged or destroyed, and actual contact with enemy forces is possible. Success in retrograde crossings depends heavily on the force possessing tactical mobility equal to, or greater than, the opposing force. Withdrawal forces should cross on existing permanent bridges whenever possible. These structures are prepared for rapid destruction as a countermobility task, and provide the best retrograde crossing means. When needed, crossing equipment that can be recovered rapidly should be used. Tactical bridging, such as the M4T6, should be removed early in the operation. Crossing assets are destroyed in place if the enemy is likely to capture and use them.

THREAT ACTIVITY DURING RETROGRADE

If the enemy becomes aware that a gap crossing is critical to the success of a retrograde operation, it will make every effort to destroy or capture the site. Deception and camouflage play a large part in opposing such efforts. The pursuing force will seek a rapid, deep penetration to cut off a successful retrograde crossing. Threat doctrine directs lead elements of pursuit columns to fix retrograding forces while other forces attempt to encircle. Motorized rifle elements can be expected to mount flanking attacks. Artillery and tactical air elements organic to the Threat attackers will attempt to place continuous fires on retrograding forces.

RETROGRADE CROSSING TASKS

Retrograde gap-crossing tasks do not consist of offensive methods conducted in reverse. One advantage is that both banks of the wet or dry gap will be under friendly control. Detailed area and crossing site information is readily available to the commander. This knowledge, combined with information of enemy strengths, dispositions, and expected tactics, allows the commander to task-organize forces in the most effective manner for defensive operations and retrograde crossings. A strong defense on both banks is important to aid those forces remaining in the entry bank to cross successfully. This defense must secure the crossing site until the bridge is removed or destroyed in place.

Detailed planning is necessary to insure the success of this phase. The initial defense force should be small. It consists of elements not involved in the retrograde as well as reserve units, if available. As forces cross the gap, they assume defensive positions. Since forces are not available to defend all points, mobility tasks must provide for rapid lateral movement to concentrate firepower. Army aviation support can assist in movement and provide economy of force coverage of lightly defended areas. This lateral movement provides favorable ground force ratios at the required time and place.

ENGINEER SUPPORT DURING RETROGRADE CROSSING

The engineer's role in retrograde gap crossings will generally involve all of the mobility-countermobility -survivability (M-CM-S) tasks. The major engineer support requirements are the crossing of the retrograding unit, the development of defensive measures on the exit bank, and the creation of obstacles on the entrance (enemy) side.

Crossing support. The techniques and methods for engineer participation do not differ from offensive crossings. Responsibilities still include operation of crossing assets and repair of crossing site points and routes. Command and control of these tasks is required so that a safe, orderly, and efficient withdrawal crossing can be executed.

Exit bank defenses. Defensive positions, including survivability measures, are developed on the exit. These positions are continually improved and expanded to accommodate elements that are crossed. Lateral combat roads and trails are provided in order to allow rapid concentration of combat power along the defense.

Obstacle development. Engineer countermobility tasks are performed on both sides of the retrograde crossing site. Obstacles and minefield that impede or channelize the enemy on approaches to the far side entry bank are emplaced to enhance the effectiveness of friendly overmatching fires. Obstacles and mines used on the exit bank side of the gap are designed to create maximum difficulty for pursuit force crossing efforts.

RETROGRADE CROSSING EXECUTION

Operation of the crossing area must provide for the following requirements.

- Rapid flow of traffic across the gap. Emphasis is placed on siting crossing equipment to accommodate varying quantities of friendly forces.
- Assurance that only essential personnel and equipment are operating in the crossing area.
- Coordination of crossing sites to insure overwatch of forces withdrawing under enemy pressure.
- Control of all movement to, across, and exiting from the gap.
- Maximum use of obscurants, close air support, and air defense support.

Crossing assets must be removed or destroyed as soon as the last withdrawing elements have passed and before the advancing enemy can cross. Commanders will provide multiple demolition systems, positive command and control, and guards adequate to insure destruction. When there is great risk or the enemy has tactical advantage, major bridges should be destroyed in advance and tactical or assault systems used in the final withdrawl.

COMMAND AND CONTROL

GAP-CROSSING CONTROL

More than any other mobility task, gap crossing involves the management of combat power, space, time, and terrain. The maneuver commander is responsible for and coordinates all gap-crossing activities which support the operation including the use of artillery, aviation support, and engineer assets. Crossings require that assets be massed and elements separated, temporarily, by the obstacle. Therefore, the details of the command and control organization are disseminated throughout the entire force. The controlling headquarters must be flexible enough to react to any changes in the tactical situation and scheme of crossing.

Management. Space and terrain management around selected crossing sites is necessary for controlling movement and enhancing survivability. Terrain is allocated on both sides of the gap for the various elements to disperse, work, move, and consolidate when required. Traffic and movement control is a responsibility of the command and control headquarters. The entire sequence of assaulting, crossing, consolidating, and then continuing movement is regulated by a tactical timetable. This allows soldiers and equipment to cross in a tactically sound sequence while making efficient use of crossing sites.

Threat considerations. The possible use of nuclear or chemical weapons against friendly crossing activities impacts on control procedures. In order to prevent them from becoming targets, concentrations of forces on either side of the gap must be minimized. During actual crossing of the assault force or main body, troops and their equipment are passed over the obstacle as swiftly as possible. The controlling headquarters also varies the crossing site location. Operation of a single crossing site over an extended period of time increases the possibility of enemy interdiction.

ORGANIZATION FOR CROSSING

Commanders and staffs should include gap-crossing considerations during the planning and preparation phase of an operation. The resulting task organization and orders will include gap-crossing responsibilities and contingencies. When engineer assets are planned for crossing activities, they should be located forward in the movement column. Whenever possible, task-organized forces conduct rehearsals on actions taken upon encountering gap obstacles. The commander organizes the forces into three elements for gap crossing. These groups are the same regardless of the category or type of gap. The elements follow.

The assault force. The primary mission of this force is to project combat power across the obstacle once the near side is secured. A foothold on the far side of the gap is established and enemy direct and observed fire eliminated. The assault force then becomes the cornerstone of the unit's consolidation effort on the far side. Normally built around infantry units, it is responsible for repulsing enemy counterattacks during the vulnerable phases of establishing and crossing the main body. Engineers generally assist in the crossing on land and water. Aviation assets move the assault force vertically over the obstacle.

The crossing means. Engineers are responsible, in most cases, for the actual crossing means and equipment. Their initial priority is the preparation of the near side of the gap while the assault force seeks to establish security for far side exits. Once enemy opposition on the far side is reduced, a method of crossing is quickly established. The responsibility for the actual crossing also includes far side exit trafficability.

The support force. The support force includes all units providing overmatching fires, indirect fires, and other combat support assistance (such as air defense artillery and smoke) and those elements waiting to cross the gap. They are essentially the main body of the maneuver force.

TRAFFIC CONTROL MEASURES

There are two control measures applicable to negotiating forces across gaps. They are staging and holding areas. Staging areas are waiting areas for convoys which will cross the obstacle. They are located far enough away from the gap to facilitate rerouting and use of the alternate roads to crossing sites. Areas selected for staging require—

- Cover and concealment.
- Sufficient area for vehicle and equipment dispersion.
- Easy accessibility.
- Sufficient trafficability to prevent delays caused by terrain problems.

Holding areas are designated waiting spaces both near and within crossing areas to handle vehicles should a sudden interruption occur in the movement of traffic across the river. Vehicles move into these areas and disperse rather than stand on roads and restrict the flow of traffic into crossing areas.

COMBAT SERVICE SUPPORT

In a gap-crossing situation, the committed combat forces will be temporarily separated from their full combat service support. In the early stages of assault only, those vehicles essential to the conduct of the operation should be allowed over or through the obstacle. Ammunition and fuel replenishment vehicles are given sufficient priority to insure timely resupply.

Helicopters. Helicopters may provide a useful linkup with combat elements. They are capable of transporting replacement personnel or equipment and supplies during all phases of the crossing. Attack helicopters are ideally suited for providing overmatching fire, while medium and heavy lift helicopters move personnel and equipment. Medical support must include collection arrangements for casualties incurred on both sides of the gap. Forward of the obstacle, medical evacuation against the flow of traffic must be considered. Helicopters are valuable in this role.

Recovery equipment. Recovery equipment must be included in the traffic control plan to insure that all routes, particularly crossing sites, are kept open. Recovery resources should be provided at both sides of the crossing sites to insure that these remain operational. Because of difficulties of recovering heavy equipment, recovery and repair support must be given special consideration.

TACTICAL AIR CONSIDERATIONS

Gap-crossing requires close interaction with the on-going tactical air operations. Friendly forces must be protected from enemy attack at crossing sites. The destruction or harassment of crossing activities by enemy aircraft will slow the momentum of the crossing. Air reconnaissance and counterair aviation lessen the chance for crossing failure. Air reconnaissance missions should be integrated into gap-crossing planning and deployment of assets. Such intelligence gathering can provide the nature of the enemy's gap defense posture. Local air superiority may be available only for limited periods of time depending on the quantity of counterair aircraft available. Therefore, assault and breaching tasks are closely coordinated with the air commander. Also, close air support missions can assist the assault force in securing an area on the far side of an obstacle.

CHAPTER 7

Combat Roads and Trails

HISTORICAL PERSPECTIVES

NEED FOR ROADS

The ability to move personnel, equipment, and supplies is essential in defeating enemy forces on land. Even before mechanization, the development and maintenance of road and trail networks was recognized as an essential combat mission. In 1887, a Confederate cavalry officer, John S. Mosby, wrote "... the line that connects an army with its base of supplies is the heel of Achilles—its most vital and vulnerable point. "

In World War II. The need for road and trail networks increased with the use of mechanized fighting systems. During World War II, armor forces achieved rates of march previously unknown. However, their consumption of ammunition and fuel also increased as did the need for supply routes and lines of communication. Road and trail construction was primitive and usually dependent on conventional engineer equipment.

In Vietnam. In Vietnam, the functional need for combat roads and trails was less than that for lines of communications. Because networks were underdeveloped or nonexistent, major road projects were undertaken. These generally provided main supply routes within the area of operations and were a general engineering mission. Also, the extensive use of helicopters for forward area maneuver, resupply, and evacuation reduced the need for combat road and trail support.

On the AirLand battlefield. The AirLand battle concept once again places emphasis on combat roads and trails. Unlike in the past, friendly combat forces will be widely dispersed for security and survivability reasons. At critical times and locations, units must be able to converge over multiple routes. The need for surprise and availability of engineers rules out extensive route construction or repair. However, there is a constant need for resupply and dispersion of combat units. Thus, there is also the need for rapidly installed combat roads and trails to maintain freedom of movement.

DEFINITIONS

The reconnaissance of routes to determine availability and trafficability differs only slightly from the means and methods used to detect obstacles. With the understanding of force mobility requirements in the forward area, existing road networks are checked for possible cross-country movement. Shortfalls are identified when the need to move or maneuver cannot be supported by the road or trail network. The reconnaissance effort also takes into consideration combat road or trail construction operations. During winter months in cold environments, this will include the feasibility of snow roads for off-route traffic or ice roads across lakes and streams.

Combat trail construction. Combat trails are built primarily for use by tracked combat vehicles as an expedient supplement to the existing road net. They are designed and built to pass a small volume of traffic over a short design life. This could vary from as long as it takes for passage of a tank platoon to as long as several days. Requirements for construction will vary, based on local conditions. At one extreme, suitable in-place soil and unrestrictive slopes will already exist. At the other extreme, limiting grades will need to be reduced (by cutting or filling), trees cleared, and expedient improvements made to the trail surface.

Combat road construction. Wheeled traffic will be the primary users of combat roads. These lines of communication are designed and built to support a moderate volume of traffic. Accordingly, the construction effort will be more extensive for combat roads than trails. However, expedient techniques are still applicable. Based on the local conditions, a combat road can be characterized by high grades and numerous curves. Follow-on units and engineers can be expected to maintain or upgrade the combat road.

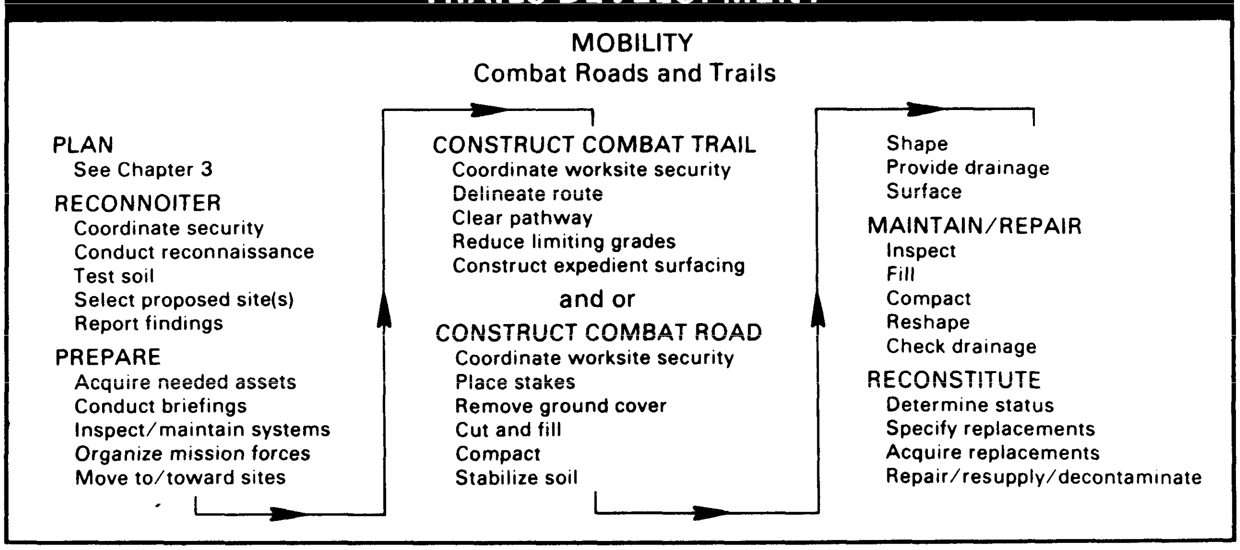
Combat road and trail maintenance and repair. Maintenance includes all actions to correct poor road or trail conditions which result from normal usage. Repair is the effort needed to restore routes due to conditions other than normal use. This includes heavy usage, accidents, enemy fire, and severe weather conditions.

COMBAT ROAD AND TRAIL ACTIVITIES

Combat road and trail activities differ from conventional road construction tasks in several ways. Although the same basic steps are followed, these steps are adjusted for shorter design life and expedient construction. Planning for the use of engineering equipment in the construction of combat roads and trails will be based on the survivability and mobility factors. The combat roads and trails functional area can be divided into seven tasks with each task further divided into several subtasks. Each subtask will vary based on local terrain conditions, tactical situation, and equipment available. Figure 7-1 depicts the relationship of the tasks within the functional area.

Reconnaissance for combat road and trail activities precedes the preparation of forces and equipment. The nature and extent of construction or maintenance is confirmed by reconnaissance. A decision to construct a new route or trail or to maintain or repair an existing one will depend on the maneuver commander's mission and priorities.

FIGURE 7-1. SUBTASKS FOR COMBAT ROADS AND TRAILS DEVELOPMENT



PLANNING CONSIDERATIONS

THE MOBILITY SCHEME PLAN

Combat roads and trails, as a function of the mobility scheme, help the combined arms team move fast over difficult terrain. Forces can then concentrate for combat, receive logistical assistance, and disperse. The responsibility for improving, repairing, or abandoning combat roads and trails is transferred to follow-on forces. The requirements for combat roads and trails frequently overlap with those for other functional areas of mobility. The establishment of bypasses for mined areas and other obstacles, for instance, may involve combat route construction or repair. Routes through urban rubble and tree blowdown created by nuclear weapons may require expedient construction methods. Similarly, successful gap crossings depend largely on the trafficability to and from the crossing site. To fulfill the combat roads and trails task, continuous reconnaissance and inspection of the battlefield is essential. Although engineer reconnaissance teams are specifically trained for this task, maneuver force reconnaissance products provide valuable input. The need for construction, repair, or maintenance of the road and trail network is best identified through combined arms team cooperation and intelligence sharing. Figure 7-2 on page 7-4 shows the reconnaissance and inspection process during a combined arms offensive operation.

ROLE OF PLANNERS

The mobility planner analyzes the avenues of approach during the estimating process. The staff engineer, if available to the maneuver operations officer, examines all information pertaining to the existing road network. The recommendation for engineer effort on combat road and trail activity is based, in large part, on this process. As the plan is developed and orders issued, the mobility planner continues to update an appraisal of the trafficability condition of the road network. The results of route reconnaissance, engineer reconnaissance, and combined arms situation reports provide this data. Engineer terrain analysis teams can provide information on engineering geology, soils, drainage, slopes, and vegetation to the road and trail builder. Engineer reconnaissance teams provide information on the availability of locally procured class four items. Thus, the monitoring of combat road and trail requirements is a continuous process. The ability of the supporting engineer to assist and support combat construction requirements will vary with two considerations.

These include—

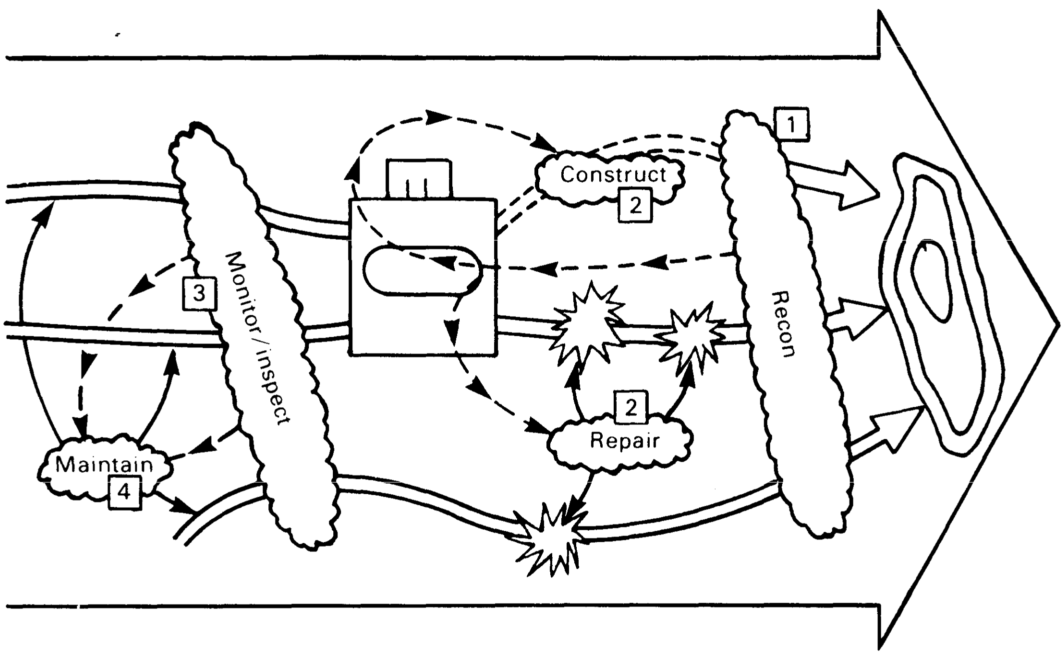
- The availability of engineer reconnaissance detachments.

- The availability and density of engineer equipment required for combat road and trail activities.

AVAILABLE PERSONNEL AND EQUIPMENT

Within a theater of operations, one divisional and up to four supporting engineer battalions may be required to support each committed maneuver division. The missions of these battalions are coordinated by the division engineer through the G3. Although the construction of combat roads and trails is but one mission in the functional area of mobility, these battalions are equipped with assets to support forward combat construction needs.

FIGURE 7-2. THE COMBAT ROADS OR TRAIL PROCESS



Key:

1. Engineer forces and forward maneuver elements conduct reconnaissance to identify combat road and trail requirements.
2. This information will be relayed to the maneuver force resulting in engineer combat road or trail activities.
3. Inspection and monitoring of lines of communications (LOCs).
4. Follow-on forces perform maintenance and repair required.

RECONNAISSANCE

TYPES OF RECONNAISSANCE

Reconnaissance may be classified as either area or specific reconnaissance. The first of these refers to a search conducted over a wide area to find a facility site. The second refers to an investigation of a specific site, or a particular undeveloped but potential facility. A facility in this context maybe the possible location for a combat road or trail. Thorough reconnaissance is essential in the selection of roads or trails. It normally starts with a study of available maps and aerial photos. Aerial reconnaissance provides much valuable information. Detailed information, however, is obtained only by ground reconnaissance.

Route reconnaissance. Reconnaissance performed in connection with military lines of communication is referred to as route reconnaissance and is an example of area reconnaissance. It includes information about roads, bridges, tunnels, fords, waterways, and other natural terrain features that may affect the desired traffic flow. Information obtained in a hasty route reconnaissance may be adequately recorded on a simple sketch or overlay. Because of the greater detail obtained in a deliberate route reconnaissance, it may be necessary to support maps and overlays with specifically designed Department of the Army (DA) forms. These formats and their use are fully explained in FM 5-36.

Road reconnaissance. Reconnaissance to check existing roads is called road reconnaissance. An example of a specific reconnaissance, it determines the classification and traffic capabilities of an existing road. It may include enough information for work estimates to bring the road up to certain standards of trafficability. Use DA Form 1248 (Road Reconnaissance Report), depicted in appendix E, to record this information. Maps, overlays, and sketches are used as necessary. Also, the bridge reconnaissance, tunnel reconnaissance, ford reconnaissance, and ferry reconnaissance reports are used when more detailed information is needed. Their use, along with DA Form 1248, will help to insure a complete, well-organized report.

Location reconnaissance. New road construction is avoided whenever possible to save time and labor. When a new road is necessary, however, the first step is location reconnaissance. This requires an area-type reconnaissance of all possible routes to insure selection of the best. Its main objective is to locate a new road or trail in an area that will hold up under anticipated traffic and meets mission requirements.

Periodic reconnaissance. The conduct of reconnaissance to verify the effects of weather or use is termed periodic reconnaissance. Periodic reconnaissance of military lines of communication is necessary to update the road situation in a specific area. A situation map is prepared showing the current condition of roads, density of traffic, need for maintenance work, and results of various methods of maintenance.

Periodic reconnaissance is especially important during frozen, wet, or unusually dry weather to determine the effects of these conditions. Maintenance requirements based on periodic reconnaissance must be coordinated with the units using the roads. This insures that engineer effort will not be spent on roads that are no longer needed and that engineer crews will not interfere with the movement of critical convoys.

PRINCIPLES OF LOCATION

Maximum use should be made of all existing facilities. In most areas of the world, an extensive road net of varying quality already exists. Where possible, this should be used to the fullest. In most cases, expansion of the roadway and preparation of adequate surfaces are all that is needed. The first step in construction is selection of the best possible location for the facility. A project site that is not well selected may not meet the requirements of the mission with respect to capacity, usability, or convenience. A poorly-selected site is sure to cause future problems.

Mission. The most important factor in selecting a site is mission fulfillment. Every line of communication must be built to accomplish a specified mission in the most direct and efficient manner possible.

Future expansion. Another important factor in selecting a site is its potential for future expansion. The unpredictability of military operations often requires engineer troops to modify and expand previously completed construction. A road or trail that is adequate today may be inadequate for follow-on operations. Improvement and expansion is a continuing job on all combat roads and trails. The ability to expand an existing route or facility will conserve labor and material and will permit more rapid completion of the project. Specific data and instructions for constructing combat roads and trails can be found in FM 5-34 and TM 5-330.

Soil and rock characteristics. In order to meet the design standards of strength and stability and to minimize the need for removal of undesirable materials, all roads and airfields should be located on terrain with the best possible soil conditions. Obviously, the best soil characteristics will minimize the construction effort and result in a better facility. Before locating any route of communication, consider the general geology of the area. Rock in sizable quantities anywhere along a construction project will present removal problems. Rock outcropping are more likely to occur in hilly terrain than in flat or rolling country.

Drainage. Unless the soil is free-draining, long stretches of flat ground should be avoided because of drainage problems. The need for drainage structures should be minimized. The bottoms of valleys or other depressed areas should be avoided because they tend to collect water.

Topography. Excessive grades should be avoided, and steep hills bypassed whenever possible. If very steep hills must be crossed, the route should run along the side of the hill rather than directly over it. This may result in a longer route but will generally be more economical. The amount of earthwork and ground cover to be removed should be minimized. Several factors should be considered.

- Earthwork. Earth-moving is the biggest job on any road or trail building project. This can be minimized by following contour lines over hills and valleys. Excessively deep cuts or high fills should be avoided. If possible, all earthwork should be balanced. When both cutting and filling are needed at various points along a project, the material excavated is used to construct the needed embankments.

- Ground cover. When crossing wooded areas, trees must be cleared before actual construction can begin. In heavily forested areas, this can be a sizable task. Therefore, all routes should avoid areas where large amounts of clearing are necessary. If this is not possible, the route should be located through areas where the clearing can be classified as light.

Required area. Combat roads or trails constructed over rolling or flat terrain seldom require more area than that necessary for the roadway itself. Road construction requiring deep cuts or fills will require greater areas and effort.

Tactical considerations. Combat routes in the forward area are built according to the tactical situation with little regard for design. In this case, several factors are considered.

- Defilade. To avoid enemy observation and direct fire, combat roads and trails are located in a defilade position on the back side of a hill or in a ravine, where possible.

- Camouflage. When it is necessary to construct a road or airfield in an exposed location, every effort is made to take advantage of natural and other camouflage.

- Sunny slopes. If tactical concealment is not a consideration (with the exception of snow, ice, or frozen soil roads), roads are located on the sunny and exposed sides of valleys or hills, particularly in wet or cold areas. Road surface and subgrade will dry faster this way and minimize the possibility of freezing. Also, maintenance is generally easier.

EXPEDIENT SOILS TESTING

Simple soil tests can be made during the location reconnaissance to determine the soil characteristics. Expedient testing techniques suitable for the combat roads and trail reconnaissance can be found in TM 5-530 and TM 5-545. They also contain technical information on soils and are valuable references in the solution of soil problems encountered in the design and construction of conventional military roads.

RECONNAISSANCE REPORTING

To swiftly report the results of combat road and trail location reconnaissance, units of all arms and services use a simple and concise format. The combat route site report (figure 7-3) is designed primarily for radio transmission. It can, however, be used for written reports and supplemented by drawings, maps, tracings, or overlays. Much of the detail required can only be provided by qualified engineer personnel. Nonspecialist personnel of other arms include only the detail they are qualified to collect and report. This report is sent through operational channels and monitored by the staff intelligence section and staff engineer, if available. At division level, terrain analysis detachments are also provided the information in order to update their data base.

FIGURE 7-3. SAMPLE COMBAT ROUTE SITE REPORT

ALFA Map sheet.

BRAVO Grid reference of site and date-time group of reconnaissance.

CHARLIE Type of combat route required (TRAIL or ROAD).

DELTA Type of vehicles considered (wheeled or tracked) and anticipated traffic (light, moderate, heavy), for example, WHEELED-MODERATE.

ECHO Classification and length (in meters) of complete site, for example, GRAY-200 meters.

- White. A site where a minimum of engineer effort is required due to suitable soils, existing grades, and sparse vegetation clearing requirements.
- Gray. A site where a concentrated engineer construction effort is required to produce the required trafficway. Heavy clearing, soil stabilization, and the provision of drainage structures are examples of work required. Vehicles may still require assistance to negotiate steep grades.
- Black. An impractical combat route site owing to the excessive amount of assistance required.

FOXTROT General information to include other limitations, for example, mines, enemy observation, enemy fire, existing or reinforcing nonmine obstacles.

CONSTRUCTION PROCEDURES

DESIGN FACTORS

The selection and design of combat roads and trails depend on several factors. These include the nature of subgrade, traffic and drainage conditions, construction times, the supply of local and imported materials, and the engineer equipment and personnel available. Road design must be practicable and adequate and based on sound principles. In a forward combat zone, military urgency almost always dictates rough, hasty work, designed primarily to meet pressing needs. Combat routes are designed for progressive improvements at different stages. In this way, follow-on forces can develop roads and trails to satisfy increased traffic demands. For road construction methods, see TM 5-330 and TM 5-337.

METHODS OF CLEARING

Land clearing consists of clearing a designated area of all trees, brush, other vegetation, and rubbish. It includes removing surface boulders and other material embedded in the ground. Grubbing consists of uprooting and removing roots and stumps. Stripping involves removing and disposing of objectionable topsoil and sod. These three operations are done primarily with heavy engineer equipment. Hand or power tools, explosives, and fire are used where applicable. The methods to be used depend on the path to be cleared, the type and density of vegetation, the terrain as it affects the operation of equipment, the availability of equipment and personnel, and the time available for completion. For best results, a combination of methods is used in a sequence most suitable and effective to the operation. In forward combat areas, clearing also includes countermine, counterobstacle, and gap-crossing tasks.

Clearing and grubbing. In most cases, engineer equipment is the fastest and most efficient means of clearing and grubbing. The use of such equipment is limited only by unusually large trees and stumps, by terrain which affects its maneuverability, and by maintenance requirements. This equipment includes bulldozers, M9 ACE, CEV, tractor-mounted clearing units, winches, power saws, and so forth. Pioneer tools are also used in certain types of clearing operations. The selection of equipment usually is limited to that which is available on the job.

Stripping. Stripping consists of removing and disposing of the topsoil and sod which would be objectionable as a subgrade, as a foundation under a fill, or as borrow material. Examples include organic soils, humus, peat, and muck. In shallow fill sections of 2 feet or less, the unsuitable material must be removed to a depth great enough to place at least 3 feet of suitable subgrade material in the fill. Stripping is done concurrently with clearing and grubbing by using bulldozers, graders, scrapers, front end loaders, and sometimes shovels. It is often helpful to stockpile good topsoil and sod for later use on bare areas for dust or erosion control or for camouflage.

USE OF EXPLOSIVES

Explosives may be used to fell standing trees, to uproot entire trees and stumps, and to remove and dispose of large boulders. Explosives have several disadvantages. They cannot be used where loud noises violate security. In loose soil, the initial charge maybe entirely expended in compacting the soil under a tree or stump, and a second charge may be required to remove it. Deep taproots are often only broken by explosives and have to be removed mechanically or by hand. Explosives generally take time to place and they create large craters which require borrow excavation and compaction to backfill. In spite of these disadvantages, however, it is still necessary to use explosives to clear an area. This necessity applies especially where the terrain impedes the operation of heavy equipment.

CAMOUFLAGE OF WORK SITE

To aid in camouflaging the construction site, standing trees and brush outside the designated cleared areas are not to be removed or touched unless necessary. For this reason, care is taken when uprooting trees. Timber for logs, piles, and lumber is trimmed and stockpiled for future use in bridge, culvert, and other types of construction. This type of timber is placed in a salvage area.

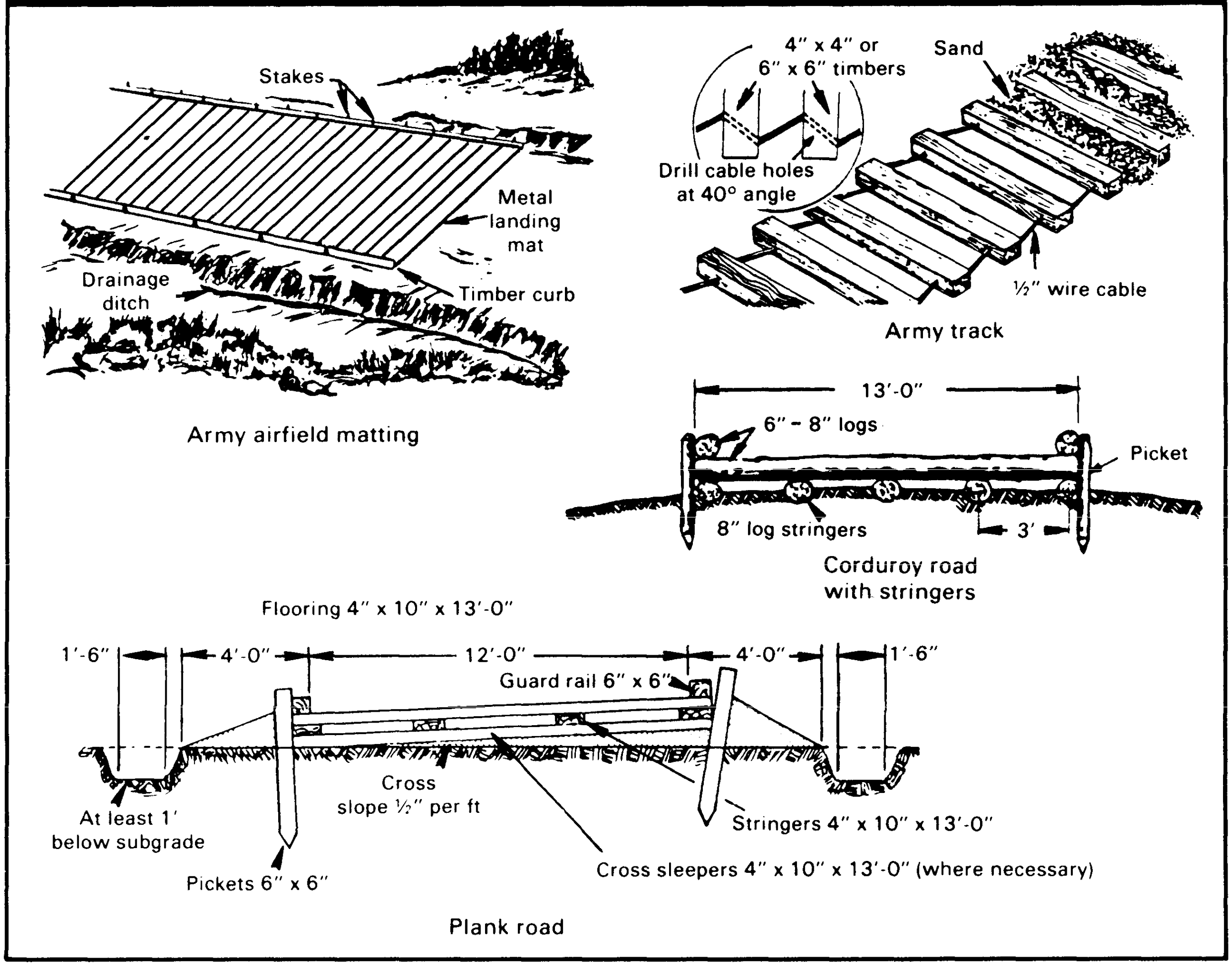
EARTHWORK

Earthwork is one of the most time-consuming construction operations. It should therefore be avoided or minimized whenever possible. The combat road or trail will be aligned along the topography in order to avoid cut and fill operations. Cut and fill operations should be undertaken only in areas where the slopes of existing terrain surpass the recommended slope for vehicles using the road/trail.

SURFACING

In the construction of combat roads and trails, expedient surfacing methods (figure 7-4) will be used to get the traffic through. Such routes will usually have earth surfaces consisting of native fine-grained soils graded and drained. These roads are designed to satisfy immediate traffic needs and to provide a subgrade for higher-type surfaces. Although unsurfaced roads may be adequate for the anticipated traffic load, terrain and weather conditions may dictate the use of expedient

FIGURE 7-4. EXPEDIENT SURFACING OF COMBAT ROADS, TRAILS



surfacing techniques. Expedient surfaces should be covered with a layer of fill material, when possible, to minimize wear from heavy armored vehicles. Specifications for use of these surfacing techniques are given in TM 5-337. In many cases, an adequate wearing surface can be obtained using soil stabilization techniques. These techniques are explained in TM 5-330.

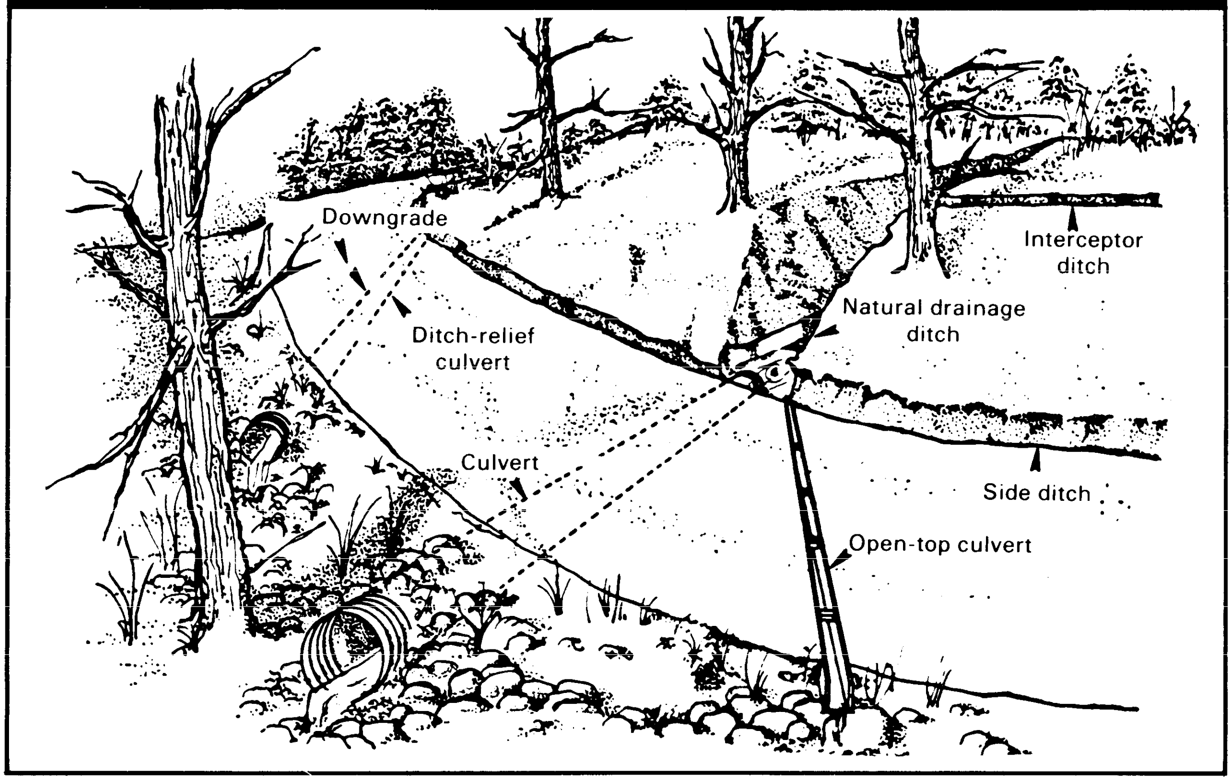
DRAINAGE FACILITIES

Properly planned, designed, constructed; and maintained drainage facilities are essential to continuous serviceability of combat roads and trails. The washout or blockage of a single culvert may close the route to traffic at a vital time. Drainage facilities should be developed in stages at the beginning of clearing, grubbing, and stripping operations to insure uninterrupted construction. Delays caused by flooding, subgrade failure, and mud can be avoided by careful development of the drainage system. Natural drainage features are used as much as possible to insure minimum disturbance of natural grades.

During clearing and grubbing operations, existing or natural watercourses must be kept cleared and holes and depressions filled. Adequate drainage for the site must be provided to insure that no water interferes with construction operations. Construction drainage measures include use of the following.

- Diversion ditches. Diversion ditches reroute surface water heading toward the project site, sending it in a controlled manner to a more desirable location.
- Existing ditches and drainage features. Maximum use should be made of existing ditches and drainage features. Where

FIGURE 7-5. SURFACE DRAINAGE OF A ROUTE



possible, grading operations should run downhill, both for economy of effort and to utilize natural drainage. Figure 7-5 shows the drainage features associated with a combat road.

- Culverts. Whenever the natural flow of surface water or flow due to existing ditches crosses a combat road or trail, an expedient culvert should be built to maintain trafficability.

DRAINAGE CHARACTERISTICS OF SOILS

Different types of soils vary in their ability to help or hinder drainage of the terrain. Soils are divided into three general groups on the basis of drainage characteristics.

Well-draining or free-draining soils. Soils that may be drained by gravity systems, such as clean sands and gravels, fall into this category. In road and trail construction, for example, open ditches sometimes may be used in these soils to intercept and carry away surface water which comes in from surrounding areas. Such ditches dug to a proper depth may also be effective in draining the base of the subgrade of groundwater.

Poorly-draining soils. Included in this group are inorganic and organic fine sands and silts, organic clays of low compressibility y, and coarse-grained soils which contain an excess of nonplastic fines. Surface water control of these soils is no different from control of well-drained soils. However, subsurface drainage may be difficult due to the relative impermeability of the soils.

Impervious soils. Fine-grained, homogeneous, plastic soils and coarse-grained soils which contain plastic fines belong in this category. Subsurface drainage is so slow in these soils that it is of little value in providing subsurface drainage. However, surface drainage is the same as with other soils.

MAINTENANCE AND REPAIR

Maintenance is the routine prevention and correction of normal damage deterioration from use and the elements as necessary to keep roads in usable condition. Repair is that work necessary, other than maintenance, to maintain surfaces and facilities in usable condition. It is the repair of damage caused by abnormal use, accidents, hostile forces, and severe weather. Repair includes the resurfacing of a road when maintenance is no longer sufficient.

PREVENTIVE MAINTENANCE

The purpose of all maintenance and repair is to keep road surfaces in as usable and safe a condition as possible. Prompt and adequate maintenance is of paramount importance. Once deterioration or destruction of the surface has started, it can proceed very rapidly. A minor maintenance job postponed can thus develop into a major repair job. Principles of good maintenance are—

- Minimum interference with traffic. Maintenance and repair activities should interfere as little as possible with the normal flow of traffic permitting at least partial use of the route. Scheduled maintenance should be done at night or during periods of reduced visibility, when possible. Otherwise, it should be done when the traffic flow best permits. Emergency repairs will be handled immediately.

- Correcting the basic cause of a surface failure. Surface repairs made on a defective subgrade are wasted. The cause of damage should be investigated and corrected before the repair is made. If not, the damage is likely to reappear.

- Priority. Priority in making repairs depends on the tactical requirements, the traffic volume, and the hazards which would result from complete failure of the facility.

DRAINAGE MAINTENANCE

Defective or inadequate drainage can cause many surface failures and deterioration.

Surfaces must be inspected after rainfall and areas marked for pending.

Ponding or delayed runoff of surface water allows seepage unless the surface is tightly sealed. Surfaces must be inspected after rainfall and areas marked for ponding. Correction is made by filling or raising local depressions and by providing additional diversion ditches or culverts, where needed.

EARTH SURFACE MAINTENANCE

Basic maintenance requirements for natural earth surfaces include shaping to maintain adequate drainage and to keep a compact, reasonably smooth surface. Traffic areas and shoulders are kept free of potholes, ruts, and similar irregularities. Light blading is done to prevent corrugation or "washboarding." Examples of earth surface road repairs are shown in figure 7-6. When possible, attention will be given to dust abatement.

CRATER REPAIR

Bombs, shells, land mines, and cratering charges produce extensive craters in traffic areas. Surface damage creates no unusual repair problem, but the explosion may displace or destabilize large areas of the subgrade. Drainage may also be disrupted so that water penetrating the broken surface accumulates and further softens the subgrade. Subgrade stability must be restored to support traffic and prevent undue settling of the surface. Gravel, rock, masonry debris, sandy soil, or other suitable stable materials can be used in filling craters (1, figure 7-7). Material blown from the crater can be used for much of this fill. In an emergency, material from the shoulders of the roads or trails may be borrowed and replaced later.

When the situation permits and where enemy action may be anticipated, stockpiles or material pits should be prepared at convenient sites. Alternate layers of filled sandbags and tamped earth furnish good subgrade compaction where other suitable material or equipment is not available (2, figure 7-7).

FIGURE 7-6. COMBAT ROAD AND TRAIL SURFACE REPAIR

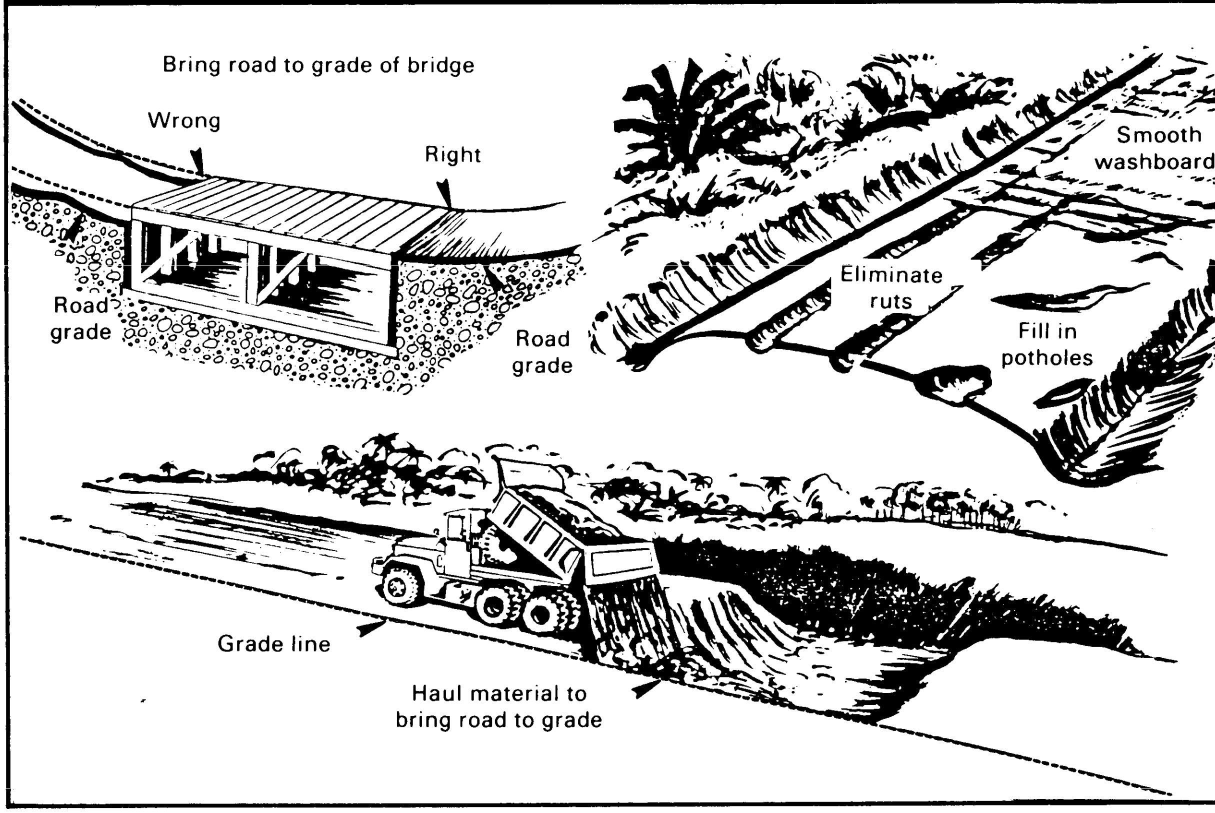
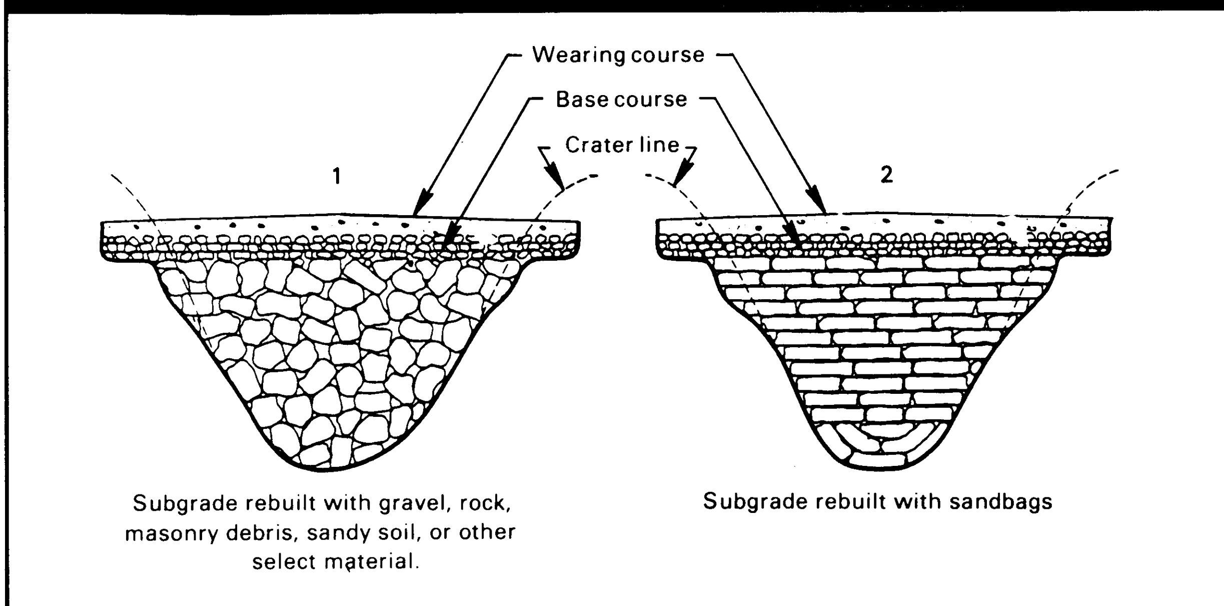


FIGURE 7-7. CRATER REPAIR METHODS



COMMAND AND CONTROL

RESPONSIBILITIES

Combat maneuver units and combat engineers are responsible for combat road and trail construction that corresponds to their equipment capabilities. Combat units are capable of creating combat trails and helicopter landing zones. Equipment such as dozer tanks and recovery vehicles provide this basic capability. Engineer units will assist combat units in combat road and trail development, as required. Extensive combat construction efforts will be accomplished by engineers. In the forward areas, priority of engineer route development and maintenance goes to preserving the mobility of the maneuver elements. Both division and corps engineers share in this task under the mobility systems concept. Division engineers concentrate on removing obstructions that hamper the freedom of movement and maneuver for combat units and their supply vehicles. The division engineer coordinates other engineer units, when available, to accomplish combat road and trail tasks which exceed the battalion's capability. Corps engineer units, in support of the division, may be employed within the forward area on an area or task basis. Combat roads and trail tasks for these engineer units generally involve maintenance of lines of communications.

MANAGEMENT CONSIDERATIONS

There are several command and staff considerations unique to combat road and trail constructions within the division areas. The management of trafficable road and trail networks involves the following individuals and activities.

- The divisional engineer battalion commander coordinates engineer assets throughout the division sector with the exception of those precluded by command/support relationships. This commander advises the division commander on mobility efforts, specifically the status of trafficable networks and engineer effort required to maintain them.

- The assistant division engineer (ADE) provides staff engineer coordination at the division level. The ADE coordinates with division engineer, brigade engineers, and assistant corps engineer to insure integration of assets and efforts for building and maintaining combat roads and trails.

- The G3/S3 formulates mobility plans and determines main supply route locations. The G3/S3 is also responsible for integrating road and trail location reconnaissance and construction efforts into the operations plan.

- The G4/S4 determines logistics road and trail network requirements. This estimate is integrated with the G3/S3 mobility operations scheme. The G4/S4 determines the general usages of combat construction materiel sites such as landfill areas and lumberyards.

- The terrain analysis team. provides the commander, staff, and engineers with terrain and soil trafficability data.

PROJECT REPORTING

In order to effectively command, coordinate, and update engineer work priorities, the commander and staff must be constantly informed of the changes to the road network capability. This is done through the use of simple reporting formats. Units of all arms and services use these reports to forward information concerning road status and the location of road-making equipment on the battlefield. The road closed, road open, and road-making equipment reports are forwarded through operational channels and monitored by the staff intelligence, logistics, and engineer sections (if provided). Also, at division level, the reports are provided to the terrain analysis detachments in order to update their data base. The combat road and trail report formats are designed primarily for radio transmission. They can, however, be used for written reports and supplemented by drawings, maps, tracings, or overlays. If not transmitted by radio, the fastest possible means of relaying this information is used. The originator completes only those parts of the format which apply to the road, trail, or road-making equipment reported. Figure 7-8 is an example of a road(s) closed report.

FIGURE 7-8. SAMPLE ROAD(S) CLOSED REPORT

ALFA	Map sheet(s).
BRAVO	Date and time of collection of information.
CHARLIE	From grid reference ________ or show on trace.
DELTA	To grid reference ________ or overlay.
ECHO	Reason for closing of road.
FOXTROT	Estimated duration.
GOLF	Detour from ________ to ________ including, if possible, class of road, or at least the following information: width of road, smooth or rough surface, gradual or sharp curves, gentle or steep grades.
HOTEL	Cross-country bypass permitted to ________ (wheeled or tracked vehicles and class).
INDIA	Any other information.

Note: Paragraphs CHARLIE and DELTA apply only to major axial or lateral routes. Classification of roads is to be given according to the weakest part of section of road under report, that is, the class of the route may be restricted by a bridge with a low military load class. The reason for closing of road should be the nature of the obstacle, that is, bridge blown at grid reference or road unusable through heavy traffic.

These reports can be written and supplemented with drawings and maps.

Figure 7-9 is an example of a road-making equipment report, and figure 7-10 is an example of a road(s) opened report.

FIGURE 7-9. ROAD-MAKING EQUIPMENT REPORT

(To cover static and mobile mechanical equipment)

ALFA	Map sheet(s).
BRAVO	Data and time of collection of information.
CHARLIE	Location (grid reference or trace).
DELTA	Type.
ECHO	Number.
FOXTROT	Condition.
GOLF	Any other information which could be given.
DELTA	Type equipment.
ECHO	Number on hand.
FOXTROT	Condition of equipment.
GOLF	Any other information which could be given.

FIGURE 7-10. SAMPLE ROAD(S) OPENED REPORT

1. First road in report.

ALFA	Map sheet(s).
BRAVO	Date and time the road is opened.
CHARLIE	From grid reference ________ or show on trace.
DELTA	To grid reference ________ or overlay.
ECHO	Class of road and characteristics of the road to include information on shoulders.
FOXTROT	Minimum widths.

2. Second road in report (include information as above).

Note: Paragraphs CHARLIE and DELTA apply only to major axial or lateral routes. Classification of roads is to be given according to the weakest part of section of road under report, that is, the class of the route may be restricted by low class of bridge.

CHAPTER 8

Forward Aviation Combat Engineering (FACE)

HISTORY

USE ON BATTLEFIELD

Forward aviation combat engineering (FACE) tasks on the AirLand battlefield are similar to those of combat roads and trails. Both activities are based on expedient horizontal construction techniques and generally involve combat engineer participation. However, FACE tasks provide freedom of movement for supply, tactical, and reconnaissance aircraft. In this manner, FACE vertically supplements the freedom of movement and maneuver furnished ground forces by the other four functional areas of mobility.

DEMAND FOR AIRPLANES

In World War I, airplanes were used for observation, ground support, and combat for control of airspace. In World War II, great fleets of airplanes were built and used by the combatant nations. Piston-propelled airplanes flew reconnaissance, interdiction, ground combat support, aerial combat, and aerial resupply missions. The Korean War brought two significant developments. The jet engine propelled fighter aircraft and bombers further and faster than ever before. Also, the introduction of the helicopter changed how reconnaissance, emergency evacuation, and battlefield control were accomplished. The use of helicopters expanded in the Vietnam War. The tactical use of bombers, fighter aircraft, cargo aircraft, and helicopters was combined to extend combat power in multiple directions over long distances. Thus, in less than a century, the extension of combat, in a vertical dimension, has greatly influenced how, when, and where ground forces operate on the battlefield. Within the context of the AirLand battle, the role of aviation continues to expand with a corresponding need for ground facilities. Whether the ground site is used for landing, rearming, discharging cargo, or protecting the aircraft, it generally requires support from ground forces. For example, Army aviation is now critical to combat, combat support, and combat service support tasks. Thus, engineer support for constructing, repairing, or maintaining aviation ground facilities is essential.

FACE MISSIONS

The development, rehabilitation, and maintenance of aviation ground facilities will be required across the depth of the AirLand battlefield. The types and sophistication of these facilities will vary with their use in the deep battle area, covering force area, or main battle area. At one extreme are ground-based aviation operations in forward areas, characterized by widely scattered aircraft there only for a short time. Aircraft on the ground at these sites are vulnerable to enemy air or ground attack. At the other extreme are Army aviation or Air Force operating bases located behind the main battle area. These facilities are characterized by surfaced runways, ground support structures, and extensive aircraft protective positions.

Types of projects. The combat engineer construction and maintenance effort in support of forward aviation operating facilities is a mobility functional area. Immediately available resources are used to accomplish FACE missions. Expedient techniques are used and extensive construction limited in order to avoid enemy detection. The four types of FACE projects that fall into this mobility function are—

- Construction of helicopter landing zones and forward arming and refueling points (FARP).
- Construction of low altitude parachute extraction system (LAPES) zones.
- Construction of landing strips.
- Maintenance, repair, and rehabilitation of existing forward aviation maintenance sites.

Need for priority. These individual FACE activities do not imply a necessary sequence. The maneuver commander, in conjunction with the supporting aviation staff officer and engineer, specifies the need and priority for one or more of these activities. This decision is part of the mobility planning process (chapter 3). As with other mobility tasks, the resources used to accomplish the work are reconstituted upon completion. Each FACE mission is divided into several subtasks. The accomplishment of each subtask will vary based on local terrain conditions, tactical situation, and equipment available. Figure 8-1 shows the relationship of the tasks within the mobility mission area. Like combat road and trail activities, reconnaissance of potential FACE sites precedes the preparation of forces and equipment necessary to accomplish any of the tasks. The nature and extent of construction or maintenance of forward aviation facilities is confirmed by reconnaissance.

DEFINITIONS

The terminology of FACE tasks differs from that of the other mobility functions. Two sets of definitions are provided in this section. The first of these focuses on the individual FACE tasks, while elements of each facility are discussed in the second. Forward aviation combat engineering missions follow.

- **Construct landing zone.** Landing zones are required during helicopter movement of troops and logistics, refueling and rearming, medical evacuation, and reconstitution. Engineer support is rudimentary for each type. All trees must be cleared from the rotor zones. Locations are selected which possess suitable soil conditions to carry helicopter loads without strength improvement. Loose objects, including loose snow, are cleared from the rotor wash area.

- **Construct low altitude parachute extraction system (LAPES) zone.** The LAPES was developed as a means of delivering heavy loads by low level extraction rather than air drop (figure 8-2). These zones require relatively flat, stump-free terrain with geometries similar to those specified in TM 5-330 for a C-130 landing strip. Since the fixed-wing transport aircraft, typically a C-130, does not

FIGURE 8-1. FORWARD AVIATION COMBAT ENGINEERING SUBTASKS

MOBILITY

Forward Aviation Combat Engineering

PLAN
- See Chapter 3

RECONNOITER
- Coordinate security
- Conduct reconnaissance
- Test soil
- Select site(s)
- Report findings

PREPARE
- Acquire needed assets
- Conduct briefings
- Inspect/maintain systems
- Organize mission forces
- Move toward/to site(s)

CONSTRUCT LANDING ZONE
- Lay out
- Clear

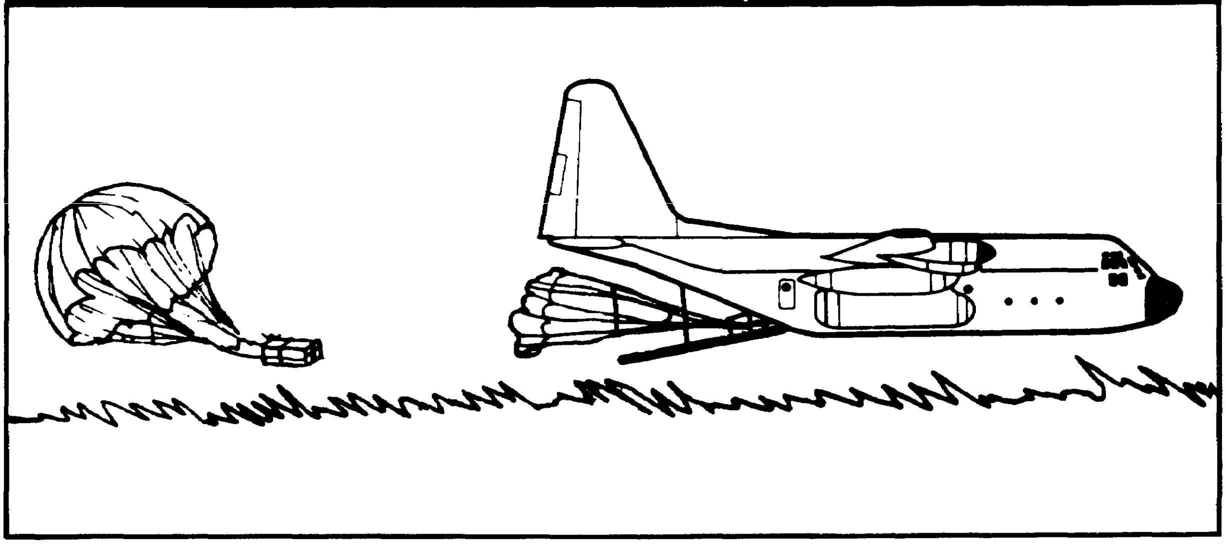
CONSTRUCT LAPES ZONE
- Lay out
- Clear
- Grub

CONSTRUCT LANDING STRIP
- Lay out
- Clear
- Grub
- Cut and fill
- Compact
- Shape
- Provide drainage
- Place matting

MAINTAIN/REPAIR FORWARD AVIATION FACILITIES
- Inspect
- Fill
- Compact
- Reshape
- Repair matting

RECONSTITUTE
- Determine status
- Specify replacements
- Acquire replacements
- Repair/resupply/decontaminate

FIGURE 8-2. LOW ALTITUDE PARACHUTE EXTRACTION SYSTEM (LAPES)



land when discharging its cargo, the ground strength requirements are based on the equipment being discharged. Information on ground strength is provided in TM 5-330.

- **Construct landing strip.** This facility will allow landing and takeoff of specific fixed-wing aircraft. Geometric criteria are established by TM 5-330. Landing strips must be relatively flat with a surface capable of supporting fully-loaded fixed-wing aircraft. Proper site selection is based on the need to minimize the requirement for wearing surface improvement and earthwork.
- **Maintain/repair forward aviation facilities.** Maintenance includes all activities required to correct deficiencies resulting from normal damage and deterioration. Repair deals with restoration of damage due to abnormal use, accidents, and hostile forces, As an economy measure, maximum use of existing facilities should be planned.

Forward aviation combat engineering facility definitions are as follows:

- **Glide angle.** A small vertical angle measured outward and upward from the end of the flight strip, above which no obstruction should extend within the area of the approach zone. It also indicates the safe descent angle for various types of aircraft and is expressed as a ratio, such as 35:1 (figure 8-3).
- **Approach zone.** An area extending outward from each end of a flight strip, within which no natural or constructed object may project above the glide angle (figure 8-3).
- **Clear zone.** A cleared area located at each end of the zone or strip. Width is equal to runway, runway shoulders, and runway clear areas. Length is normally equal to the overrun (figure 8-3).

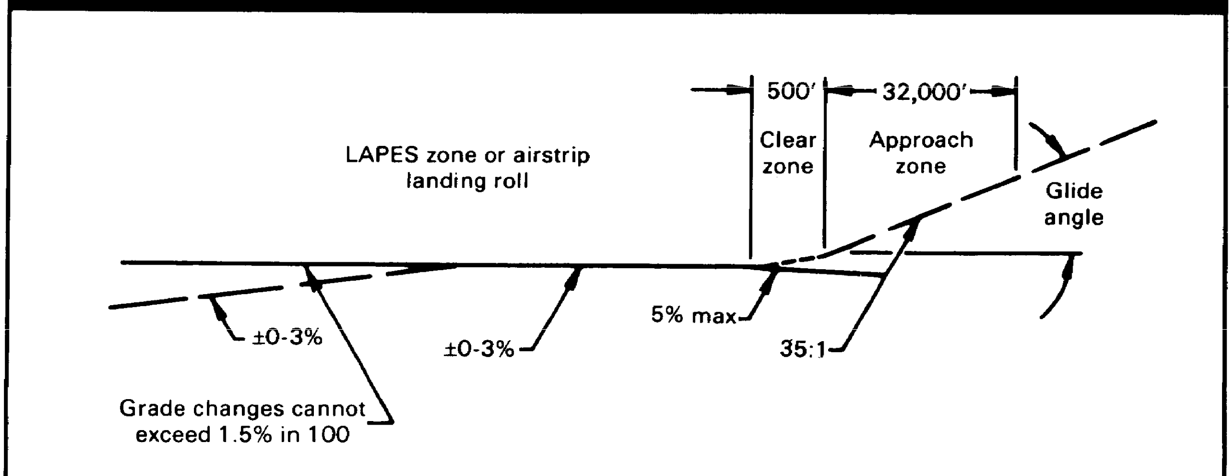
Flight strip. Includes area of the runway, shoulders, clear area, overruns, and clear zones.

Flight way. Includes flight strip area together with the two approach zones.

Full touch zone *{FTZ).* This helicopter landing area is capable of sustaining the entire weight of the craft. The surfacing of the FTZ is either natural or expedient.

- **Landing strip.** An area of land prepared for the landing and takeoff of aircraft.

FIGURE 8-3. LAPES ZONE AIRSTRIP LONGITUDINAL SECTION



- **Landing roll.** The necessary ground-contact distance, from touchdown to stop, traveled by an aircraft when landing (figure 8-2).

- **Skid touch zone.** This helicoper landing zone is capable of supporting only a portion of the craft's weight. Rotor assist during loading or unloading is required to sufficiently reduce the pressure on the zone's surf ace.

- **Nontouch zone (NTZ).** A helicopter landing zone without necessary ground stability for touchdown. The aircraft can only hover over this site.

PLANNING CONSIDERATIONS

FACE CAPABILITY

Forward aviation combat engineering, as a function of the mobility system, assists the combined arms team to project combat power over difficult terrain. These tasks allow forces to be transported across or around obstacles, receive logistical assistance, and disperse quickly when required. Forward aviation ground facilities are improved or abandoned depending on the aviation requirements of follow-on forces.

RESPONSIBILITIES

It is the responsibility of Army engineers to plan, design within their areas of responsibilities, and construct forward aviation facilities. To insure that these facilities meet proposed mission requirements, there must be close coordination between the responsible engineer officer and all appropriate ground and air commanders. The engineer is normally dependent on the appropriate commanders for information on the weight and traffic frequency of using aircraft, the facility life, and the time available for construction. Tactical time will often limit planning, reconnaissance, and site investigation activities, as well as the actual construction. In some cases, ground reconnaissance and site investigation will be inhibited by the presence of the enemy, and maximum use will have to be made of air photo interpretation. In such cases, the engineer must make every effort to obtain air photo coverage of the desired area. Normal ground reconnaissance and "on-site" investigations should always be conducted when time and security permit.

Location. Within the established site requirements, the geographic location will be made primarily on the basis of topographic features (grading, drainage, and hydrology), soil conditions, vegetation, and climate. All existing transport facilities, including ports, rail lines, road nets, and other nearby aviation sites, are evaluated.

Security. The mobility planner insures that adequate security forces are provided. An adequate plan must keep troops, equipment, and materials safe from harassment and sabotage during construction.

Construction. The planner evaluates the availability and type of engineer construction forces to determine if construction capability is enough to accomplish the task. The equipment and personnel planning factors given for combat roads and trails in chapter 7 also apply to FACE tasks. However, the planner is limited in certain respects by the initial condition of the proposed site. For example, forward helicopter landing zones are required in certain forward areas because helicopters are the only effective means of transportation. In this case, engineers rappel into the site to clear a zone, thereby limiting the type of equipment that can be used to clear a landing zone. The planner should then compare the type and availability of local construction materials with the overall needs of the project, examining both the naturally occurring in-place materials, which might have to be graded, and the possible sources of select materials for subgrade strengthening.

If it is necessary to import special materials for surfacing, drainage, and dust control, this must be done in accordance with available time and resources.

RECONNAISSANCE

FACE SITE RECONNAISSANCE

Forward aviation combat engineering reconnaissance differs from road location reconnaissance (FM 5-36) not so much in the type of information sought as in the comprehensiveness of that information. Ordinarily, a FACE requirement (especially airstrip or LAPES zones) involves more engineer resources than does combat road or trail construction. Consequently, for reasons of economy, it is even more important that the site selected is the best one available. Also, certain additional requirements are imposed on a FACE site by the operational peculiarities of flight. As with roads, FACE sites must be both feasible, in an engineering sense, and suitable for the traffic which will use them. Here, too, the difference is one of degree. Air traffic, by its very nature, imposes greater limitations on its traffic facilities than does vehicular traffic.

Advance planning. Advance planning is a prerequisite for execution of FACE requirements, particulary when the AirLand battle initiative has been gained. Tentative FACE sites within enemy territory are selected by map and aerial photograph reconnaissance. This map study is supplemented with any available reports of aerial observers or other intelligence sources. These sites may be either undeveloped potential sites or operating enemy installations. As soon as friendly forces have advanced sufficiently to make these potential sites or installations accessible to reconnaissance teams, they are promptly reconnoitered. In the case of a potential undeveloped site, the object is to verify or amend tentative selections and layouts, and to estimate the material, equipment, and troop requirements involved for the construction. In the case of a captured enemy airfield, a decision to use the existing field or develop a completely new site must be made. Appropriate estimates of the engineering effort necessary to restore the field are required. Advance planning should include preparation for briefing a reconnaissance party on the specific missions.

Criteria for selection. New aviation ground facilities should be added suitably distant from already operating friendly sites. The mobility planner looks for sites which are large enough, preferably flat with good natural drainage, with unobstructed air approaches, and accessibility to routes of communication. The most likely FACE sites are assigned to reconnaissance parties for appropriate air and ground investigation.

Face site aerial reconnaissance. Reconnaissance, detection, and reporting are important during the planning phase of any mobility task. However, FACE tasks also require aerial reconnaissance with active participation from aviation personnel. Enroute to a particular site or a general area, the engineer observer notes such items as open borrow pits, large stockpiles of construction material, rail and road accesses to the site or area, and changes and additions to maps. The pilot relates flying problems such as approaches and physical obstructions to the type of aircraft that may use the proposed installation. Several circuits are flown around the proposed site at varying altitudes, if the tactical situation permits. In departing from the area, dispersal areas are reviewed, and access roads are checked. Other possible sites are then inspected. Complete notes are kept to minimize reviewing sites already checked. However, a reinvestigation of the final site and any selected alternate sites may sometimes be necessary or desirable.

Face site ground reconnaissance. Map and air reconnaissance should precede ground reconnaissance to discover what specific sites and questions warrant ground investigation. Enroute to the site to be investigated, the reconnaissance party should note and record the general condition of roads and bridges and the location of locally available materials and equipment.

Preliminary check. When the site is reached, the most likely possibilities for construction or repair are swiftly reconnoitered. If the terrain is sufficiently open to permit good general observation, these places may be quickly traversed by vehicle, if possible, or on foot. Lengths are paced, critical slopes are measured, and directions are determined with a magnetic compass. The type of soil is noted, and hasty observations of a few samples are made. A preliminary check of a forward aviation facility can thus be made in 15 minutes or so, provided the country is reasonably clear and open and not mined.

Detailed search. If the country is rough and not sufficiently open to permit quick selection, a more detailed search must be made, usually on foot. The reconnaissance officer follows the perimeter of the site. The officer notes on a large scale map or sketch all obstacles which cannot readily be eliminated, such as gullies, rock outcrops, and swampy places. The reconnaissance of a designated site in the detail indicated here is accomplished as quickly as possible unless hostile forces delay the work.

Role of pathfinders. Engineer units involved in FACE activities frequently work in close coordination with Army pathfinder personnel. Their primary mission is the reconnaissance and establishment of Army aviation landing sites. Engineers should consult pathfinder personnel on matters concerning orientation, size, approach/departure zones, and aircraft capabilities.

PRINCIPLES OF LOCATION

Maximum use should be made of all existing aviation facilities. Existing airstrips and landing zones are often adequate, with a minimum of repair, to accommodate the type of Army aircraft operating in the forward and battle areas. They are, however, seldom adequate to handle high-performance aircraft. Also, helicopters and light planes can often take off and land from existing surfaces such as roads, pastures, and athletic fields. Maximum use should be made of these features. The following paragraphs discuss the principles of location and layout as they apply to mobility FACE tasks. Throughout the entire reconnaissance and preparation phases, problems can be avoided by a wise choice in site location. A project that is started without regard to location principles may not meet the requirements of availability, capacity, or convenience. These principles follow.

Mission. The governing factor in selection of a FACE site is mission fulfillment. Each forward aviation facility is constructed, maintained, or repaired in the most direct and expeditious manner possible to insure continuing aviation support capabilities.

Future expansion. Military operations place a burden on engineer troops to modify and expand previously completed construction. As operations progress, forward aviation facilities built for small aircraft with a limited mission may have to accommodate larger aircraft with far more stringent design criteria. The location of a ground facility should provide for future expansion.

Soil characteristic. In order to meet the design standards of-strength and stability listed in TM 5-330, and to minimize the need for removal of undesirable materials, all forward aviation sites should be located on terrain with the best possible soil conditions. Obviously, the location of a FACE site on terrain with soil that can quickly and easily be compacted to the desired standards will facilitate construction and result in a better site.

Drainage. Drainage is often a problem. Because of the nature of most airstrips and LAPES zones, it is often necessary to divert water around the field or construct long culverts and other drainage structures that are difficult to maintain. The bottoms of valleys or other depressed areas should be avoided because they tend to collect water. Airstrips and LAPES zones are constructed across long, gentle slopes because of the relative ease of diverting water around the installation.

Topography. With few exceptions, earthwork is necessary at most points along the FACE project. The amount of work can be minimized, however, through a wise choice of location. The engineer should take advantage of all prevailing grades that fall within the required specifications.

Flightway obstructions. The safe operation of aircraft, either fixed or rotary wing, requires the removal of all obstacles above certain heights, as specified by pertinent design criteria. These criteria vary and depend upon the operating characteristics of the aircraft. For example, most heliports require an approach zone with a 10:1 glide angle, whereas heavy cargo aircraft usually require a glide angle as flat as 50:1, In order to get this glide angle, it is often necessary to remove hills and remove large quantities of earth at considerable distance from the airfield. When siting the airfield, the engineer should keep this glide angle requirement in mind and avoid locations that will need extensive clearing. This is particularly difficult because of the large area involved.

Approach orientation. Normally, landing strips, LAPES zones, and helicopter landing approach zones are oriented in accordance with the prevailing winds in the area. Particular attention should be paid to gusty winds of high velocity in determining the site location. The established direction should insure 80 percent wind coverage, based on a maximum allowable beam wind (perpendicular to the runway) of 13 miles per hour, A favorable site, however, should not be rejected on this requirement alone. Where dust may be a problem on the landing surface, the runway should be located at an angle of about 10 degrees to the prevailing wind so that dust clouds produced by takeoffs will blow diagonally off the runway.

SOIL TRAFFICABILITY

As mentioned in chapter 7, the procedures for conducting simple soil tests can be found in TM 5-530 and TM 5-545. There are, however, three aspects of soil trafficability that require engineer attention in FACE reconnaissance. These are the possibility of frost action, the shearing resistance of the soil, and the determination of necessary compaction. These three soil characteristics are pertinent to FACE requirements due to the possibility of heavy loads being introduced anywhere on the site surface.

Frost action. Frost action refers to the freezing and thawing of water in soils. The upward displacement of the soil surface from frost action is called frost heave and causes a dramatic loss of bearing capacity. Frost heave may cause damage to forward aviation sites supported on the soil involved. The engineer determines whether or not frost action must be considered in the project design.

Shearing resistance. From an engineering viewpoint, shearing resistance or shear strength is one of the most important soil properties, It refers to a soil's ability to withstand loads under given conditions.

Compaction. Compaction is the process of mechanically densifying a soil. Densification is accomplished by pressing soil particles together, expelling air from the soil mass in the process. Because of certain advantages which accompany the compaction of soils, the process is a standard procedure in the construction of earth structures. However, certain soils under natural conditions will support considerable loads without need for compaction. They save time and effort in site preparation.

RECONNAISSANCE REPORTING

In order to quickly report the results of forward aviation site reconnaissance, units of all arms and services use a simple and concise format. The airstrip reconnaissance report can be used to report possible airstrip, helicopter landing zone, or LAPES site locations. This format is designed primarily for radio transmission. It can, however, be supplemented by drawings, maps, traces, or overlays for written reports. Much of the detail required can only be provided by qualified engineer personnel. Nonspecialist personnel of other arms include only the detail they are qualified to collect and report. This format implements STANAG 2096. A sample airstrip report is given in figure 8-4.

FIGURE 8-4. AIRSTRIP REPORT

ALFA	Map sheet(s).
BRAVO	Date-time group of information collection.
CHARLIE	Location.
DELTA	Dimensions.
ECHO	Type and condition of the facility. Also type and condition of possible helicopter landing zones and LAPES sites.
FOXTROT	Access by road.
GOLF	Feasibility of expansion (or airstrip extension).
HOTEL	Any other information which could be provided such as work required to make the facility serviceable for sustained limited operations.

EXECUTION

SITE SELECTION

The selection and design of a forward aviation site, such as a landing zone, LAPES zone, or airstrip, depends on several factors. These include the nature of the soil, drainage conditions, construction time, available material, and the engineer equipment and personnel available for technical advice or physical assistance. In certain cases, personnel other than engineers might be required to provide helicopter landing zones or other aviation sites with their organic equipment. In all circumstances, forward aviation facilities are simply designed, practical, and developed swiftly to meet the immediate needs of the mission. In forward aviation combat engineering, consideration is always given to the use of stage construction. This method satisfies the immediate requirements of units and aircraft in the forward areas while allowing follow-on forces to improve the facilities to meet increased traffic needs. The subtasks involved for each FACE task will depend on the site selected. The construction, maintenance, or repair of forward aviation facilities is primarily influenced by four variables related to the actual site. These are—

- The amount of effort required in clearing a suitable flight path.
- The effort involved in clearing the ground.
- The work and material required to provide an expedient surface of sufficient bearing capacity.

The following paragraphs explain the techniques used to overcome these restrictions. Other techniques can be applied, however, as the procedures in this manual focus on the most expedient means.

CLEARING FLIGHT PATHS

A forward aviation site may be desirable in every way except for such obstructions as houses, railroads, power lines, trees, and other structures. These obstructions could be located in the flight path or near enough to endanger the safe operation of aircraft. The reconnaissance party often selects a site where limited clearing will be necessary before full-scale operations can take place.

CLEARING, STRIPPING, AND GRUBBING

Clearing, grubbing, and stripping operations are essentially the same as those used during road and airfield construction. In FACE construction, the areas to be cleared are usually larger than those in road construction and the number of personnel and amount of equipment used are greater. The disposal of unsuitable materials often requires more planning and longer hauls on forward aviation projects than on road projects. Cleared material can be disposed of and, at the same time, serve a useful purpose as fill material in revetments around hardstands, when such passive measures are desired.

Clearing buildings. There are three principal methods of removing buildings. The building may be completely razed, through explosives or heavy equipment with little or no salvage, or it may be razed in such a way as to conserve as much usable material as possibIe. The third method is to move the entire building for use at another location.

Clearing roads and railroads. In general, a forward aviation ground facility may be located near roads or railroads if traffic on them will not interfere with the approach or takeoff of aircraft. It is usually unwise to destroy main paved highways and main railroad lines because they will be required later for ground operations, if not already in use. Also, landing zones, LAPES zone, or airstrips near a road can sometimes be disguised as part of the road net. Instead of rerouting a road, which involves great effort, the flight path and landing zone may be built to butt against the edge of the road or even cross it at grade. However, air traffic will always have precedence over ground traffic.

Clearing power lines. Power lines which are found in the way of construction or in glide angles in forward areas are removed. In rare instances, where the lines may be needed, they can be lowered to within 5 feet of the ground depending on the voltage being carried, ***or*** a different approach to the airfield could be used, This close-to-the-ground stretch must be protected with a fence and warning signs. As a last resort, they may be installed underground if armored underground cable is available to adequately insulate the lines.

Clearing trees. Criteria for glide angles and approach zones for airstrips and landing zones are described in TM 5-330. Obstructions, such as trees, which extend above the glide angle must be removed. Although glide angle requirements may be met by only topping trees, generally it is best to fell or uproot the trees which extend above the glide angle. To aid in camouflaging, standing trees and brush outside the designated cleared area should not be removed or touched unless necessary. For this reason, care is taken when uprooting trees to control their fall and to avoid breaking off surrounding trees. Timber useful for logs and lumber is stockpiled for future use in bridge, culvert, berm revetments and other types of construction. This timber is pushed or skidded into a salvage area and later removed, trimmed, or milled with little difficulty.

Clearing with equipment. In most cases, engineer equipment provides the most rapid and efficient method of clearing. Such equipment is limited only by unusually large trees and stumps, by terrain which affects its maneuverability, and by maintenance requirements. This equipment includes bulldozers, the M9 ACE, CEV, tractor-mounted clearing units, winches, and powersaws. Pioneer tools are also used in certain types of clearing operations. The selection of equipment is usually limited to that which is available on the job. In all cases, the best type of equipment for the job should be used. The speed of clearing depends on the material to be cleared, equipment, and methods used. Production rates of equipment under normal operating conditions are used for determining the total time required for the FACE task. With knowledge of the area and type of clearing and the production rates of the available equipment, the time can be estimated and a job schedule prepared. Methods for determining production rates of equipment are contained in TM 5-331 series. A time-estimating technique for the construction of aviation facilities based on site conditions is provided in TM 5-330.

Removing rocks and stripping. In certain FACE operations, all surface rocks must be removed. There are three methods used in this subtask.

Hand methods. Where sufficient time and personnel are available, rocks are picked up and loaded into hauling units by hand. This is a very slow method and is used only as an expedient.

Bulldozer. The bulldozer, M9 ACE or CEV are the most commonly used engineer equipment for moving rocks to a fill or disposal area. The rocks may be pushed by dozers to the designated disposal area.

Power shovels, scoop loaders, and trucks. Clearing an area of surface rocks by this method alone is possible, but it is a slow operation. However, if the rocks are first moved into piles by bulldozers or graders, the trucks can be quickly and efficiently loaded. The rocks can be hauled away from the site for disposal.

Stripping consists of removing and disposing of objectionable topsoil. Some examples of this type of surface material include humus, peat, and muck. Stripping is accomplished at the same time as clearing and grubbing. It can be done with bulldozers, the M9 armored combat earthmover, or scrapers. Stockpile the resulting topsoil and sod for later use.

DRAINAGE

Properly planned, designed, constructed, and maintained drainage facilities are essential to the serviceability of forward aviation ground facilities. Surface water is removed from site wearing courses by adequate crown or transverse slopes. Drainage systems accommodate this water and the surface water from adjacent areas. Natural and artificial means are used, generally in combination, to collect, intercept, control, and dispose of surface water with minimum erosion. Natural elements include streams, lakes, dry runs, and pending areas. Artificial or manufactured facilities used for expedient drainage include gutters, open channels, or ditches. In many instances, artificial drainage facilities can be avoided by grading the airstrip, LAPES zone, or landing zone to facilitate natural drainage. In other cases, required drain capacities may be greatly reduced by shallow ponding basins in nonuse areas. In these areas, runoff from heavy rainfall of short duration may be stored for brief periods of time without interfering with the use of the facility. A detailed discussion of the methods and design for draining both surface and subsurface water is provided in TM 5-330.

EXPEDIENT SURFACING

Landing mats and membranes are used as expedients for FACE site surfacing. Landing mats are used when the strength or smoothness of landing surfaces is not adequate. Membrane surfacing is used where soil strength is adequate but may become too weak when wet. Membrane is placed under all landing mats in high traffic areas such as runways and taxiways, thus providing a waterproof covering for the soil. Membrane is also used for dust control in aircraft traffic areas where chemical dust palliative are either less satisfactory or require greater time or effort to use. Several new materials and techniques are currently under study as expedient surfacings. The types, specifications, and emplacement of matting material are described in TM 5-330. Placement techniques, anchoring, repair, and maintenance of surfacing membrane are discussed in TM 5-337. Helicopter landing zones in heavily wooded areas can be developed with manual and explosive methods of clearing. Time permitting, or under marshy conditions, the timber felled may be used to prepare a hardened landing pad. Landing pad logs are leveled to insure a satisfactory surface upon which the helicopter skids can rest without danger of skid damage. The perimeter of the landing area must be checked to assure vertical clearance.

MAINTENANCE AND REPAIR

The maintenance of forward aviation sites will be accomplished by combat engineers augmented when necessary by other engineer units. This includes LAPES zones and Army logistical resupply strips in the forward areas including strips used by Air Force C-130 type aircraft. The immediate emergency damage recovery of forward aviation facilities is generally considered to be the minimum work required to permit aircraft to land and take off.

Maintenance during flying operations. Maintenance and repair work during flying operations must be coordinated with tactical operations and with minimum interference to air and ground traffic. Much of this work must be done at night or during inclement weather. Hazardous equipment must not be left on the landing surface or other areas. Areas under construction or repair must be clearly marked on the surface so as to be visible from the air.

Mud control. Mud on the landing surface is hazardous to aerial traffic because it can impede takeoff and increase the stopping distances for landing or taxiing aircraft. Muddy taxiway and runway surfaces decrease tire life and increase the wear and the necessary maintenance of brakes. Flying particles of mud may cause damage to propellers, rotors, and jet engines. Also, the removal of mud from wheels, struts, and fuselage is an additional maintenance burden. Mud on airfield and heliport surfaces is deposited by vehicular traffic from adjacent muddy area. It is also caused by the failure of the subgrade due to excess moisture and the action of traffic. Localized soft or muddy spots in an otherwise satisfactory surface are repaired, replacing the unsatisfactory subgrade material with a more suitable one. If the muddy area is too large, all traffic may need to be stopped until the surface dries. In extreme conditions, resurfacing may then be necessary. Under some conditions, surfaces may be kept in operational condition by removing the surface mud. It can be removed by hand shoveling, blading, or the use of a drag.

Repair of captured facilities. An appraisal of the damage to a captured aviation facility precedes the decision to rehabilitate it. Occasionally, the effort to restore a badly damaged site is greater than that required to construct a new one. Damage to the installation includes the war damage by our forces in battle and the deliberate damage by the enemy before yielding the facility. The enemy will usually resort to one or more of the following destructive measures:

- Placing delayed-action bombs, mines, and booby traps.
- Demolishing drainage systems and pavements.
- Placing obstacles and debris in the landing surface.
- Flooding surfaced areas.
- Blowing craters in runways and handstands.

The first priority in restoring a captured airfield is to establish minimum facilities for immediate operation of friendly aircraft. This implies the removal of delayed-action bombs, mines, and bobby traps from the traffic areas, the clearance of debris from the traffic areas, and the repair of craters and the landing surfaces. Adequate repair must be promptly made to the drainage system.

COMMAND AND CONTROL

Combat engineer units have responsibilities for forward aviation facility construction that correspond to their equipment capabilities. Engineer units will assist combat units in forward aviation site development, as required. Combat units are capable of creating helicopter landing zones. Assignment of equipment such as dozer tanks and recovery vehicles provide this basic capability in extreme cases. Extensive combat construction efforts will be accomplished by engineers. FACE requirements will be generated through the division G-3. Aviation assets, organic and attached to the division, along with supporting Air Force elements, will be represented by special staff positions within the G-3. The commander will establish and control priorities for engineer support requirements. Both division and corps engineers share in this task under the mobility system concept. Division engineers concentrate on repairing existing sites or the expedient development of facilities that enhance the freedom of movement and maneuver for combat aviation units and their supply vehicles. The engineer coordinates other engineer units, when available, to accomplish combat road and trail tasks which exceed the battalion's capability. Corps engineer units, in support of the division, may be employed on an area or task basis. FACE tasks for these engineer units generally involve the construction of landing strips or the expansion of facilities built by divisional engineers.

CHAPTER 9

Mobility Support in Special Situations

CONTINGENCY OPERATIONS

POSSIBLE SCENARIOS

Future combat will see US forces involved in two possible scenarios. In one case, war may begin where substantial US Army units are already stationed. In the second, conflict could begin in areas where there are few or no existing US forces. Combat operations in this second case will be required generally for two reasons: vital natural resources require immediate US protection, or an allied nation is militarily threatened. Such operations will require a rapid deployment of US forces into unfamiliar terrain or environments. Deployment of US forces under these circumstances is called contingency operations.

INITIAL FORCES MOBILITY

Mobility planning (chapter 3) will be critical to the actual deployment phase of a contingency operation. Once the mission to deploy is given, the estimate, planning, and preparation process begins. The engineer terrain analysis detachments, using their tactical terrain analysis data base, develop all available information on the contingency area.

Special topographic products and tactical maps are then produced. Using this information, the mobility planner analyzes the contingency deployment area. Obstacles, mined areas, and the existing road and communications network are studied in detail. The analysis of existing air landing facilities and availability of suitable areas for development of forward aviation landing sites is extremely important. Once analyzed, the designation and priority of countermine, counterobstacles, gap crossing, and mobility combat construction (combat roads and trails and FACE) tasks are made. This information determines the structure of the engineer force in the deployment plan.

Assault phase. The assault force will usually consist of lightly equipped combat units. Light infantry, airborne, or air assault units are commonly tasked for contingency assault missions. These forces may not require extensive engineer mobility support for clearing mines and booby traps, but their logistics support will often demand concentrated engineer effort. Engineers could be tasked to construct helicopter landing zones and low altitude parachute extraction system (LAPES) zones, and to repair or expand existing airfields.

Lodgement and expansion phases. In the lodgement and expansion phases, the ability to move units and supplies over land will increase in importance. Because of enemy resistance, greater emphasis will be placed on countermine and counterobstacle activities. Mobility efforts, although expanded in quantity, are executed within concentrated areas of terrain. Once the theater becomes developed, mobility support for offensive operations will predominate. Combat engineer units that supported the initial deployment and lodgement phases would be reinforced to maintain unit freedom of movement.

THE THREAT

Any conceivable Threat configuration could oppose friendly forces in a contingency operation. To insure that friendly forces establish a strong foothold, enemy mobility and air superiority must initially be countered. Countermobility, survivability, and mobility tasks are used to protect the assault force, achieve initial objectives, and prohibit the enemy from maintaining uncontested superiority on the ground and in the air.

TERRAIN ASPECTS

Topography, climate, and habitation of the contingency area will significantly affect mobility activities. Section III of this chapter deals with mobility techniques that apply to special terrain areas and environments. These include the terrain in mountains, deserts, and jungles and the environments associated with cold weather regions and urban combat operations.

EQUIPMENT AND SUPPLY LIMITATIONS

Contingency operations begin with a rapid deployment of forces. Normal supply and resupply operations will be delayed and will have to catch up with the initial forces. As initial deployment will most likely consist of a light force, heavy engineer equipment will be scarce. This will significantly limit mechanical breaching methods and combat trail development. Contingency forces must plan extensively for manual and explosive means to maintain the momentum of operational movement.

ALLIED FORCES

The United States maintains substantial forces in Europe. In the event of combat there, these forces can materially assist force development and sustainment. The European theater of operation has been well defined for years. This has enabled peacetime planning, base development, and the establishment of detailed host nation support agreements.

COMBINED OPERATIONS

OTHER THEATERS

In other potential combat theaters, international agreements with US allies on principles and procedures do not exist or are only partially developed. These theaters will present more demanding challenges. In both of the possible theaters of operation, combat activities will involve combined operations with allied forces.

INTEROPERABILITY

Interoperability is the capability of multinational forces to operate together smoothly in combat operations. This includes the ability to plan, exchange information, and execute mobility tasks in support of one another. Commanders involved in combined operations must be aware of SOPs, STANAGs, and any other procedural agreements made between forces. In addition, a commander should train as much as possible with equipment, methods, and supplies organic to friendly foreign forces mobility efforts. When a host nation with the required capability exists, host nation support (HNS) agreements may provide equipment or labor for road maintenance or development of aviation ground sites. These assets can free US engineer assets for other high priority engineer tasks.

OPERATIONS IN THE NORTH ATLANTIC TREATY ORGANIZATION

European forces come under the umbrella of the North Atlantic Treaty Organization (NATO). The mobility planner in Europe is concerned with the terrain and climatic characteristics of the three NATO regions.

AFNORTH. The Northern European Command, also know as Allied Forces, Northern Europe (AFNORTH), is made up of Norway, Denmark, and the northern portion of Germany. Climatic conditions in this area vary from cold and wet in the southern areas to almost subarctic in the northern tip of Norway and Sweden.

AFCENT. Allied Forces, Central Europe (AFCENT) includes most of Western Europe, specifically West Germany. The climate of this area is cold and wet most of the year. The terrain is generally rolling and open, with many urban and built-up areas of 50,000 population and greater. Mobility tasks, especially gap crossing, will be critical, as this region possesses a diverse network of drainage features.

AFSOUTH. Allied Forces, Southern Europe (AFSOUTH) includes Italy, Greece, Turkey, and the Mediterranean. The climate is bitter cold in some regions but is generally warm in most areas. The terrain of northern Italy, Greece, Turkish Thrace, and eastern Turkey is mountainous. The plains of the Po River Valley, however, provide for generally unrestricted mobility and direct fire. The ability to overcome enemy reinforcing obstacles will dominate the battle for this key mobility corridor.

OPERATIONS IN THE PACIFIC COMMAND

Forces stationed from the west coast of the Americas across the Pacific Ocean to the western shores of Southeast Asia come under the umbrella of the Pacific Command (PACOM). Two important areas of the command are Japan and Korea. As in NATO, important differences in capabilities, doctrine, and equipment exist among various national forces in PACOM. Unlike NATO, few STANAGs exist to negotiate the differences. Again, environmental considerations are critical for the mobility planner in these areas.

Korea. The threat to the Republic of Korea is the powerful North Korean Army. The climate and terrain in which mobility activities in Korea would take place include mountainous, rugged topography with a temperate, monsoonal climate. Most of the terrain favors light infantry operations, yet two major avenues of approach from the north allow mechanized activity. Freedom of movement revolves around the trafficability of existing routes and aircraft landing facilities. The cultivation of rice in most regions and confluence of rough terrain has created numerous tactical choke points. The repair or maintenance of existing trafficways and the development of combat routes are critical factors in mobility planning.

Japan. The five major islands of Japan have climate similar to that of the US east coast. The terrain of the islands is mostly mountainous, with the urban and population centers located in the remaining habitable areas. As in Korea, there is limited written agreement on operational activities between US forces and Japan. Significant efforts must be made to insure interoperability of forces. Mobility tasks will most likely involve freedom of movement for forces in mountainous terrain.

OPERATIONS IN THE CENTRAL COMMAND

Forces stationed or selected for operations within a region bounded by the Persian Gulf, the horn of Africa, and the nations of Southwest Asia come under the control of the Central Command (CENTCOM). Formerly known as the Rapid Deployment Joint Task Force (RDJTF), the CENTCOM focuses on contingency operations within its assigned area. As is the case with the PACOM, few agreements exist among multinational forces which influence the CENTCOM region. The mobility planner, in developing operational considerations for CENTCOM, must consider desert and jungle environments.

SPECIAL TERRAIN AND ENVIRONMENTS

CONSIDERATIONS

Mobility tasks undertaken in areas with special terrain or unique environmental conditions will require special considerations. Terrain and weather extremes tax the combat capabilities of personnel and equipment. Mobility planners and engineers must understand the special characteristics of these terrain areas and weather environments. Knowledge of the critical advantages and disadvantages of these areas is necessary in applying the different mobility functions under combat conditions. This section will explain operational differences in the planning and execution of mobility support tasks for mountain, desert, jungle, cold region, and urbanized terrain.

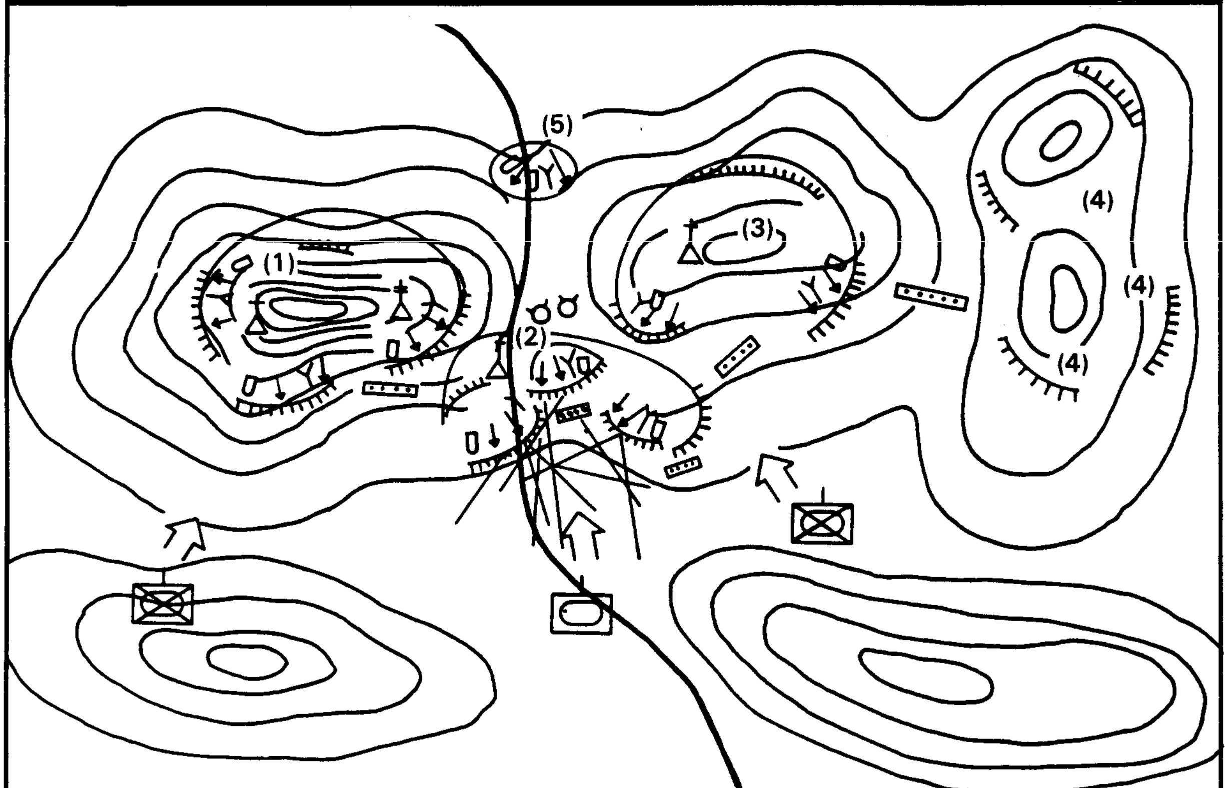
MOUNTAINOUS TERRAIN

Specific characteristics of mountainous regions vary widely. Mountains may rise abruptly to forma terrain barrier or they may rise gradually as a series of parallel ridges extending for miles. They may also be a combination of isolated peaks, rounded crests, eroded ridges, and high plains. In almost all cases, these regions have rugged, poorly trafficable terrain with steep slopes and local relief greater than 500 meters. They do differ in climate, however. In desert regions, the mountains are dry and barren with daily temperature extremes. Mountains in jungle regions are frequently covered by lush vegetation, further limiting trafficability. The Alpine-type ranges are generally inaccessible to vehicles.

Mobility planning considerations. Tactical movement of forces and supplies will be difficult in rugged mountain areas. Most of the terrain is divided into narrow valleys bounded by high hills. Roads and trails are usually few with steep gradients and numerous curves. The objective of most mountain operations is to open, secure, or deny the use of passes, choke points, or other key points on lines of communication. Usually, these operations require significant combat engineer participation.

The Threat will use the largest part of its force to defend mountain passes as they are considered the tactical key to an entire mountain range. Figure 9-1 depicts a deliberate Threat mountain defensive position. In defending a pass, the Threat occupies the heights dominating the pass as well as the most important spurs on the approaches to it. Weapons are distributed in depth along the slopes. The approaches to the pass are covered by flanking fires and crossfire. Roads through the pass are mined and narrow spots prepared for demolition. Explosives also may be installed for the purpose of creating slides. In wooded terrain, Threat defensive positions are organized at the forward edge of the

FIGURE 9-1. THREAT COMPANY IN THE DEFENSE (MOUNTAINS)



Key:
(1) First motorized rifle platoon.
(2) Second motorized rifle platoon.
(3) Third motorized rifle platoon (-).
(4) Adjacent unit.
(5) Reserve (one squad from 3d platoon).
Light machine gun.
Antitank grenade launcher.
Observation post.
Company commander's command and observation post.
Antitank mines.
Fougasses or explosives.
APC.

woods or on commanding heights. Elevated platforms are built in trees for machine guns and observation posts. Antitank and antipersonnel mines, artificial landslides, and other obstacles are widely used.

Countermine tasks in mountainous terrain. Minefields in mountainous areas normally require breaching activities as the reinforcing value of the rugged terrain makes such minefield almost impossible to bypass. Command and control of a breaching, hasty or deliberate, is more difficult than in open terrain. This is due to the lack of maneuver space and the increased chance of observed covering fire from concealed enemy forces. Mechanical mine devices, such as mine rollers or plows, are not easily employed in mountainous terrain. The lack of roads and trails and predominance of large rock outcropping force the use of explosive or manual methods. Care must be used with explosive line charges to prevent rockslides or avalanches started by the explosive shock. Breaching forces should use military judgment in establishing safe stand-off distances in these cases.

Counterobstacle tasks in mountainous terrain. A series of well-placed obstacles will create a formidable barrier in rugged terrain. Engineer mobility support to counterobstacle tasks will be extensive. Due to restricted trafficability, counterobstacle equipment and personnel should be employed near the front of advancing forces. Washouts, craters, landslide rubble, and point obstacles will have to be breached or reduced. Bypass will almost always be difficult or impossible. In certain mountain areas, light equipment, demolitions, and manual efforts will have to be used. Obstacles covered by fire will present particularly dangerous situations. Support and assault forces must gain superior fields of fires over defending forces. This will involve selection and use of key high ground protecting the breach site.

Gap-crossing tasks in mountainous terrain. Gap-crossing requirements in mountainous terrain could be extensive. Well-placed enemy point obstacles or strongpoint defenses of trafficable routes can easily deny mechanized maneuver. Light forces, supported by engineer assets for spanning short gaps, are best suited to mountain operations. Deliberate gap crossing will normally have to be executed in order to maintain mobility. The time factors involved will generally be restrictive for swift moving operations.

Combat road, trail, and FACE tasks in mountainous terrain. Combat engineer construction in mountainous areas is directed mainly at opening or maintaining the use of passes and other key terrain. Usually, excessive amounts of cut and fill are required for construction of mountain combat roads and trails. Expedient combat construction work is thus limited to the repair and maintenance of existing roads and trails. Sidehill cuts will be used when possible. Because of extensive slopes, rains, and seasonal thaws, the design of drainage facilities is very important. Abnormal gradients on combat trails and roads may be necessary to insure that construction keeps pace with tactical operations. Turnouts should be planned and built at least every one-half kilometer. These expedient holding areas can accommodate slow or stalled vehicles and reduce traffic congestion.

The development of air landing strips or helicopter landing zones will constitute the majority of FACE tasks in mountainous terrain. Due to rocky ground, extensive clearing is difficult, if not impossible. Standoff space from rock wall faces must be cleared and a level landing surface provided. Demolitions may be required for the clearing of large rocks.

DESERT REGIONS

Deserts are arid, barren regions of the earth incapable of supporting normal life due to lack of freshwater. Temperatures vary according to latitude and season. Annual rainfall may vary from 0 to 10 inches but is often totally unpredictable. Desert terrain also varies considerably from place to place, the sole common denominator being lack of water. The three types of deserts are mountain, rocky plateau, and sandy or dune.

Mountain deserts are characterized by scattered ranges or areas of barren hills or mountains, separated by dry, flat basins. High ground may rise gradually or abruptly from flat areas to a height of several thousand feet above sea level. Most of the infrequent rainfall occurs on high ground and runs off rapidly. This runoff takes the form of flash floods, eroding deep gullies and ravines, and depositing sand and gravel around the edges of the basins. Water rapidly evaporates, leaving the land barren (figure 9-2).

Rocky plateau deserts, shown in figure 9-3 on page 9-8, have relatively slight relief interspersed by extensive flat areas with quantities of solid or broken rock at or near the surface. These desert areas usually have steep-walled eroded valleys, known as wadis in the Middle East and canyons in the United States. The narrower of these valleys can be dangerous to personnel and material due to flash flooding.

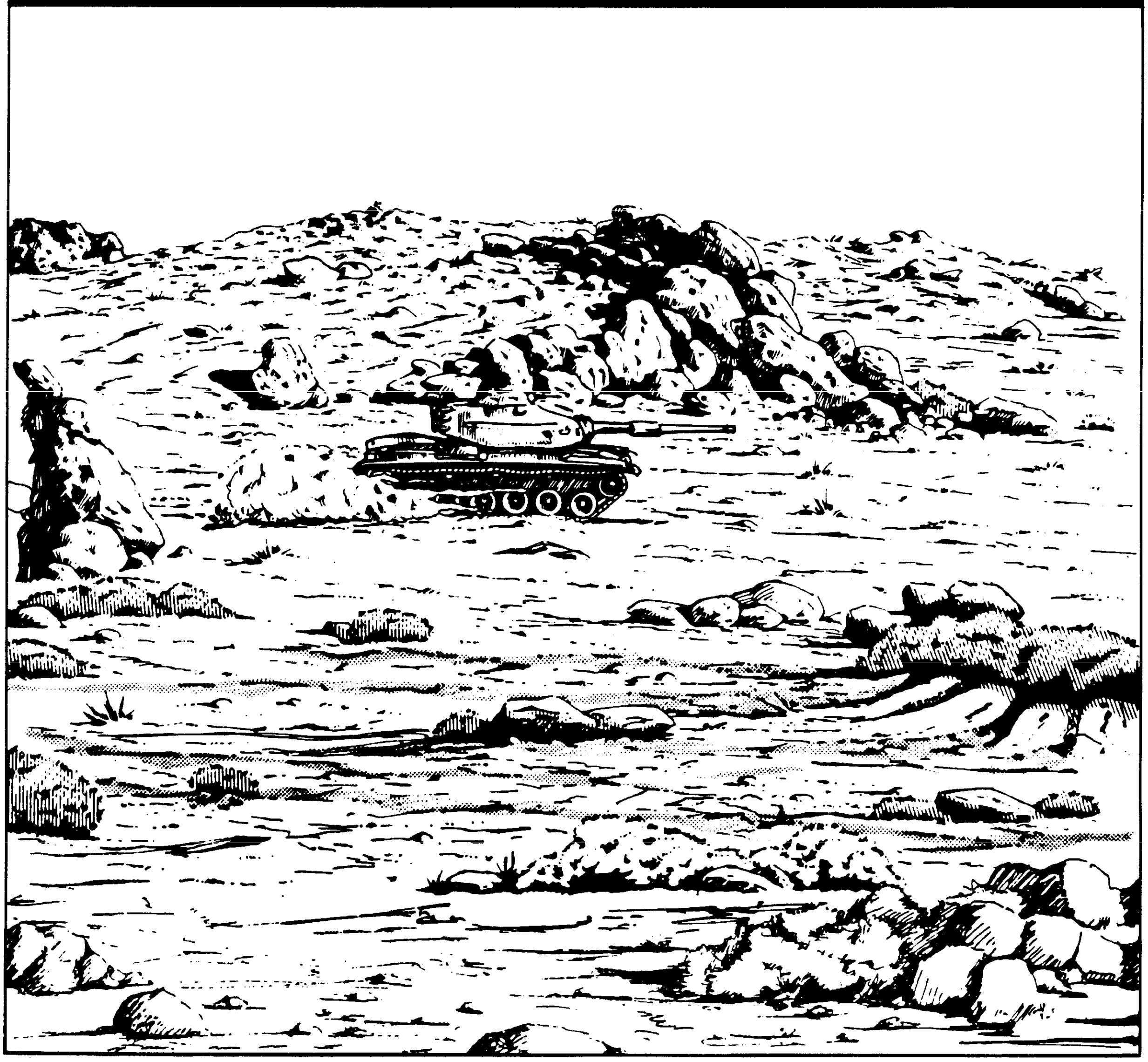
Sandy or dune deserts are extensive flat areas covered with sand or gravel. "Flat" is relative in this case, as some areas may contain sand dunes that are over 1,000 feet high and 10 to 15 miles long. Trafficability in such terrain will depend on gradients of the dunes and texture of sand. Other areas, however, may be totally flat for distances of 3,000 meters or more (figure 9-4 on page 9-9).

FIGURE 9-2. MOUNTAIN DESERT

Mobility planning considerations. Roads and trails are scarce in the open desert, as complex road systems are not needed. Some surfaces, such as lava beds or salt marshes, may preclude any form of routine vehicular movement. However, ground forces can often travel in any direction necessary, although speed of movement will vary depending on surface texture. Trails exist in many deserts for use by caravans and nomadic tribes and vary in width from a few to over 800 meters. Vehicular travel in mountainous desert country may be severely restricted.

Extremes. Extremes in desert weather and light conditions must be considered in the planning and execution of mobility tasks. The day to night temperature may fluctuate as much as 70 degrees Fahrenheit, imposing a strain on personnel and sometimes affecting equipment. Desert winds can achieve almost

FIGURE 9-3. ROCKY PLATEAU DESERT



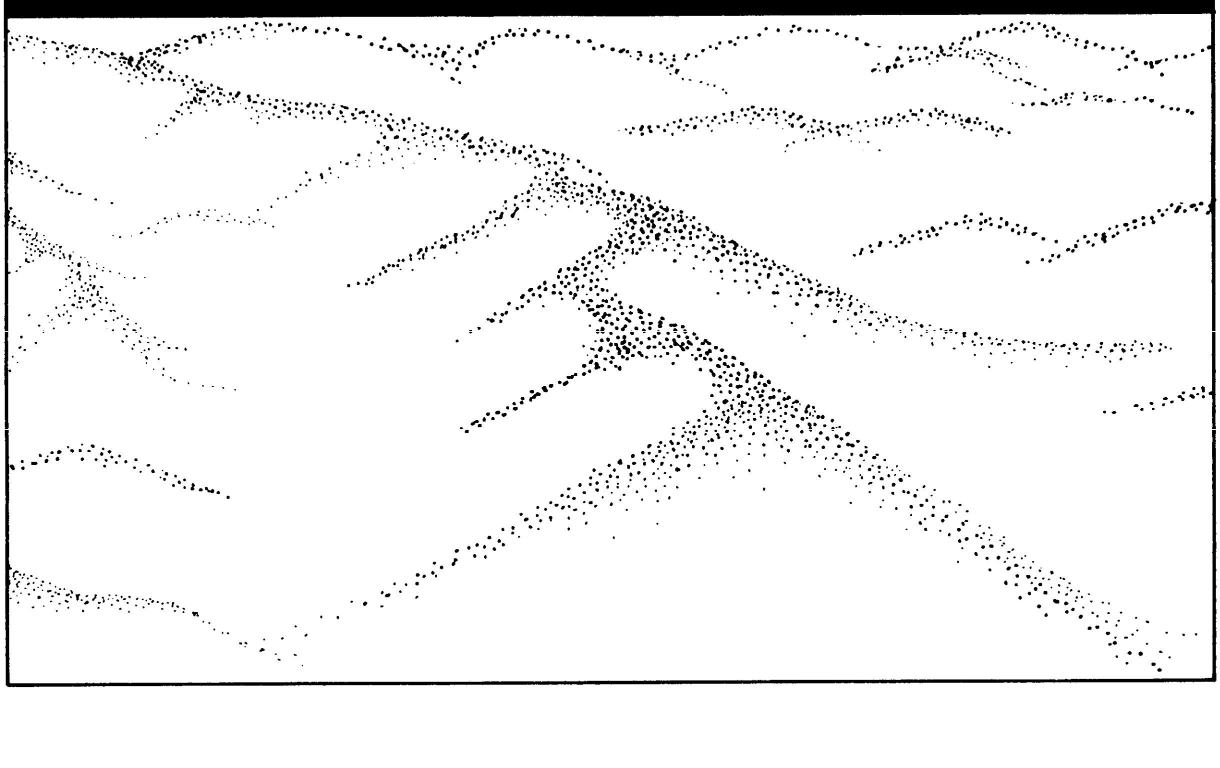
hurricane force. The dust and sand blown by these winds can make maintenance very difficult and restrict visibility to a few meters. Rain may consist of a single violent storm per year with high surface water runoff which will either reduce trafficability in wadi areas or somewhat improve it if the terrain is pure sand. Also, rain occurring several hundred miles away can cause flooding with otherwise dry streambeds suddenly becomming hazardous.

Threat defensive. Threat defensive tactics in desert terrain are marked by a wide dispersion of forces with large unoccupied areas between Threat forces. These gaps are kept under observation by patrols and ambush parties during the day and by observation posts at night. Alternate direct-fire weapons positions are prepared to cover gaps, and they are also covered by indirect fire. Regimental minelaying teams, supported by division minelayers, emplace minefield to protect company strongpoints and canalize enemy armor into fire pockets. They can lay approximately 500 meters of minefield per hour, with a density of 500 to 1,000 mines per kilometer. Minefield are covered by antitank weapons and can be rigged for arming or detonating by remote control. Dummy positions are also used.

Night defensive. The Threat emphasizes defense at night and during sandstorms. Motorized rifle companies move to alternate positions after early evening nautical twilight (EENT) as a deception measure, and tanks and infantry carriers protected by infantry squads move forward and to the flanks to ambush and to cover intervals between units. Strongpoints maybe encountered not only as part of a deliberate defense, but also as protection for vital installations or key terrain features. The type of strongpoint will vary. Two examples of likely platoon-size strongpoints are shown in figure 9-5 on page 9-10.

Countermine tasks in desert terrain. Mines will be used frequently to impede force mobility. Since bypass of small minefield is

FIGURE 9-4. DUNE DESERT



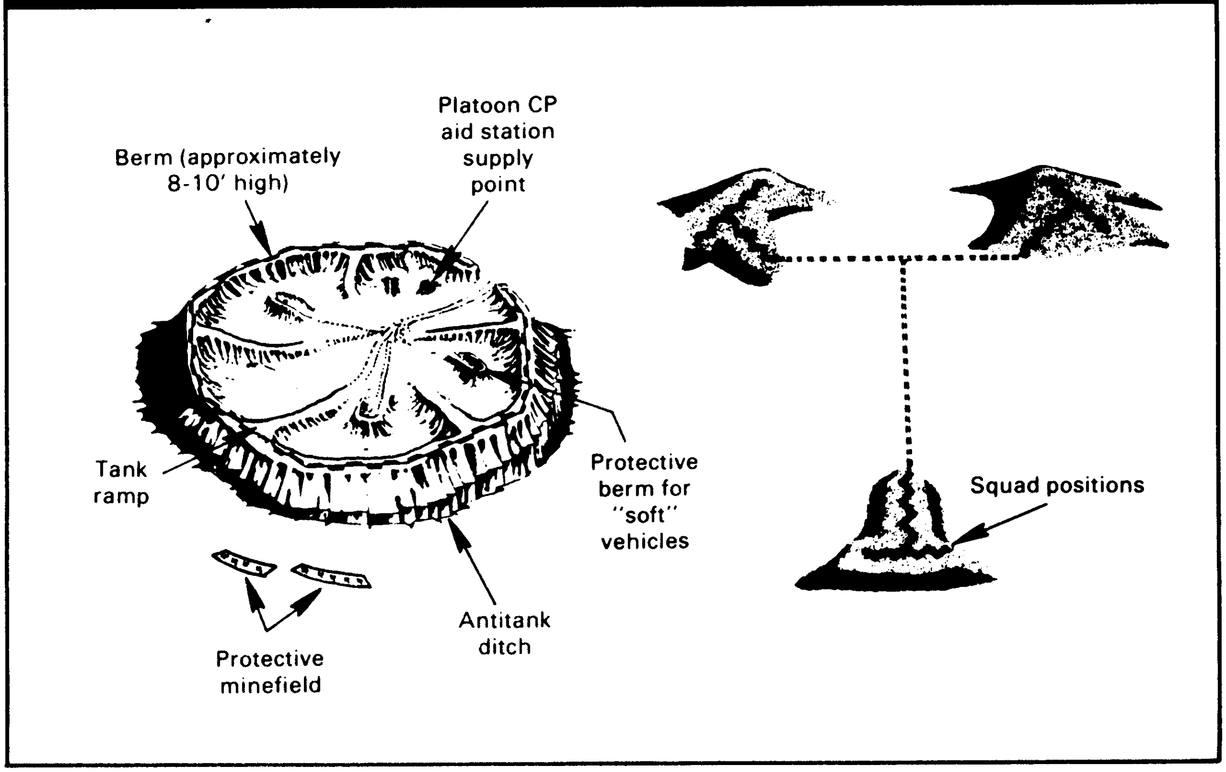
relatively easy in desert terrain, enemy minefield will need to be extensive. However, US forces should be alert for the nuisance mining of desert tracks and road edges. Mines are easy to emplace and camouflage in most desert soils. Large phony minefield, prominently marked, might be effective once US soldiers are mine-conscious. Engineers must be well forward to quickly locate and breach or bypass minefield and preserve force mobility. Since minefield can be easily installed or altered by the enemy, thorough and constant mine reconnaissance is required in a desert environment.

Counterobstacle tasks in desert terrain. Use of existing desert obstacles may permit a force to establish a defensive position that cannot be turned from either flank. However, these are rare. For example, only five natural defensive positions exist over a distance of 3,800 kilometers west of El Alamein in Egypt. In any case, an attacking force capable of airmobile or extended ground operations can usually find away over or around an obstacle. The defending force can then be bypassed, contained, or taken from the rear.

Gap-crossing tasks in desert terrain. Although trafficable across the basins, desert routes present unique gap-crossing difficulties. Desert areas may be cut by dry, steep-walled eroded valleys. In dry weather, these gaps are trafficable without the use of extensive gap-crossing equipment. However, flash flooding can swiftly turn them into wet gaps. Desert areas present several other unique gap-crossing considerations.

Pipelines. Exploration for and exploitation of

FIGURE 9-5. THREAT PLATOON STRONGPOINTS



minerals occur in many desert areas, especially in the Middle East. Wells, pipelines, refineries, quarrying and crushing plants may be of strategic and tactical importance. Pipelines are often raised 1 meter off the ground. Where this is the case, pipelines can inhibit movement. These obstacles can be crossed by assault bridging in areas where bridging is possible, by tunneling under the pipes, or by building earthen ramps over them. In locations where pipelines do not need to be kept intact, they can be breached by explosives.

Irrigation ditches. Many desert areas are fertile when irrigated, and a number of villages in deserts depend on irrigation canals. Agriculture in these areas has little effect on military operations except that canals may limit surface mobility. The effect of destruction of an irrigation system on the local population may become an important consideration in an operation estimate. Such ditches can be effectively crossed with assault assets.

Combat road, trail, and FACE tasks in desert terrain. Desert roads are usually scarce and primitive. They may marginally sustain the battle area and forward area traffic. The limited hard surface routes will be necessary for resupply. Therefore, considerable engineer effort may be necessary to develop and maintain combat routes forward to maneuver units. Local resources, such as marsh mud laid on sand, provides an expedient trafficable surface. These routes should be restricted to wheeled traffic only. An abundance of flat, open terrain exists in many desert areas for possible use as forward aviation sites. Soil stabilization may be required but will be limited by the amounts of water and equipment required. Selection of aircraft landing sites should focus on level, open areas. Dust palliative should be used, since soils of desert regions cause extensive dust. These soils also may have limited or varying bearing capacity.

JUNGLE TERRAIN

Jungles are common in tropical areas of the world, mainly Southeast Asia, Africa, and Latin America. The climate varies with location. Close to the equator, all seasons are nearly alike, with rains throughout the year. Farther from the equator, jungles have distinct wet (monsoon) and dry seasons. Jungles are characterized by high temperatures, heavy rainfall, and high humidity throughout the year. The jungle environment includes densely forested areas, grasslands, cultivated areas, and swamps. Cultivated areas exist in jungles and range from large, well-planned and well-managed farms and plantations to small tracts cultivated by individual farmers. Three general types of cultivated areas are rice paddies, plantations, and small farms.

Mobility planning considerations. Jungle terrain and climate impose many restrictions on the freedom of movement for conventional forces. Densely forested areas may make movement difficult. Thick stands of bamboo may slow or even stop tracked vehicles. Jungles in rugged mountainous areas will impede vehicular traffic. Rainy seasons (monsoons) cause rivers and streams to rise and become unfoldable, and heavy rains may cause damage to roads.

Influence on waterways. The inland waterways and coastal (delta) regions are land environments dominated by water routes. There may be one or more major waterways and an extensive network of smaller waterways. Usable roads are scarce, and cross-country movement is extremely difficult. The three regions of drainage features found in jungle terrain follow.

- Upper sector (headwaters). The headwaiters of a waterway are usually formed in a mountainous region. These consist of numerous tributaries which merge to form a river system as the water flows down to the valley. Headwaters are characterized by waterfalls, rapids, and variations in water depth (figure 9-6 on page 9-12).

- Middle sector (central valley). When the waterway reaches the central valley, it has formed a broad river. The river in the valley is wide, slow, and often meanders.

  During periods of heavy rainfall, the course of the river may change. The jungle vegetation grows up along the riverbanks to form an almost solid wall. The banks of the river are often steep and slippery (figure 9-7).

- Delta region (figure 9-8). When the river reaches the low coastal area, it becomes a number of river tributaries depositing a great amount of sediment into a gulf, bay, or ocean. Bottoms of the tributaries normally slope up to a crest or bar at the river's mouth. In some instances, only watercraft with a draft of 1 to 2 meters will be able to cross the crest or bar at high tide.

Use of camouflage. A jungle enemy can be expected to be skilled in the art of camouflage, using bunkers and tunnels as protective survival measures. To slow opposing forces, obstacles, mines, and booby traps may be used. The enemy will move on covered and concealed routes, using darkness for cover. Jungle enemies will probably depend heavily on streams and rivers to provide concealed routes of movement and drinking water.

Role of engineers. Engineers "open up" the jungle. Combat road and trail building and repair, and gap-crossing activities are continuous tasks for the engineers in jungle terrain. Engineers support the infantry in the

FIGURE 9-6. HEADWATERS OF A WATERWAY

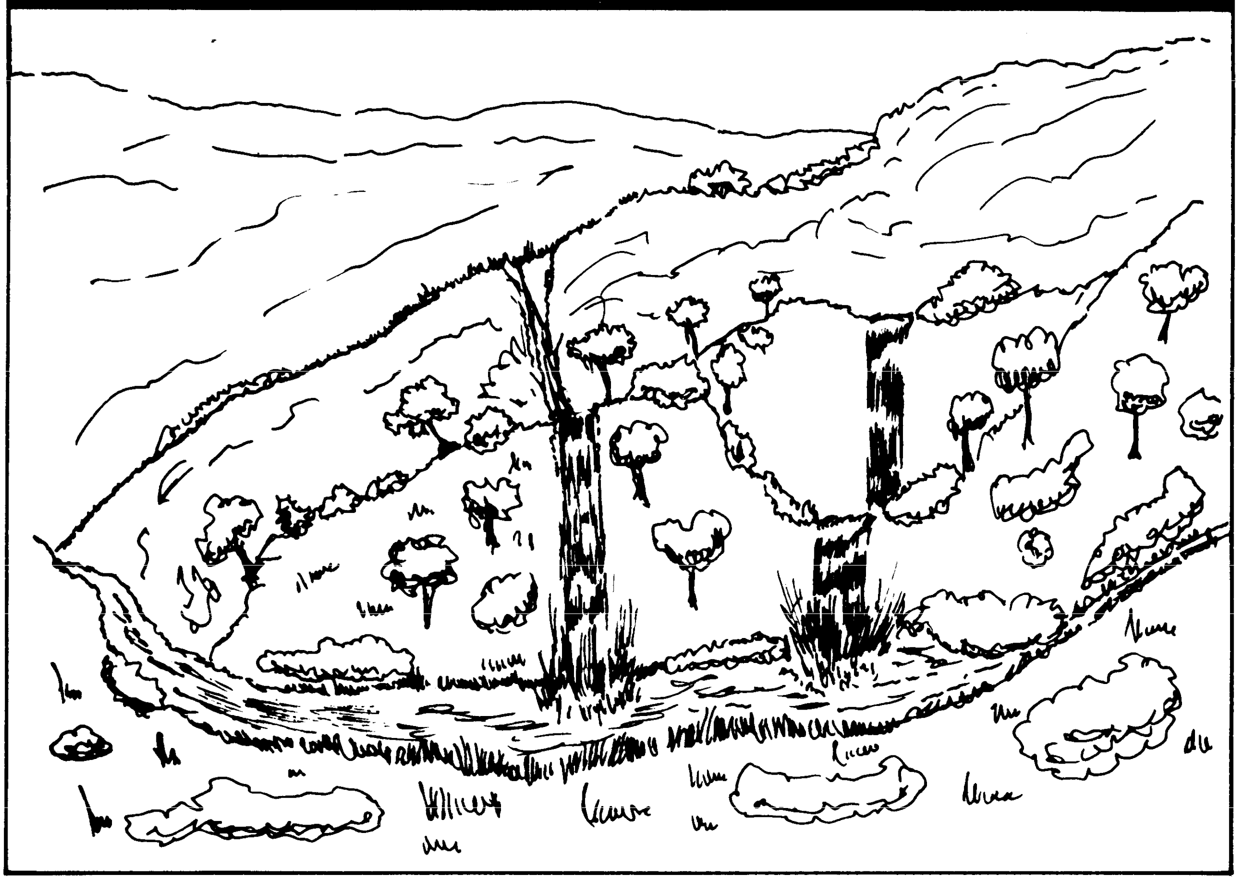


FIGURE 9-7. CENTRAL VALLEY WATERWAY

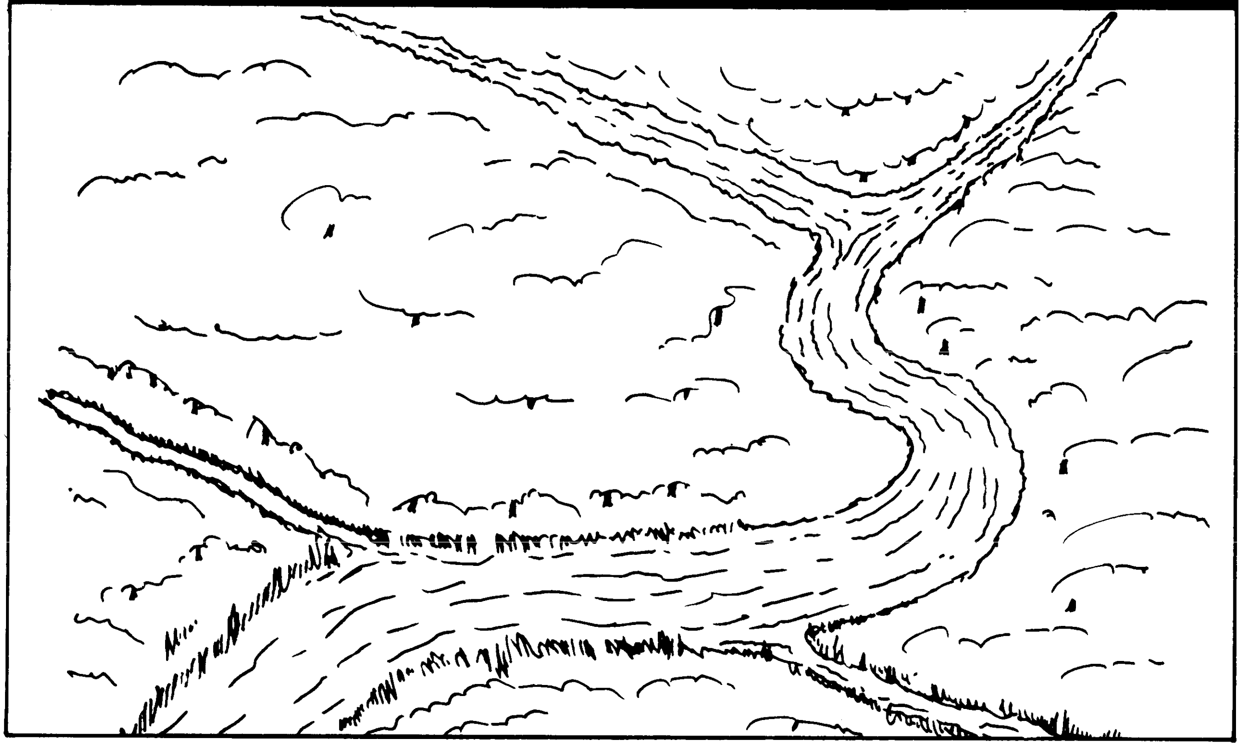
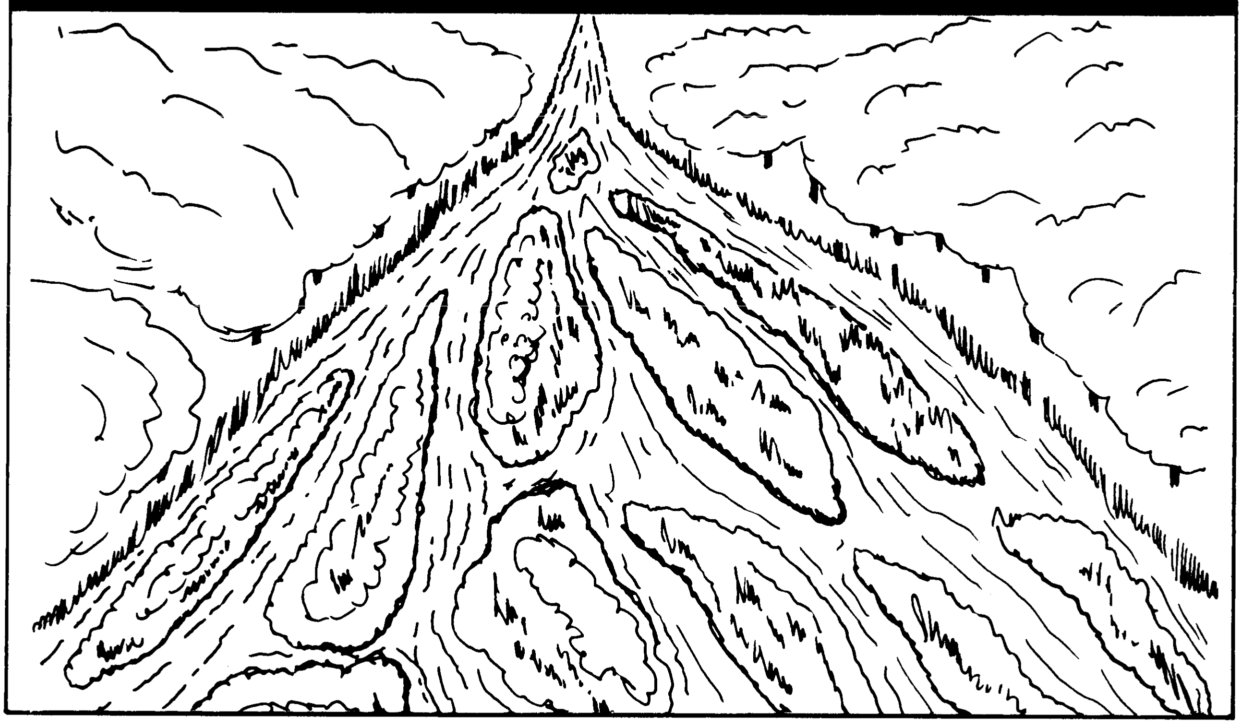


FIGURE 9-8. DELTA REGION



jungle primarily by clearing the way for the movement of friendly forces. It is also essential that the infantry support the engineers, as engineers are extremely vulnerable during construction activities.

Countermine tasks in jungle terrain. Enemy mines will generally be used on or near trafficways or potential helicopter landing zones. Large minefield are unnecessary due to the restrictions of jungle terrain. Countermine tasks are usually conducted as route clearance and security missions. These activities are oriented on a specific route and the surrounding areas to insure that vehicular operations are not interrupted. Whenever possible, route clearance is a combined arms effort involving as a minimum the use of armor, infantry, engineers, artillery, and Army aviation. Route clearance involves deliberate, detailed, and coordinated actions which are slow. The route must often be walked by minesweep teams, and the areas adjoining the route cleared by dismounted infantry. Route security missions are characterized by continuous activity to prevent the enemy from cutting the route or ambushing elements using it.

Gap-crossing tasks in jungle terrain. Inundated areas containing yellowish reeds and cloudy water usually have bottoms too soft to support tracked vehicles. River and stream bottoms usually are untrafficable. The armored vehicle launched bridge (AVLB) can span 17 meters (57 feet) and is more than adequate for most stream crossing. The shoulders of the banks must be able to support the AVLB while tanks cross. When the AVLB is not available, matting or membraned surfaces can be used to provide a firm surface on which vehicles ford small streams. Suspension traverses, bridges, and cableways can be used to move large numbers of soldiers or heavy equipment over wide rivers and ravines or up and down cliffs in a short period of time. Because heavy or bulky material or equipment is needed to construct these expedients, their use is practical only if the needed items can be transported to the site by sea or surface means.

Combat road, trail, and FACE tasks in jungle terrain. Existing roads, normally narrow and winding, are capable of sustaining limited military traffic without expedient repair or surfacing. Generally, all combat roads and trails will have to be built. Special attention should be paid to subgrade drainage. Expanding the right-of-way on roads and trails wider than normal will aid in the drying of road or trail beds.

Airstrips. Construction of LAPES zones, helipads, and airstrips in remote areas are also important tasks for engineers in the jungle. Using demolition and tools, they make an initial clearance of trees and underbrush. For large jobs, follow-on engineers with heavy equipment are brought in to finish the work.

Special problems. Due to the extensive natural drainage systems and high water tables in most jungle areas, drainage and surfacing may require special effort. Most fill materials in jungle environments have a clay base which complicates trafficability. Any protective covering to aid subgrade stability, such as matting or membranes, should be considered. Protecting the surface of these sites from erosion in the rainy season, and protecting aircraft from dust in the dry season, present other problems. Steel matting, T17 membrane (a tough, rubberized fabric), or Peneprime (oil surfacing) are all materials which will keep the dust down and enhance trafficability under varying conditions.

COLD REGION OPERATIONS

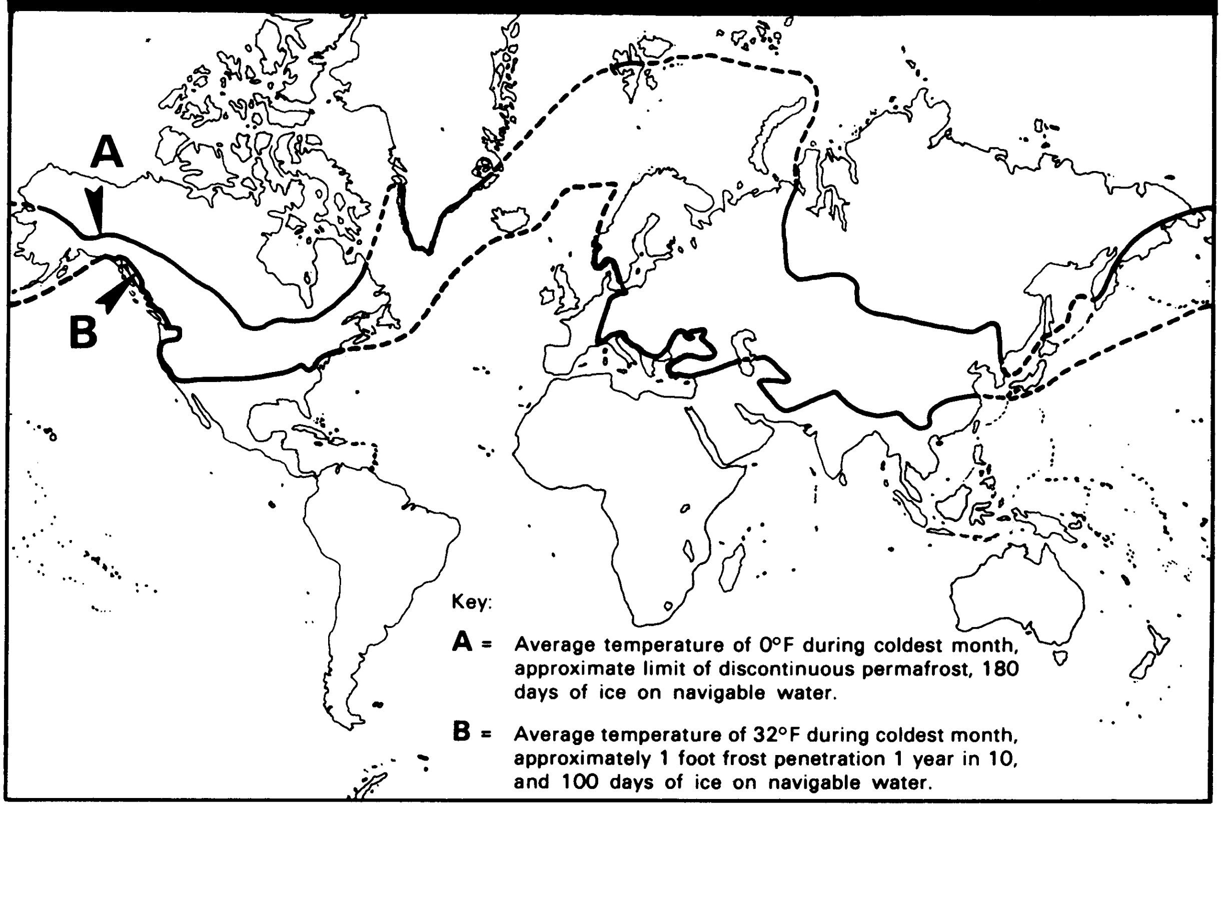
Within the area that lies north of line A, figure 9-9, mobility is affected by inadequate transportation nets. During the winter, low temperatures, snow and ice, and the difficulties of constructing roads and trails, hinder movement. In warmer weather, ice is weakened on lakes and streams, and existing roads may become almost impassable. In arctic areas where permafrost exists, extensive overland movement is difficult during the summer because the underlying permafrost prevents effective drainage, and extensive swampy areas result. Movement by helicopter or by fixed-wing aircraft equipped with conventional landing gear, skis, amphibious landing gear, or flotation kits offers an effective means of mobility in the generally underdeveloped cold regions (figure 9-10 on page 9-16).

Terrain problems. Various types of terrain present different problems. Obstacles to movement in summer include close tree spacing and fallen trees in forested areas, boulders, bogs, rivers, lakes, and swamps. In winter, deep snow becomes an obstacle to movement. In summer, large tundra areas are covered with a thick layer of moss interspersed with extensive marshes. The depth to the permafrost level usually varies from 15 to 60 centimeters (6 to 24 inches). Cross-country tracked vehicular traffic is possible. However, soft, waterlogged soils afford little or no wheel traction. In temperate climate zones (above line B, figure 9-9) terrain varies from rural to urban. Freeze/thaw cycles occur more frequently.

Northern regions comprise about 45 percent of North America and 65 percent of the Eurasian land mass. They are characterized by deep snow, permafrost, and frozen lakes, rivers, and ground. Military operations in cold regions are also influenced by vast distances and isolation.

Glaciers. During the arctic summer, the greatest obstacles to movement over glaciers

FIGURE 9-9. NORTHERN REGION TEMPERATURE BELTS



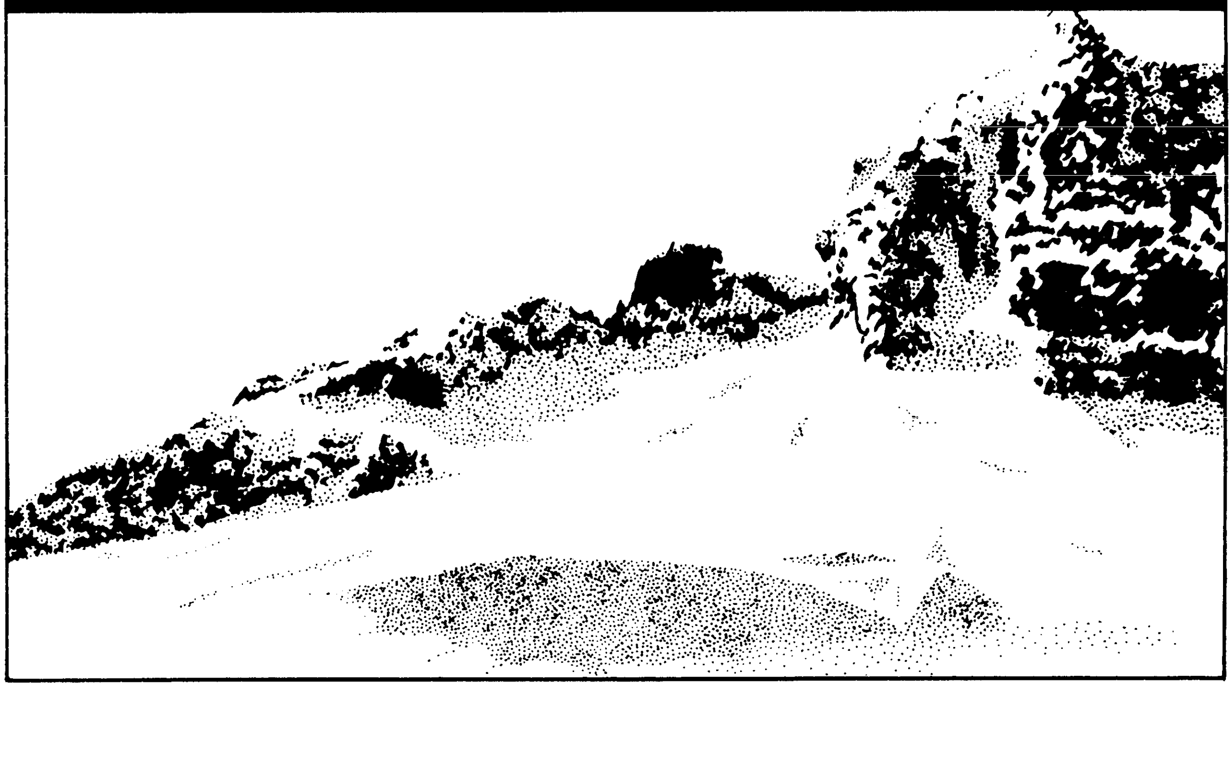
can be the restricted visibility caused by whiteouts and the opening of deep crevasses, many concealed by weak snow bridges. During the arctic winter, visibility is limited by long hours of darkness and surface travel by vehicle is slowed by periodic ridges (sastrugi) of wind-packed snow. Drifted snow on the lee side of the ridges can cause difficult movement of foot troops. Sastrugi is generally 1 meter (3 feet) in height or less.

Mobility planning considerations. Mobility during winter operations varies considerably. On well-frozen ground with minimal snow cover, mobility can be excellent. Marginally frozen soils and thin frozen crusts break down rapidly under traffic, reducing mobility. Trafficability during thaws or periods of heavy snow deteriorates, especially for wheeled vehicles. Most tracked vehicles produce lower ground pressure than wheeled vehicles and, therefore, generally perform better in deeper snow.

Use of special equipment. Tracked vehicles can become immobilized when snow depth exceeds vehicle ground clearance. High winds combined with heavy snow can produce whiteouts “and snow drifting and bring all movement to a standstill. When such conditions exist, special equipment should be furnished to permit operations over snow. During icing conditions, track pads should be removed from armored vehicles and tire chains mounted on wheeled vehicles. Wheeled vehicle mobility in deep snow can be improved by reducing tire inflation pressure up to 50 percent. This reduces contact pressure which decreases vehicle sinkage and increases the tire’s traction. Tire or track slippage in deep snow should be minimized. The effect of spinning is to increase sinkage which increases the possibility of becoming immobilized. It also loosens the snow along the route making it more difficult for subsequent vehicle passage.

Environmental factors. Environmental factors increase the difficulties of mobility tasks. During heavy snowfall, engineer snow

FIGURE 9-10. COLD REGION TERRAIN



removal capability will be necessary to clear main lines of communication and airfields. In remote northern regions, where the road network is usually limited, a major construction effort may be needed to gain access to an area. Satisfactory pioneer roads can be built by grading and compacting existing snow. The numerous streams, swamps, and lakes necessitate increased quantities of gap-crossing equipment as well as increased effort to install and maintain them. Cross-country movement of large forces requires augmented engineer effort. Also, special equipment such as tire chains for wheeled vehicles or removal of track pads on armored vehicles may be necessary.

Countermine tasks in cold region environments. Countermine operations are usually easier in cold weather. Mines are difficult to emplace and are not as effective. Deep snow, either on top of or under mines, may minimize or neutralize the mine's effectiveness. Mined areas are usually easy to bypass. However, detection and breaching may be more difficult due to freezing temperatures and frozen ground, and the concealment of snow cover. Mines placed in a snow cover can be plowed away to make a passage rather easily.

Counterobstacle tasks in cold region environments. Two types of obstacles tend to adversely affect mobility in cold region environments. These are the enemy obstacles constructed with snow or ice and the natural restrictions from movement on snow. Roadblocks can be created by icing roads and snowdrifts or by using ice, timber, and wire cable in conjunction with mines and barbed wire. It is impractical to establish definite rules for through-the-snow operations due to the varied conditions. Most tracked vehicles are slowed by 60 to 70 centimeters (24 to 29 inches) of wet snow. Normal speeds may be maintained after a packed snow trail has been formed. Track-laying vehicles operating in the north should be equipped with steel chevron tracks for all-season, cross-country operations. Dry snow causes few operating difficulties as it has little tendency to pack on suspension systems. Wet clinging snow accumulates on the tracks, suspension idler wheels, and sprockets, and has to be removed occasionally.

Gap crossing tasks in cold region environments. Wet gaps, such as lakes and streams, may be crossed on the ice during the winter months if the ice is sufficiently thick and reasonable precautions are taken.

Crossing sites must be investigated for cracks in the ice cover, air pockets, erosion or bridging of the ice near shore, and thin spots before crossing vehicles or soldiers. Cracking sounds usually precede breakthroughs and give enough warning for troops to get off the ice if they keep moving. Fresh water ice for crossing is subdivided into categories.

Normal or clear ice. Clear ice is transparent ice that freezes at 32 degrees Fahrenheit on rivers and lakes and is the ice by which strength characteristics are measured.

Snow ice. In most northern areas, lake or river ice will become snow-covered during the winter. The snow load depresses the ice cover and the ice fractures. Water then rises up through the ice, saturates the snow, and freezes. Snow ice is generally white because of entrapped air. It is always less dense than clear ice and consequently weaker. The thickness of snow ice should be reduced by one-half when determining its load-carrying capacity from thickness tables for clear ice crossings. For example, when the ice is 24 inches thick, 12 inches of which are white ice and 12 inches are clear ice, the thickness for use in the table would therefore be 18 inches.

Irregular ice. The ice on many streams and small rivers forms under highly variable conditions. The result is an ice cover that does not coincide with the principles of the bearing capacity tables. The ice surface may be hummocky, stepped ridged, and so forth for various reasons. This type of ice may be crossable if it is solid and supported by water.

Table 9-1 shows some of the critical requirement for thickness of clear ice crossings for various loads. Risk ice measurements can be used with safety for individual crossings. The normal ice measurements are for repeated crossings.

Ice bridge. As the freezing process takes place and snowfall accumulates, the natural insulating properties of the ice and snow tend to slow down the freezing process significantly. When time is critical, an ice bridge can be constructed by adding water to the top of the ice. If there is a snow cover, the snow should be removed and stacked on shore or used as berms along the edge of the proposed bridge. The wider the bridge the better. The initial ice thickness should exceed 4 inches to insure troop safety during the construction process. Maximum bridge strength is obtained when the width of the bridge is between 150 and 200 feet. The following points should be considered when planning an ice bridge.

The best method of construction is to flood the ice cover using pumps at various locations along the center of the bridge and let the water spread as it will. Water should be added to the ice surface in 1- to 2-inch increments per day provided this amount freezes solid in 24 hours. If the temperature is below -20 degrees Fahrenheit, up to 3½ inches may be added per day.

Adding logs, brush or grasses to ice bridges to reinforce them should be avoided everywhere but in the arctic because of the solar heat absorption of dark materials.

The last consideration in building a bridge is the addition to the final surface of 3 to 4 inches of snow, if available. The cover provides a wearing surface and prevents the thawing effects of solar penetration. Table 9-2 provides data on time and personnel required for construction of an ice bridge.

Combat road, trail, and FACE tasks in cold region environments. These regions normally have deep snow, permafrost, and reasonably frozen ground and waterways. Cross-country mobility on frozen ground is excellent. However, during thaw conditions, mobility is severely degraded. High winds can create severe snow drifting. Construction of compacted snow walls will reduce the drift buildup on forward area roads. Roads made by combat troops under winter conditions will be improved only to the extent of the capabilities of organic equipment. Roads must be made wide enough to accommodate vehicles which will be using them.

Influence of seasons. Route-selection criteria vary by season. Tracked vehicles do not eliminate the need for roads, regardless of the season. "Permafrost areas require special

TABLE 9-1. ICE-CROSSING DATA

LOAD	THICKNESS OF ICE (inches) 0 - 10°F		MINIMUM DISTANCE BETWEEN UNITS (meters)
	Risk	Normal	
Single soldier on skis	1½	2	5
File of soldiers, 2-meter interval	3	4	-
¼-ton truck	5	8	15
2½-ton truck	13	15½	25
UH-1 helicopter, landing or parked	8	10	20
M109 howitzer	17½	20	40
M60 tank	26½	31½	70

engineer attention in cold region environments. Although these areas are trafficable when frozen, thawing renders them capable of only one pass traffic. Once the soil (or permafrost) is broken by repeated traffic, ruts swiftly erode into deep gullies. These spots then require crossing support from AVLBs.

Selection factors. Selection factors for forward aviation sites such as size, approaches and exits, takeoff and landing direction, and security are the same as for normal operations. Helicopter landing sites can be prepared in winter by packing the snow with troops on skis or snowshoes or with tracked vehicles, if available. Helipads should be marked by an inverted "Y" that contrasts with the snow to provide a reference for depth perception. Airstrips must be marked by objects which contrast with the snow. The panel marker, when used for this purpose, must be adequately secured to the snow-covered surface.

URBAN AREA ENVIRONMENTS

Tactical terrain analysis has traditionally considered some elements of the urban environment such as the allocation of land to agriculture or forestry and the distribution of railway or road networks. However, the focus has been on natural terrain elements. In Europe and other urbanized areas of the world, however, the effects of artificial terrain features on the overall tactical scheme must be considered. How urban terrain elements impact on operations is an important consideration in determining tactical options. A built-up area is a concentration of structures, facilities, and population which forms the economic and cultural focus for the surrounding area. The four categories are large cities, towns and small cities, villages, and strip areas.

Large cities (population greater than 100,000) frequently form the core of a larger, densely populated urban complex consisting of the city, its suburban areas, and small towns. Such complexes have the appearance of a single, large, and continuous city containing millions of people and occupying vast areas of land.

Towns and small cities (3,000 -100,000 people) are, in many cases, located along major lines of communications and situated in river valleys.

Villages (less than 3,000 people) are, in most cases, agriculturally oriented and are usually distributed among the more open cultivated areas of a country.

Strip areas are built-up areas which generally form connecting links between villages and towns. They are also found along lines of communications leading to larger complexes. Although the size and population of strip areas vary, they normally assume along thin linear pattern.

TABLE 9-2. ICE BRIDGE CONSTRUCTION DATA

TYPE OF BRIDGE	LENGTH (feet)	WIDTH AND THICKNESS	PERSONNEL REQUIRED	CONSTRUCTION TIME (hours)
Straight bridge	330	150 feet wide Minimum ice thickness, 16 inches	32	4
Skew bridge	330		32	4
Skew bridge	600		32	8

Note: Fewer personnel are required if mechanical means are used for snow removal.

Villages and small towns will often be caught up in the battle because of their proximity to major avenues of approach or to lines of communications that are vital to sustaining mobility of combat forces.

Mobility planning considerations. The decision to attack or defend an urban complex can result in massive damage and destruction. Constraints on firepower to insure minimum collateral damage within its built-up areas can be expected. Combat operations may be hampered by the presence of civilians in the battle area. Concern for their safety can seriously restrict the combat options open to the commander. The necessity to provide life support and other essential services to civilians can siphon off a substantial amount of military resources and personnel.

Advantages and disadvantages. On the urban battlefield, advantages and disadvantages in the areas of mobility tend to even out for attacker and defender. Initially, however, the defender has a significant tactical advantage over the attacker because of knowledge of the terrain. Unlike deserts, forests, and jungles, the urban battlefield is composed of an ever-changing mix of features. Frequently, commanders of larger forces will have units fighting on open terrain, within built-up areas, or where two distinct terrain forms merge.

Avenues of approach. Urbanized terrain normally offers numerous avenues of approach for mounted maneuver well forward of and leading to urban areas. In the proximity of its built-up areas, however, such routes generally become convergent and restrictive. Bypass may be blocked by urban sprawl and the nature of adjacent natural terrain. Avenues of approach within built-up areas are determined by street patterns, building arrangements, open areas, and underground systems. Mounted forces are restricted to streets, alleys, and open areas between buildings. Dismounted forces should make maximum use of available cover by moving through buildings and underground systems, along edges of streets, and over roofs.

Countermine tasks in urban area environments. Urban operations are time-consuming and dangerous. They restrict mobility. Mine warfare may be extensive. Most developed countries have urban areas that will be difficult to bypass. Mines will be used on streets and alleys to restrict mobility. Off-road or standoff mines will frequently be employed due to the difficulty of burying mines in pavement. Command-detonated mines and mines with trip wires and anti-handling devices will be used extensively against dismounted troops. Buildings, streets, and obstacles may be mined to impede operations (figure 9-1 1).

Counterobstacle tasks in urban area environments. Counterobstacle activities in urbanized terrain place a premimum on thorough reconnaissance. Cities, towns, or urbanized areas provide the enemy with an environment that is easily converted to a fortified position. Therefore, the types of obstacles, their location, and depth must be determined in advance of hasty or deliberate breaches. Engineers must be well forward in urban offensive operations. The engineers must have the capability to reduce mines and obstacles under fire to preserve force mobility. Buildings and areas that may be mined should be bypassed when possible. They should be cleared after enemy resistance has been eliminated. Armored engineer equipment is essential for combat operations in urban areas. The armored combat earth-mover (ACE) and the combat engineer vehicle (CEV) are well suited. The ACE can remove rubble and obstacles, rapidly fill craters, and repair roadways. The CEV can remove obstacles and rubble with its blade, winch, and boom. Its 165-millimeter demolition gun is effective against close hardened positions. Bulldozers and other equipment with exposed operators are used only when there are no enemy fires delivered upon the worksite.

FIGURE 9-11. URBAN AREA OBSTACLES REINFORCED WITH MINES

Rubble obstacles

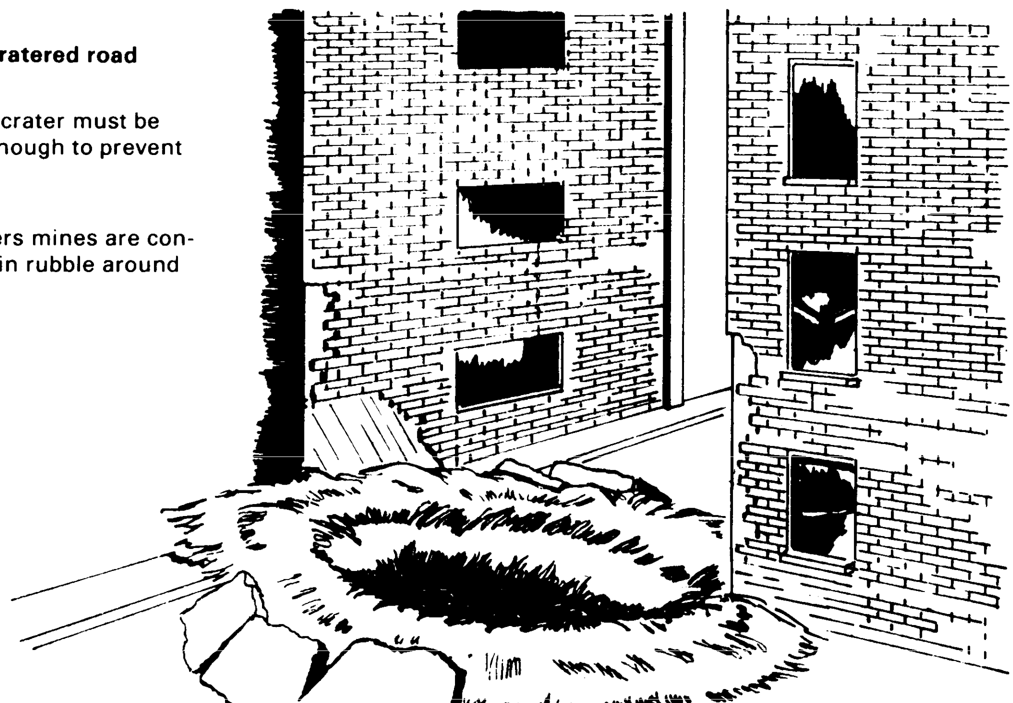
At/Apers mines concealed in and around rubble.

Tape/wire with booby traps hinders clearing groups.

Cratered road

Size of crater must be large enough to prevent bypass.

At/Apers mines are concealed in rubble around crater.



APPENDIX A

Selected Threat Countermobility Equipment and Obstacles

THREAT ENGINEER ORGANIZATION

OVERVIEW

This appendix provides a detailed discussion of Threat obstacle equipment and the types of obstacles that Threat forces could employ, including existing obstacles. A knowledge of this equipment and obstacles is essential to understand Threat countermobility forces and doctrine. This section contains the organization and equipment of Threat engineer units. The following units are displayed in this section:

- **Engineer company,** motorized rifle and tank regiment (figure A-l).
- **Engineer battalion,** motorized rifle and tank division (figure A-2).
- **Personnel within the engineer** battalion, motorized rifle division (MRD) and tank division (TD) (figures A-3 through A-9). The major items of equipment that are organic to each Threat engineer company are included in table A-1.

MAJOR ITEMS OF EQUIPMENT

ITEM	QUANTITY
ATGL, RPG-16	4
APC, BTR-60	3
Truck, UAZ-69/469	1
Truck, KrAZ/Ural/ZIL	8[1]/9[2]
Truck, dump, MMZ 555	2
Truck, van, ZIL (maintenance)	1
Truck, crane, K-61	1
Truck, crane shovel, E-305V	2
Bridge, tank-launched, MTU/MT-55	1[1]/3[2]
Bridge, truck-launched, TMM	4
Ditching machine, BTM/MDK	1
Dozer, BAT/BAT-M/PKT	1
Dozer blade, BTU	3
Bucket excavator, PZM	3
Minelayer, towed, PMR-3/PMZ-4	3
Mineclearing plow, KMT-4/6	9[1]/27[2]
Mine roller-plow, KMT-5	3[1]/9[2]
Water filtration set, MAFS, on ZIL with trailer	1
Trailer, cargo, 2-axle	2

ITEM	QUANTITY
Radios:	
HF or VHF, manpack, low-power, R-104m or R-107	4
VHF, vehicle mount, medium-power, R-123	4[1]/7[2]

Notes:
1. Personnel and equipment for the engineer company, motorized rifle regiment, BTR or BMP equipped.
2. Personnel and equipment for the engineer company, tank regiment.
3. Numerous variations may exist: Frogmen may be attached to assist in the reconnaissance of water obstacles. Some companies may be equipped with 5 KMM truck-launched bridge spans instead of 4 TMM bridge spans. PMR/PMZ minelayers are normally towed by trucks. Some units may have BTR-152s for this purpose. Some units may have GMZ armored tracked minelayers instead of PMR towed minelayers. Some units may have up to six one-axle cargo trailers in addition to the two-axle cargo trailers. Some units may have tractor-trailers to carry heavy tracked equipment on long road movements.

Table A-1

ENGINEER COMPANY, MOTORIZED RIFLE AND TANK REGIMENT

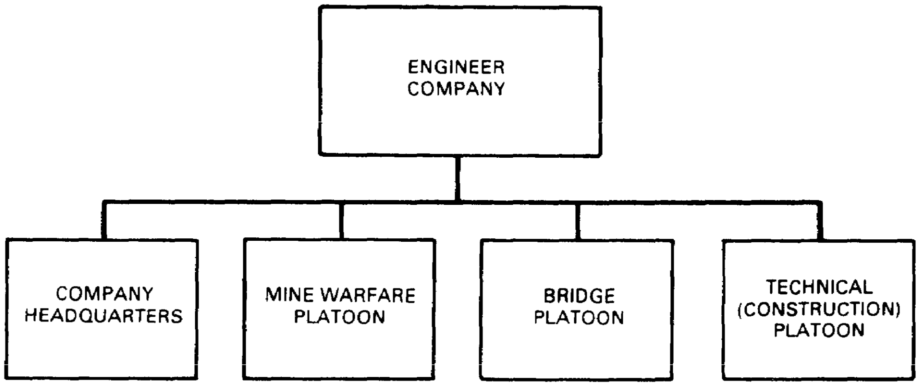


Figure A-1

ENGINEER BATTALION, MOTORIZED RIFLE AND TANK DIVISION

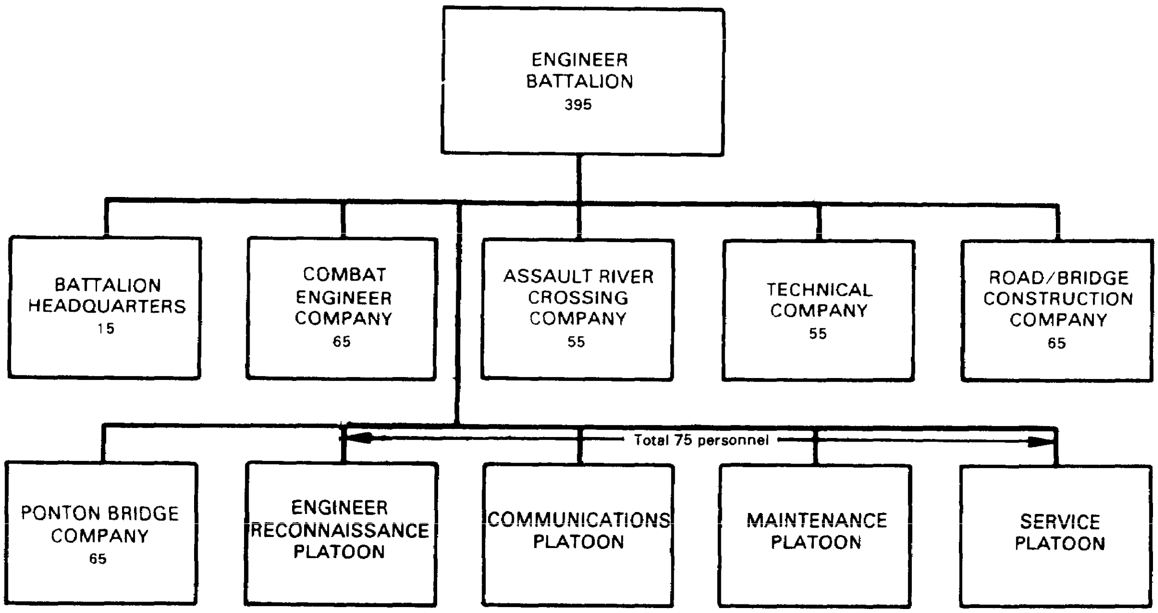


Figure A-2

BATTALION HEADQUARTERS, ENGINEER BATTALION, MRD AND TD

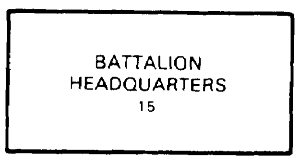


Figure A-3

COMBAT ENGINEER COMPANY, ENGINEER BATTALION, MRD AND TD

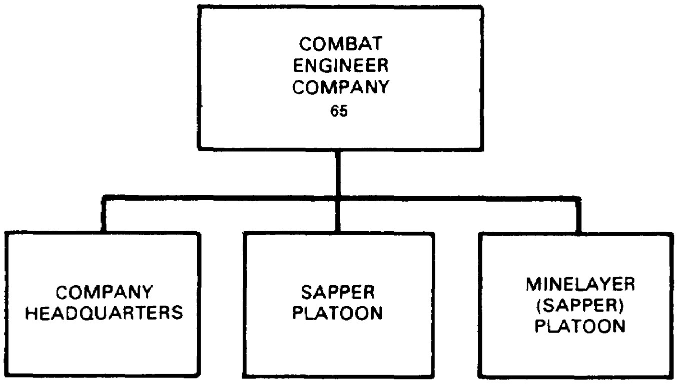


Figure A-4

ASSAULT RIVER-CROSSING COMPANY, ENGINEER BATTALION, MRD AND TD

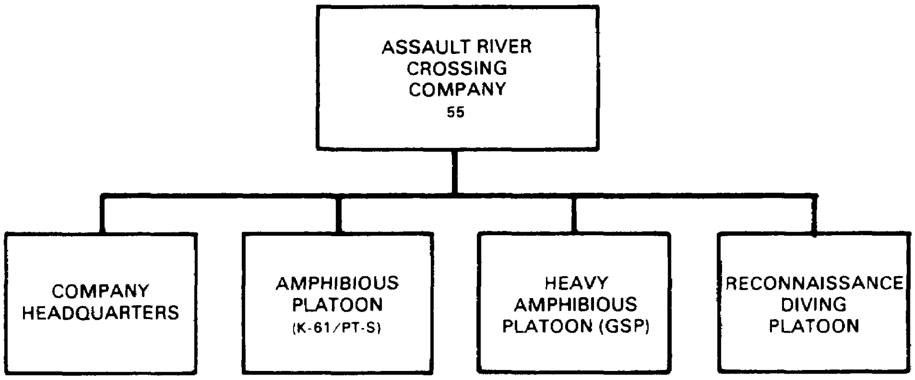


Figure A-5

TECHNICAL COMPANY, ENGINEER BATTALION, MRD AND TD

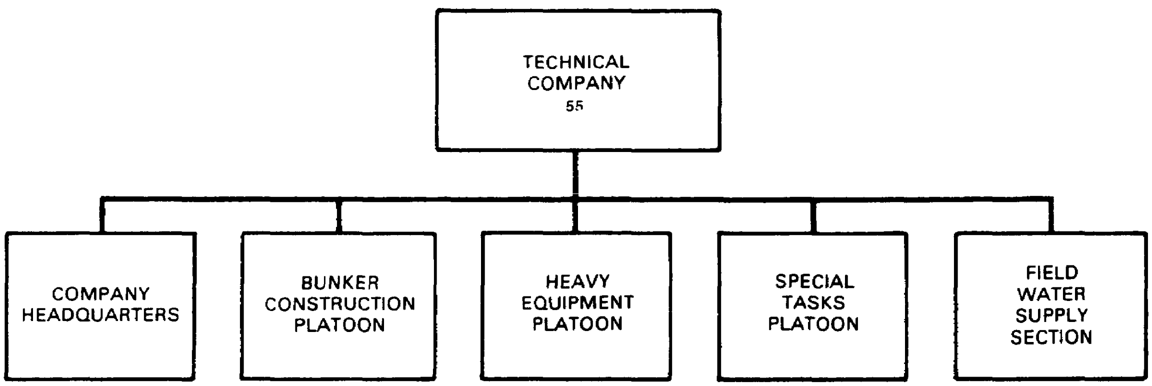


Figure A-6

ROAD/BRIDGE CONSTRUCTION COMPANY, ENGINEER BATTALION, MRD AND TD

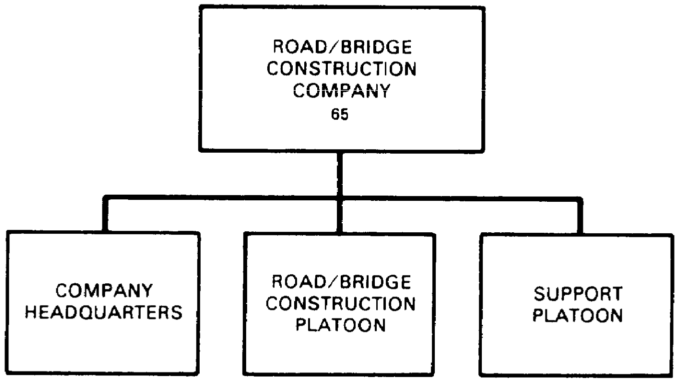


Figure A-7

PONTON BRIDGE COMPANY, ENGINEER BATTALION, MRD AND TD

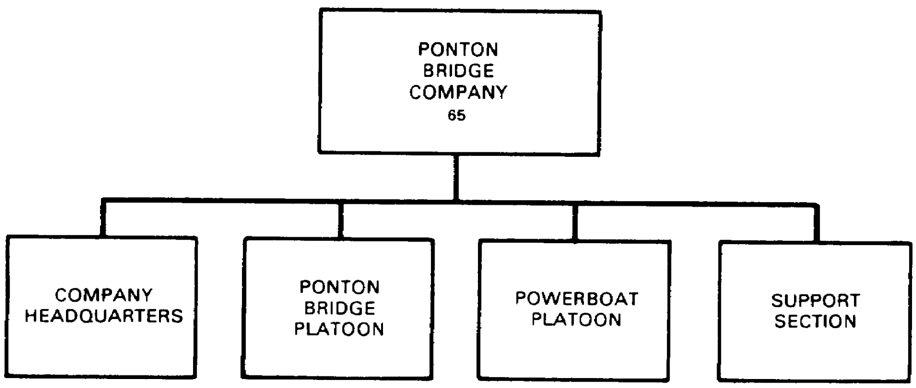


Figure A-8

COMBAT AND SERVICE SUPPORT STRUCTURE, ENGINEER BATTALION, MRD AND TD

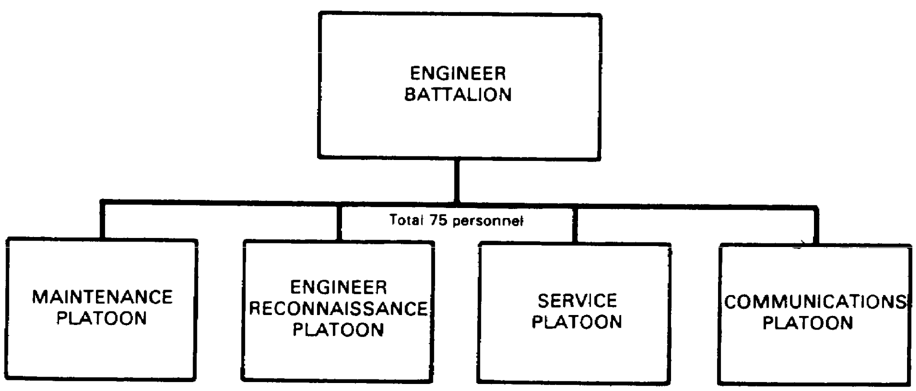


Figure A-9

THREAT COUNTERMOBILITY EQUIPMENT

THREAT MINE DELIVERY EQUIPMENT

The following is a description of equipment included in Threat mine delivery systems (figures A-10 through A-13).

MINELAYING CHUTES

Before the introduction of mechanical mine-laying equipment, the Warsaw Pact made wide use of simple chutes for laying antitank mines. They were attached to the sides or rear of trucks or BTR-152 armored personnel carriers. The mines were fed on the chute by hand and slid to the ground. This method was used when a minefield had to be laid rapidly. Later models of these chutes incorporated an automatic arming device for use with TM-62 type mines.

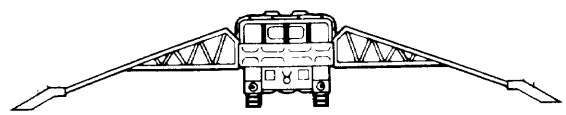
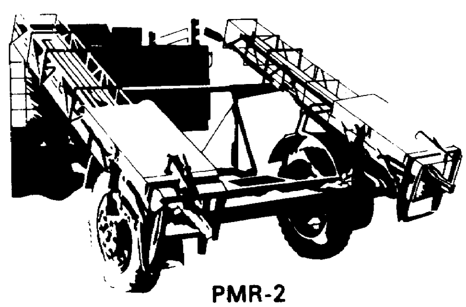


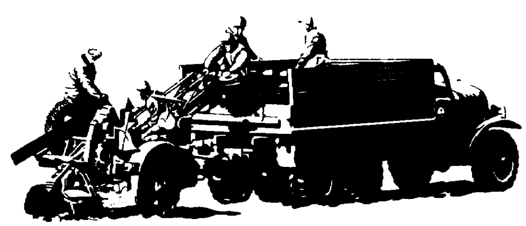
Figure A-10

PMR-2 AND PMR-3 TOWED MINELAYERS

The PMR-2 is a two-wheeled trailer with two chutes. The upper part of the chute has a wide mouth into which the antitank mines are loaded. They then slide down a double roller conveyor into the distributing mechanism, which spaces them at intervals of 4.0 or 5.5 meters. The mines are laid on the surface and buried by a follow-up team if required. The trailer is normally towed by a heavy truck or a BTR-152 armored personnel carrier. The PMR-3 has a single chute and the operator can select mines to be either surface laid or buried 30- to 40-centimeters deep. Mines are laid at predetermined spacings of 4.0 or 5.5 meters. The PMR-3 is normally towed by a ZIL-157 truck which carries 300 TM-46 or similar antitank mines. A fully loaded BTR-152, carrying 120 mines, can lay a minefield 0.48 kilometers long when the mines are spaced at 4-meter intervals.



PMR-2

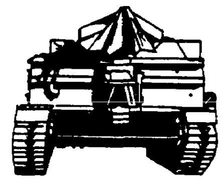


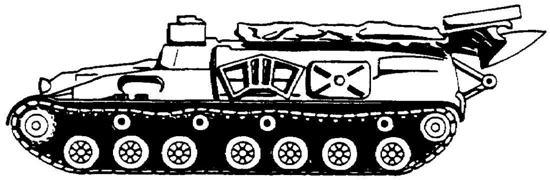
PMR-3

Figure A-11

GMZ TRACKED MINELAYER

The GMZ tracked minelayer is based on the chassis of the SA-4 (Ganef) surface-to-air missile system. The driver is seated at the front of the vehicle on the left side with the engine to the right. This leaves the rear of the vehicle clear for the mounting of the mine-laying equipment and the stowage of mines. The suspension of the GMZ consists of seven road wheels with the drive sprocket mounted at the front and the idler at the rear. There are four track return rollers. The minelayer mechanism is of the plough type and resembles the Soviet PMR-3 and the East German MLG-60 mechanical minelaying systems. Like the latter systems, the GMZ can lay the mines on the surface or bury them. Infrared vision equipment enables the GMZ to carry out minelaying operations during darkness. The GMZ is replacing the PMR series of towed minelayers throughout the Threat forces. Specifications include—





Crew: 4

Weight: 25 tons

Width: 3.2 m (10.5 ft)

Length: (vehicle) 8.7 m (28.7 ft)

(plough lowered) 10.3 m (33.9 ft)

(plough raised) 9.1 m (30.0 ft)

Height: 2.7 m (8.5 ft)

Max speed: (road) 50 km/h

Mine storage: 200

Burial depth: 4/min

Minelaying rate, surface: 8/min

Figure A-12

ANTITANK MINELAYING HELICOPTERS

Soviet military periodicals have indicated that they are using a helicopter-borne antitank minelaying system to protect the flanks of armored spearhead units. The system is basically a chute attached to the side of the helicopter down which mines slide to the ground. Helicopters seen with this system are the Mi-4 Hound (estimated carrying capacity 200 metallic antitank mines such as the TM46 with MVM fuze) and the Mi-8 Hip C (estimated carrying capacity 400 metallic antitank mines).

Figure A-13

EARTHMOVING EQUIPMENT

The following is a discussion of Threat earthmoving equipment (figures A-14 through A-19).

BTM DITCHING MACHINE

The BTM ditching machine, first appearing in 1958, consists of a rigid-wheel, multibucket excavator, mounted on an AT-T heavy tracked artillery tractor chassis. The ditching wheel has 10 buckets and is mechanically regulated for depth by a cable. The latest model tractor has an insulated, heated cab, plus an engine preheater that enables it to function in extremely low temperatures. It is also believed to be equipped with a special vent which, combined with the tightly sealed cab, permits it to operate in contaminated areas for limited periods of time. Specifications include—

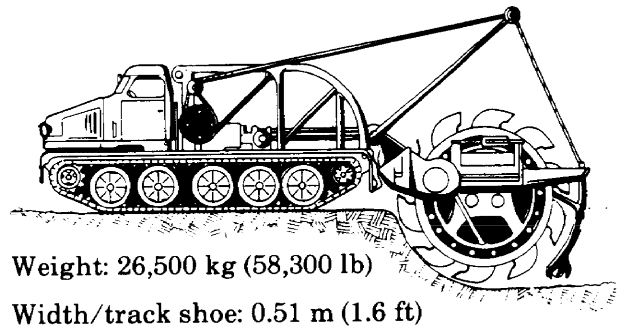
Height: (transport position) 4.3 m (14.1 ft)

Height: (operating position) 3.5 m (11.4 ft)

Width: 3.2 m (10.4 ft)

Length: (transport position) 7.22 m (23.6 ft)

Length: (operating position) 10.82 m (35.4 ft)



Weight: 26,500 kg (58,300 lb)

Width/track shoe: 0.51 m (1.6 ft)

Ground clearance: 0.42 m (1.3 ft)

Maximum speed: 35 km/h (21 mph)

Ditching depth: 1.5 m (4.9 ft)

Ditching width: 1 m (3.2 ft)

Digging capacity: 240 m^3/h (8,474.4 ft^3/hr) to 800 m^3/h (27,462 ft^3/hr) (depending on soil type)

Figure A-14

BTM-3 DITCHING MACHINE

The BTM-3, which entered into production during 1968, is a modified version of the BTM and was developed for the primary mission of excavating frozen soil. Although the outward appearance is the same as the BTM, the bucket assembly is much heavier and stronger, and on occasion is equipped with as few as eight buckets. The BTM-3 was previously designated the BTM-TMG. Specifications include—

Length: 7.6 m (24.7 ft)

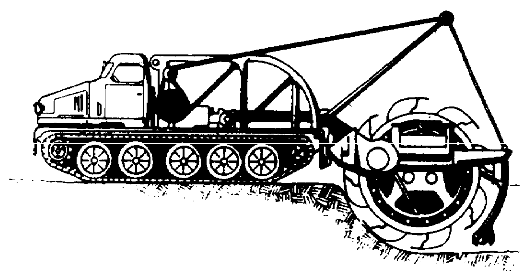
Height: (transport) 4.3 m (14.1 ft)

Height: (operating) 3.5 m (11.4 ft)

Weight: 29 tons (23,636 kg)

Width of track shoe: 0.51 m (1.6 ft)

Ground clearance: 0.42 m (1.3 ft)



Maximum speed: 35 km/h (21 mph)

Ditching depth: 1.5 m (4.9 ft)

Ditching width: 0.61 m (2.0 ft)

Digging capacity: 90 m^3/h (3,177.9 ft^3/hr) in frozen soil, 240 m^3/h otherwise

Figure A-15

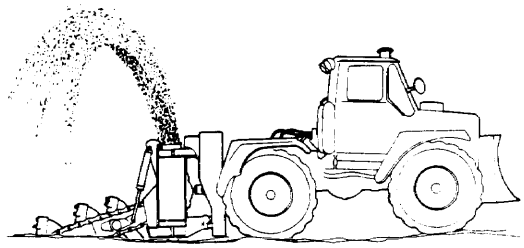
PZM/PZM-2 DITCHING MACHINE

The PZM consists of a bulldozer blade mounted on the front of the T-150K wheeled tractor and a trenching component mounted on the rear. The PZM-2 is also equipped with a front-mounted winch for use in excavating in frozen soil when traction may be insufficient. The unique feature of the PZM is that it can slew its boom to excavate either a narrow trench or a wide ditch. No other ditching machine is known to have this capability. The PZM can make repeated passes through the trench. The PZM is equipped with filtration vents for operating in contaminated environments. Specifications are—

Height: 2.87 m (9.4 ft)

Width: 2.5 m (8.2 ft)

Length in travel position: 5.9 m (19.3 ft)



PZM

Wheel width: 2.5 m (8.2 ft) or 3.5 m (11.4 ft)

Bucket width: 0.6 m (1.9 ft)

Trench width: 0.8 m (2.6 ft)

Trench depth: 1.5 m (4.9 ft)

Digging capacity: 250 to 300 m^3/h

Maximum speed: 50 km/h

Figure A-16

BAT DOZER

The BAT dozer first appeared in 1958 and is used extensively by the Soviet Union and other Communist countries. However, due to serious deficiencies, it is being replaced by the BAT/M. Specifications are—

Height: 3.2 m (10.5 ft)

Width: 4.8 m (15.8 ft)

Length: 10 m (33 ft)

Weight: 25,300 kg (51,999 lb)

Width of track shoe: 0.51 m (1.6 ft)

Ground clearance: 0.42 m (1.4 ft)

Maximum speed: 23 km/h (14.4 mph)

Winch capacity: 18,181 kg (39,998 lb)

Earthmoving capacity: 120 to 200 m^3/h (4,237 to 7,062 ft^3/h)

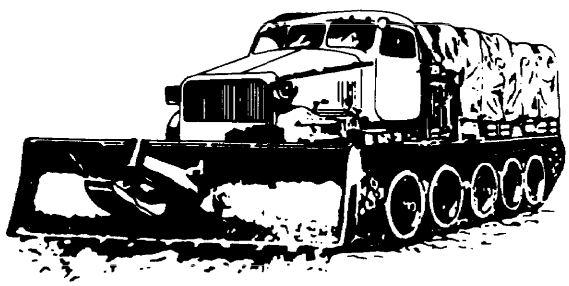
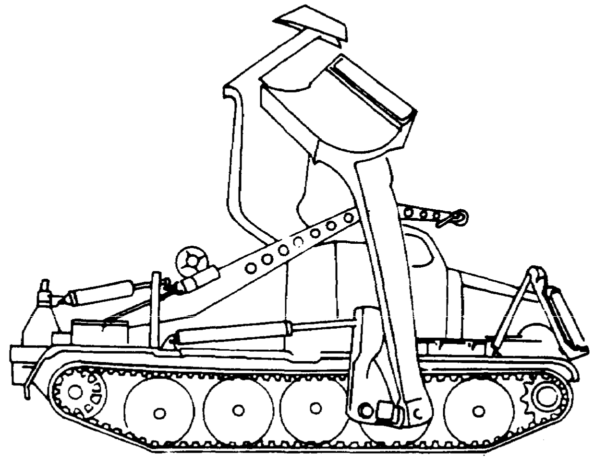


Figure A-17

BAT/M DOZER

The BAT/M dozer consists of a hydraulically operated bulldozer blade mounted on the heavy tracked artillery tractor, AT-T, and a full slewing crane which has an earth auger attachment (mounted behind the cab). The bulldozer blade is tilted back over the cab in the transport position, thus eliminating the heavy nose effect of the BAT dozer. The BAT/M is a highly versatile piece of equipment and is replacing the BAT as the standard dozer of Soviet engineer units. Some of its uses include the preparation of river banks prior to bridge launching, route preparation and the preparation of artillery fortifications. Specifications are—



Weight: 27.8 tons (25,300 kg)

Height: (transport position) 3.51 m (11.5 ft)

Height: (operating position) 3.2 m (10.4 ft)

Width: 4.79 m (15.7 ft)

Length: (transport position) 6.9 m (22.7 ft)

Length: (operating position) 10.00 m (32.8 ft)

Weight: 26,000 kg (57,200 lb)

Width of track shoe: 0.51 m (1.6 ft)

Ground clearance: 0.42 m (1.3 ft)

Maximum speed: 35 km/h (21 mph)

Winch capacity: 25,000 kg (55,000 lb)

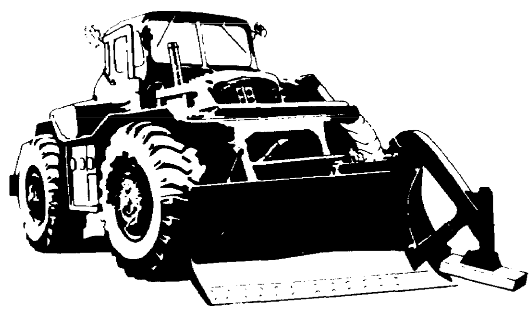
Crane capacity: 2,000 kg (4,400 lb)

Earthmoving capacity: 120 to 400 m^2/hr

Figure A-18

PKT WHEELED TRACTOR

The PKT is a large all-wheel-drive tractor which began production in 1970. It has a hinged blade on the front which is equipped with a float boom to limit the depth of the cut to 150 millimeters. The blade can be used in the V-blade configuration for snow clearing, in the straight position for bulldozing, and in the angled position for angle-dozing. Specifications are—



Height: (operating position) 3.07 m (10 ft)

Width: 3.23 m (10.5 ft)

Length: (operating position) 7.9 m (25.9 ft)

Weight: 21,000 kg

Maximum speed: 45 km/h (27 mph)

Winch capacity: unknown

Earthmoving capacity: 80 to 100 m^3/h (2,824.8 - 3,531 ft^3/hr)

Figure A-19

THREAT MINES AND OBSTACLES

DEFINITION

Threat doctrine broadly defines obstacles as anything that can get in the way or hinder the movement of a military force. Threat tactical literature describes the following two major categories:

- **Incidental obstacles.** Incidental (existing) obstacles are those which are part of the normal environment such as urban areas, forests, or rivers. They also include obstacles created as a byproduct of warfare rather than intentionally. Examples are destroyed equipment, urban rubble, shell craters, and fallout from nuclear weapons.
- **Deliberate obstacles.** Deliberate obstacles are created with the intention of impeding an enemy's maneuver. The emphasis of Threat obstacle employment is stopping or delaying enemy tank forces. Minefields are an example of a deliberate obstacle. However, the Threat is aware of the obstacle value of incidental obstacles and is capable of enhancing that value.

The purpose of this section is to catalog mine and other obstacles that US forces might encounter. All of the obstacles considered are deliberate. Figure A-20 shows the three major categories of deliberate obstacles. Most of these obstacles are commonly understood, in general terms, from their names.

DELIBERATE OBSTACLES

Can be contaminated with toxic chemicals and/or nuclear radiation

MINEFIELDS	NONMINE ANTITANK OBSTACLES	NONMINE APERS OBSTACLES
Nuisance	Rivers/canals	Barbed wire/tape
Scatterable	Craters/ditches	Field/permanent fortifications
Hasty/protective	Abatis/tree blowdown	Caltrops
Deliberate	Posts/dragon's teeth	
	Walls, embankments and cribs	
	Field/permanent fortifications	
	Inundated areas	
	LOC demolitions	
	Urban rubble	

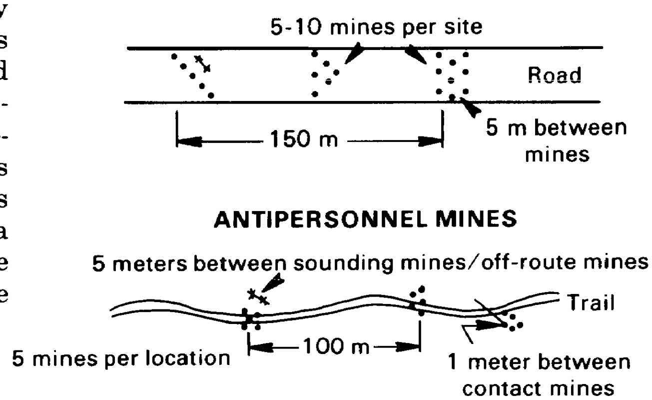
Figure A-20

MINEFIELDS

This section will subdivide mines and minefields into four broad groupings. These are nuisance minefield, remotely delivered minefield, hasty/protective minefield, and deliberate minefield (figures A-21 through A-23). All of these may contain all antitank mines, antipersonnel mines, or a mixture of the two in any proportion.

NUISANCE MINEFIELDS

A relatively small number of mines employed to harass, confuse, and demoralize an enemy is known as a nuisance minefield. The mines may be placed behind enemy lines by inserted forces or left behind when the Threat withdraws. Nuisance mines are considered especially effective once an attacking force has become mine-conscious. The minefield causes an attacker to pause and deploy every time a few mines are encountered. The mines are usually buried or concealed and may not be covered by fire.

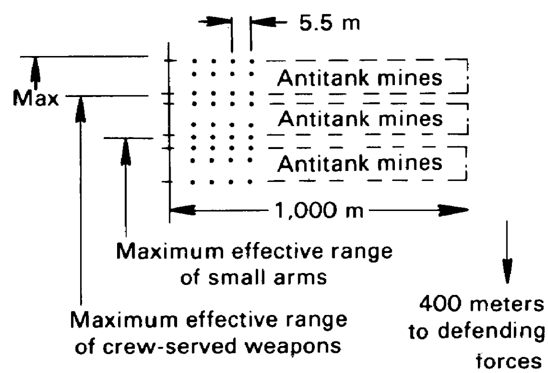


Notes: Mines are placed to minimize detectability and buried to 2.5 cm. They are integrated with other obstacles.

Figure A-21

DELIBERATE MINEFIELDS

Deliberate minefields are a belt or belts of buried conventional AT and/or APers mines. The mines may be placed and buried by hand or by a mechanical plow-type planter. In the latter case, some hand work would be necessary to reduce evidence of disturbance to the ground. The mines are laid in accordance with some pattern in anticipation of eventual recovery by the laying force. Generally, deliberate minefields will be of considerable depth and density and will be covered by fire.



Notes:
Mines are placed to minimize detectability and buried up to 40 cm below ground.

Some nuisance AP mines likely.

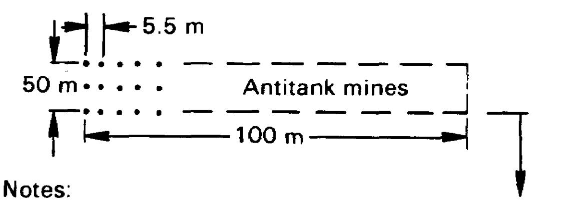
Figure A-22

REMOTELY DELIVERED MINEFIELDS

There is currently little evidence that the Threat has devoted extensive interest to the development of remotely delivered mine systems. Given the technical capability of Threat countries, development of more sophisticated mines and delivery systems is highly probable.

HASTY/PROTECTIVE MINEFIELDS

Hasty/protective minefields are rapidly emplaced, surface-laid fields of conventional mines (antitank or antipersonnel). They consist of one or more belts with the mines surface-laid in some kind of pattern for ease of recovery. The mines may be placed by hand or from dispensing chutes mounted on vehicles or helicopters. The purpose of such a field is to protect a unit during halts, to protect working parties, or to protect exposed flanks from attackers. Hasty minefields can be con-verted into deliberate minefields and will usually be covered by fire.



Notes:
Mines placed on surface.

Some nuisance AP mines likely.

Mines laid without specific linear pattern.

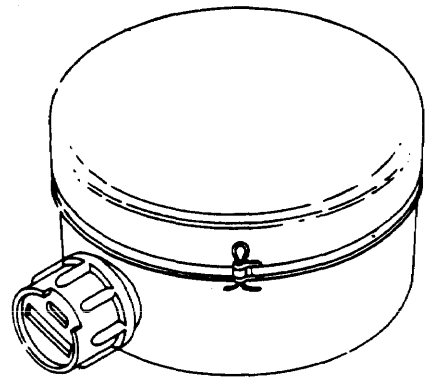
Figure A-23

MINES, ANTIPERSONNEL

The following paragraphs describe antipersonnel mines currently in use by Threat forces (figures A-24 through A-28).

PMN ANTIPERSONNEL BLAST MINE

This mine is one of the standard Soviet antipersonnel mines. It has a plastic cylindrical case that contains an adapter for the firing assembly and one for the detonator. Four equally-spaced radial ribs on the bottom of the mine give the case added strength. The PMN is pressure activated and will detonate when .015 pounds per square inch is applied. Specifications are—



Weight: 600 g

Dimension: 11.1 cm diameter x 5.6 cm height

Main charge: 240 g TNT

Type: blast

Activating force: pressure

Lethal radius: unknown

Figure A-24

POMZ-2 AND POMZ-2M

The POMZ-2 antipersonnel fragmentation mine consists of a sharpened wooden stake approximately 30 centimeters long, a serrated cast iron cylinder filled with Trinitrotoluene (TNT), an MUV or VPF pull fuze, and a trip wire. The POMZ-2 is one of the standard Soviet antipersonnel mines. Late models are designated the POMZ-2M. They have a threaded fuze well and five rows of fragmentation, whereas the POMZ-2 has six rows. Specifications are—

Weight: 2 kg

Dimensions: 6-cm diameter x 13.5-cm height

Main charge: 75 g TNT

Activation force: pull fuze and trip wire

Lethal radius: 5 meters

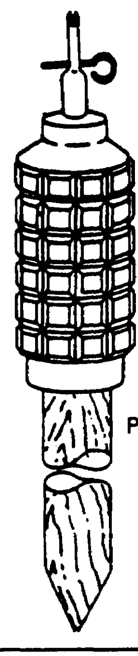
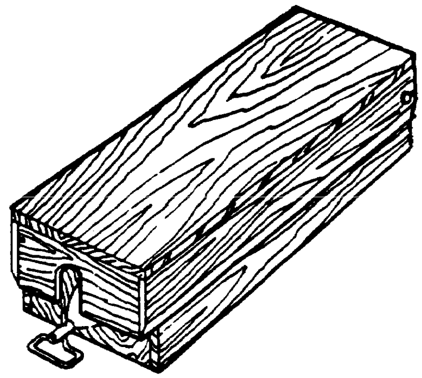


Figure A-25

WOODEN ANTIPERSONNEL BLAST MINES

The PMD-6 wooden antipersonnel mine was developed before World War II and was first used operationally in the Soviet/Finnish Winter War of 1939/40. The mine consists of a wooden box with a hinged lid that overlaps the sides. A deep groove is cut in the front end of the lid so that it may fit over the fuze and rest on the striker retaining pin. Some mines have a safety device which consists of a safety rod which prevents the lid from actuating the fuze prematurely. Pressure on the lid forces the winged retaining pin from the striker, and this detonates the mine. The PMD-6M is the postwar model of the PMD-6 and has the MUV-2 pull fuze. The PMD-7 followed the PMD-6 and is a smaller mine and therefore has less explosive. The PMD-7ts has a mine body made of a single block of wood hollowed out for the charge. The PMD-57 is a postwar wooden antipersonnel mine. Specifications are—



PMD-6

Weight: 300 g

Dimension: 15 x 7.5 cm x 6.5 cm

Main charge: 75 g TNT

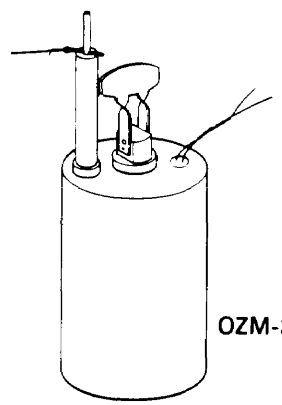
Activating force: pressure

Lethal radius: unknown

Figure A-26

BOUNDING ANTIPERSONNEL MINES

During World War II, the Soviets used the improvised OZM (fragmentation obstacle mines). These consisted of an artillery shell (122 or 152-millimeter) or a mortar (120-millimeter) shell buried in the ground, nose down. Under the nose was UVK-1 propellant assembly and a flash tube running to the surface. These were detonated by remote control. Although intended primarily for antipersonnel use, these mines were capable of disabling an armored vehicle. The cylindrical OZM-3 bounding fragmentation antipersonnel mine, introduced after the war, can be set off by remote control, pull fuze, pressure fuze or a pull-tension fuze. When set off, the base of the mine detonates, causing the mine to bound. The height of the explosion (1.5 meters) is determined by a tethering wire. This mine has a lethal radius of 9 meters. No information on the OZM-4 mine is available.



OZM-3

Specifications for the OZM-3 are:

Weight: 3 kg

Diameter: 7.5 cm

Height: 12.0 cm

Main charge type: TNT

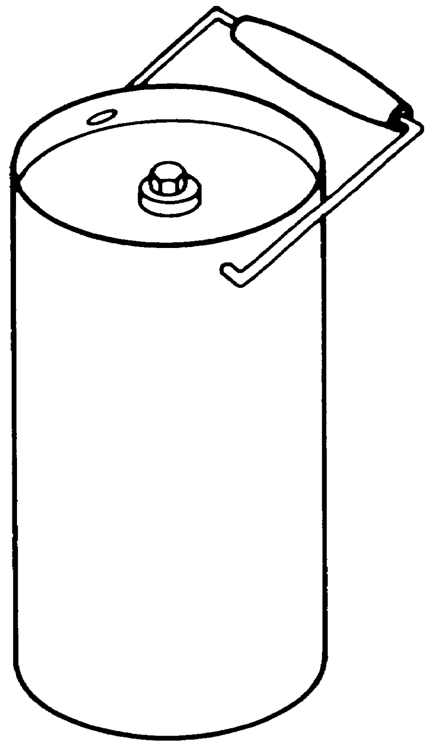
Weight of main charge: 75 g

Figure A-27

MINES, SPECIAL PURPOSE (CHEMICAL)

The KhF-2, dating from World War II, is still in the Threat force inventory. It is fired electrically by an observer stationed up to 300 meters distant. The firing of the electric detonator ignites the propellant, which hurls the mine upward out of the container, simultaneously igniting the delay fuze. After a delay of 1 to 1.5 seconds, the delay fuze sets off the explosive charge, shattering the mine and spreading the liquid contaminant over an area of 250 to 300 square meters with an average concentration of 20 to 25 grams per square meter. Characteristics are—

	KhF-1	KhF-2
Weight:	8.71 kg	8.71 kg
Diameter:	150 mm	185 mm
Height:	350 mm	280 mm
Main charge:	tolunol or melinite	unknown
Weight:	103 g	unknown
Quantity of agent:	4.5 liters (mustard or lewisite)	unknown



KhF-2

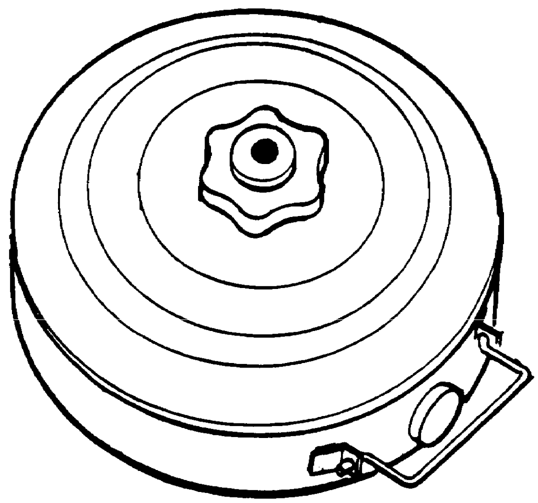
Figure A-28

MINES, ANTITANK

The following paragraphs list antitank mines currently in use by the Threat (figures A-29 through A-35).

TM-46 ANTITANK MINE

The TM-46 is metallic and can be laid either by hand or mechanically. The MVM pressure fuze is used for mechanical laying, or the MV-5 fuze for hand laying. The mine is detonated as follows (MV-5): pressure applied to the pressure plate compresses the striker spring in the fuze until the striker-retaining ball escapes into a recess in the pressure cap, releasing the spring-loaded striker which detonates the mine. In appearance, the TM-46 is almost identical to the TMN-46, which has a fuze well in the bottom of the mine for booby trapping. Specifications are—



Weight: 8.7 kg

Diameter: 3.10 cm

Height: 7.4 cm

Main charge type: TNT

Main charge weight: 5.3 kg

Booster charge: TNT

Booster charge weight: 194.85 g

Operating force: 180 kg

Fuze model: MV-5 or MVM (angled tilt rod)
MVSH-46

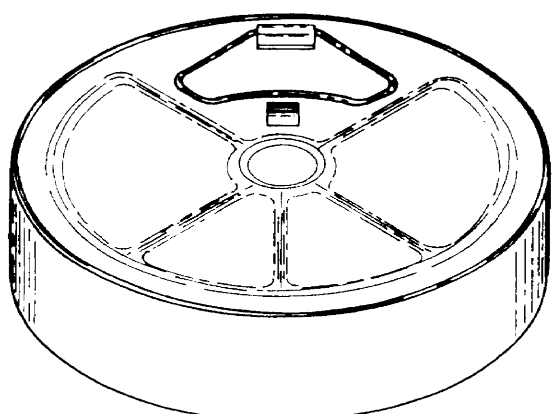
Figure A-29

TM-57 ANTITANK MINE

In appearance, the TM-57 metallic antitank mine is very similar to the TM-46 and TMN-46 antitank mine. The TM-57 has a larger charge and improved fuzing, and can be laid by hand or mechanically. It is easily recognized as it has no well in the bottom for an antihandling device (the TMV-46 has a well) and has seven ribs underneath (the TMN-46 has five ribs). Specifications are—

Weight: 9.5 kg

Dimension: 29.9 cm in diameter



Bottom view

Main charge: 7 kg TNT

Activating force: pressure 200 to 700 kg

Height: 9.9 cm

Note: This mine may be fitted with a tilt rod or pressure fuze.

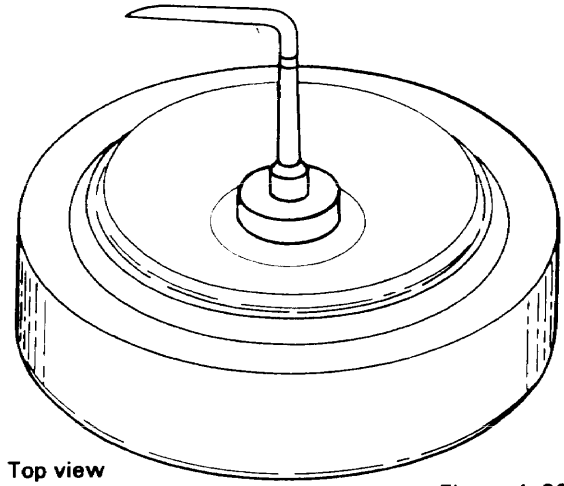
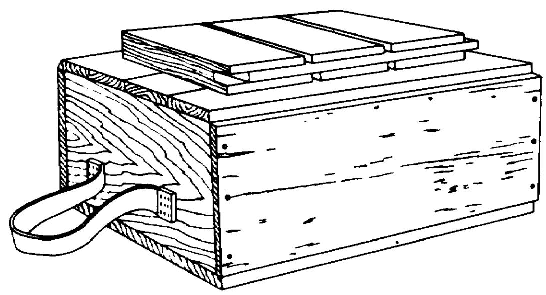


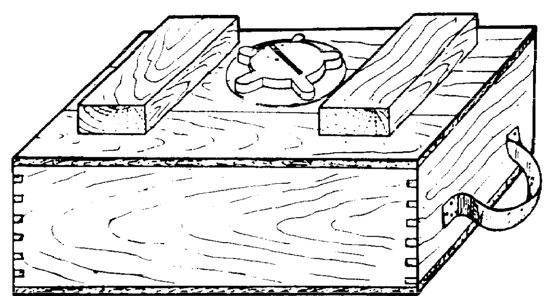
Figure A-30

TMD-B AND TMD-44 ANTITANK MINES

The wooden box is of simple construction with the boards either nailed together or fastened by tongue-and-groove joints. On the top of the mine are three pressure boards. The center board is hinged to allow the MV-5 fuze to be inserted. When armed, the pressure board is held in place by a wooden locking bar. The main charge normally consists of two waterproof paper-wrapped blocks of pressed amatol, ammonite, or dynammon. The mine operates as follows: when weight is applied, the top breaks down the cover at the sawed grooves and transmits pressure to the pressure block, which actuates the fuze and sets off the mine. The TMD-44 is similar to the TMD-B but has a centrally located plastic fuze well cover and only two pressure boards. Like the TMD-B, it uses the MV-5 pressure fuze.



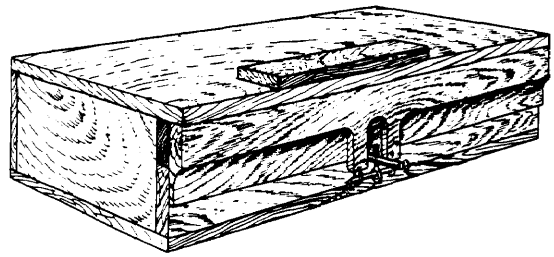
TMD-B



TMD-44

Figure A-31

YAM-5 AND YAM-10 ANTITANK MINES



YAM-5

The YAM-5 series of wooden antitank mines were widely used during World War II. The four models, which differ only in size, weight, and size of the pressure board on the mine lid, are designated the YAM-5, YAM-5K, YAM-5M, and the YAM-5U. They are easy to manufacture, and when constructed without nails, are difficult to detect. The mine consists of a wooden box with a hinged-lid lip which overlaps the box, recessed in the center to fit over the protruding end of the fuze striker. A staple is placed at each end of the recess which accommodates the pin, and then passes through the eye of the striker retaining pin. The pull fuze is actuated by pressure. Inside the box are the two explosive charges, booster charge, fuze holder block, and the fuze. The mine operates as follows: when pressure is applied to the lid, it collapses, forcing the overlapping edge down. This removes the striker retaining pin and activates the fuze. To reduce the operating pressure, the underside of the lid may have sawed grooves. The YAM-10 is a postwar mine and is similar in construction to the YAM-5, but is larger and contains more explosive.

Figure A-32

LMG ANTITANK GRENADE MINE

The LMG (flying mine galitsky) was developed during World War II. The mine consists of a spigot-launched projectile with a HEAT warhead. The launcher and spigot launcher are attached to a wooden platform which is staked to the ground in a shallow trench and aimed at a probable tank approach. A wire is attached to the MUV pull fuze in the launcher spigot. The mine can be operated by a trip wire or an observer. The warhead of the projectile has a base-detonating fuze and detonates on impact. The mine is normally aimed to hit the side of an armored vehicle. Specifications are—

Weight: 9.98 kg
(main charge) 3.2 kg
(booster charge) 0.78 kg

Fuze: MUV pull and impact (warhead)

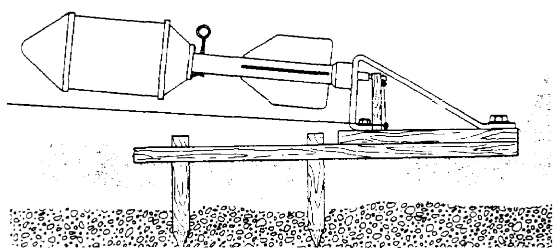


Figure A-33

TMK-2 ANTITANK MINE

This is a plate charge antitank mine that is equipped with a flash igniter fuze which operates on the tilt rod principle. The height of the rod is adjustable; therefore, this mine/fuze combination could be employed in deep snow, underwater, and as a triggering device for railway mines. This mine is believed capable of penetrating more than 250 millimeters of armor and is classed as a tank-killing mine that can destroy any armored vehicle. Specifications are—

Weight: 12.5 kg or 27.5 lb

Dimension: height - 350 mm,
diameter - 300 mm

Main charge: unknown

Activating force: tilt rod with booster charge

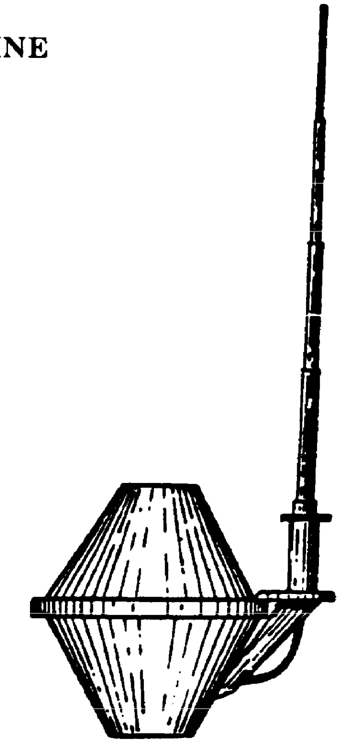


Figure A-34

PDM-6 (RIVER BOTTOM MINE)

The PDM-6 fluvial mine has a metal case and can be fuzed by either a tilt rod or a command-detonated electric firing device. It was designed to be anchored in shallow water and was produced to counter fording and assault boat operations. It would produce a mobility kill of heavily armored vehicles but would probably destroy lightly armored vehicles. The PDM-2 comprises an estimated charge of from 15 kilograms of TNT and ammonite. Specifications are—

Weight: 47.5 kg

Dimension: 100-cm base x 55-105 cm

Main charge: 28 kg TNT and pentolite

Activation force: tilt rod

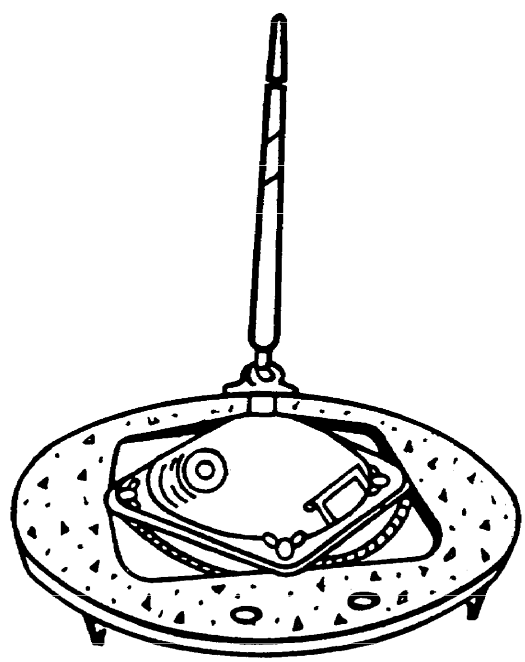


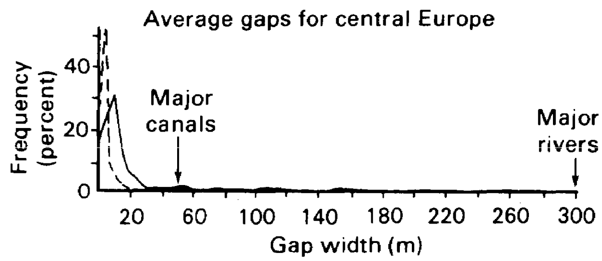
Figure A-35

OTHER ANTITANK OBSTACLES

There are many types of nonmine obstacles that can impede mobility (figures A-36 through A-46).

RIVERS/CANALS

Gaps caused by rivers and canals can be obstacles to the passage of tanks and wheeled vehicles. Even dry gaps can cause severe problems if the sides are steep or soil trafficability conditions are poor. Major obstacles like the Rhine River have been historic barriers in central Europe, but there are also many smaller streams and steep-sided canals which have delayed armies in the past.



Note:
20% of gaps are dry. 20% have water depth 1 m (TACGAP-75). Average height of bank is 2 m (TACGAP-75).

Figure A-36

CRATERS

Craters are spot obstacles generally circular or elliptical in shape. They are created by drilling a line of holes, filling with explosives, and blasting. The explosives can be prepared in advance and not set off unless needed. Craters can be formed rapidly. To be effective, they must be located in defiles or precise critical locations. Both ditches and craters should have steep sides and be of sufficient width so tanks cannot cross.

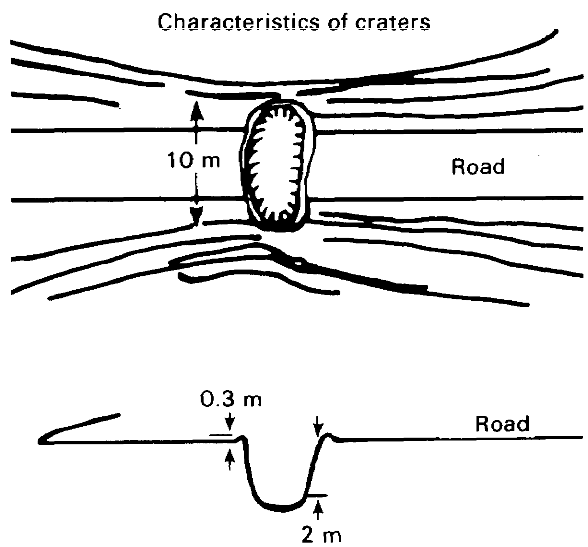


Figure A-37

DITCHES

Ditches are deliberate obstacles which an enemy may employ to deny use of high-speed road approaches. They can be used to reinforce natural defiles or to integrate with other obstacle systems such as minefields. Ditches are relatively long trenches which are dug, usually by machine, across an avenue of approach. However, Threat antitank ditches could probably be short segments placed in critical locations. To be effective, the ditch should be integrated with a minefield or anchored at each end by some other obstacle such as a forest, a minefield, or an unfordable river so that it cannot be easily bypassed.

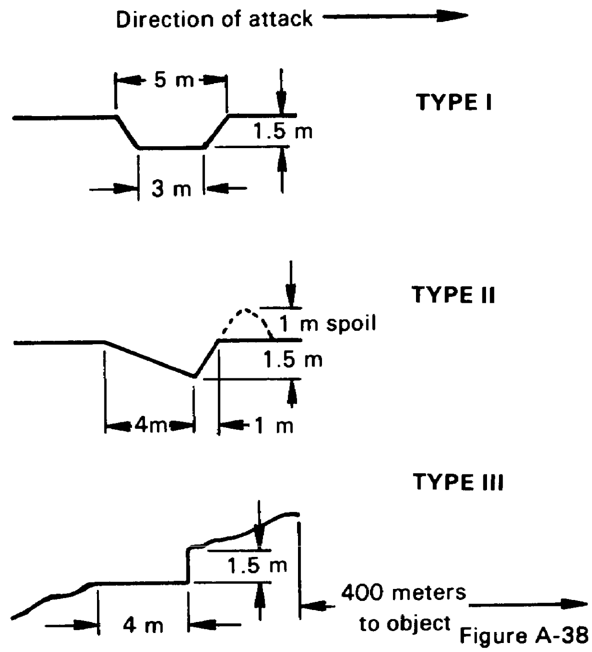
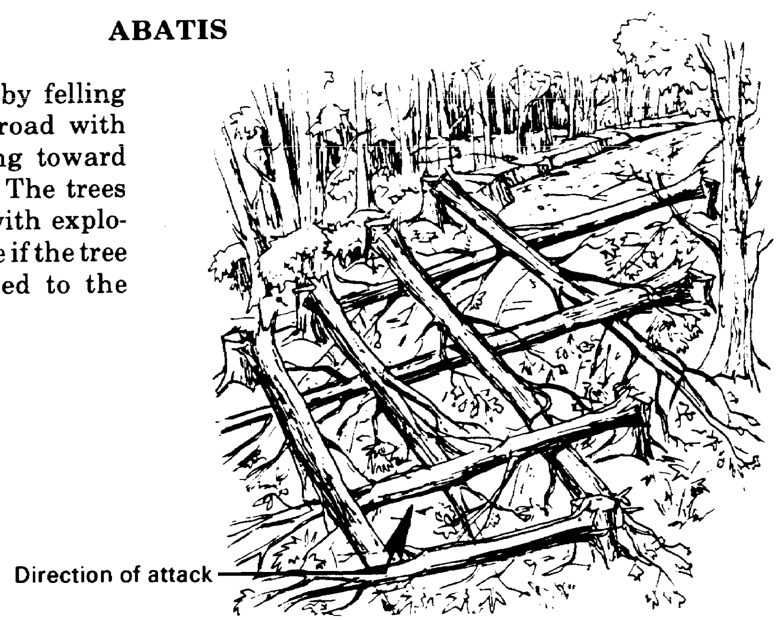


Figure A-38

ABATIS

An abatis is an obstacle formed by felling trees so that they fall across a road with branches interlocked and pointing toward the direction of enemy approach. The trees may be cut with power saws or with explosives. The obstacle is more effective if the tree trunks are left partially attached to the stumps.



40 trees 0.5 m in diameter/100 m

Figure A-39

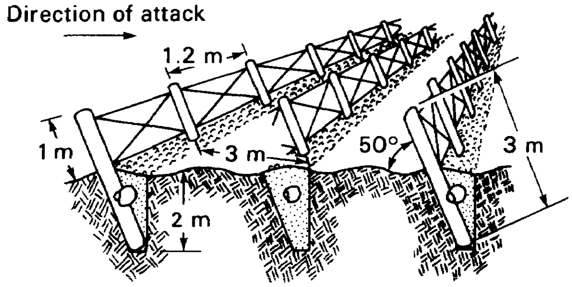
TREE BLOWDOWN

Tree blowdown from a nuclear blast, in or near a forested area, would occur in a ring-shaped pattern approximately centered on ground zero out to a distance dependent on the overpressure. The resulting jumble of uprooted trees would block any existing roads or trails through the area. The effectiveness of such an obstacle would depend upon the density of the forest stand, the size of the trees, and the extent of the original forest.

Figure A-40

POSTS

Posts are wood or steel piles driven into the ground and braced against being pushed over. A post obstacle consists of several lines of posts across an avenue of approach.



Post diameter = 0.3 meters

Figure A-41

DRAGON'S TEETH

Dragon's teeth are usually fabricated, concrete pyramids or truncated cones about 1-meter thick at the base. They are placed in multiple rows across an avenue of approach. Germany's Siegfried line in World War II was the main example of the extensive use of dragon's teeth, but similar obstacles can still be found on a more limited scale along some international borders today.

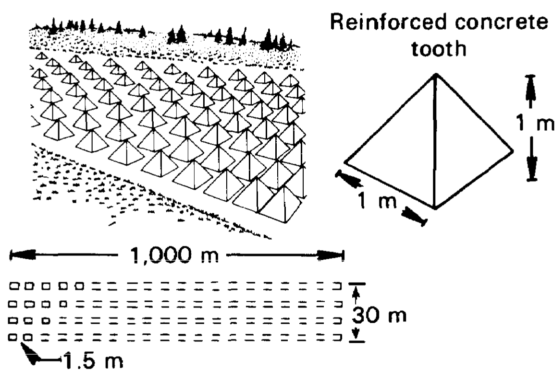
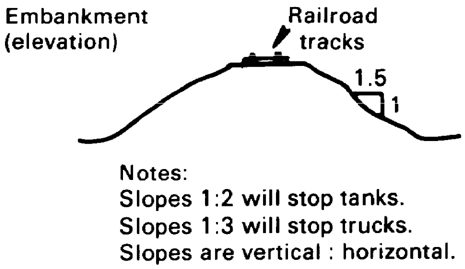


Figure A-42

WALLS AND EMBANKMENTS

With the increasingly dense population of Europe and the proliferation of urban sprawl, constructed obstacles pose a sizeable threat to military mobility. Walls, railroad embankments, and the towns and cities themselves prevent free maneuver of forces.



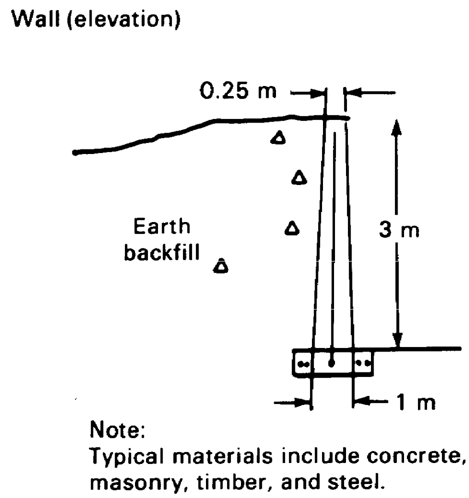


Figure A-43

CRIBS

Cribs are more like a point obstacle. They are formed by driving posts in a square or triangular pattern and then filling the enclosed space with rubble or earth. Cribs have been used to block roads, especially at constricted areas.

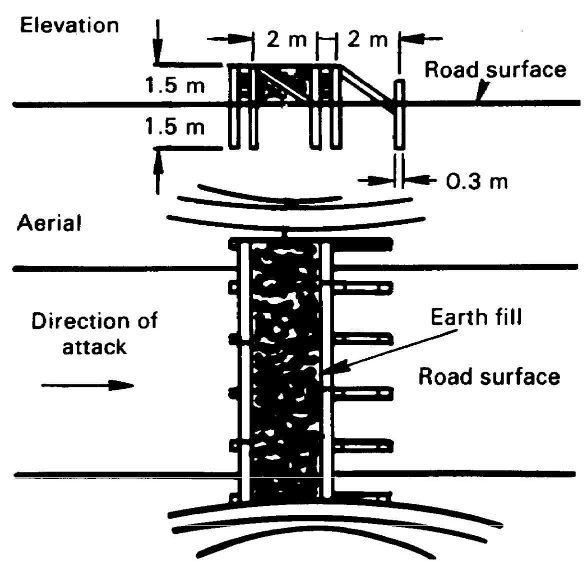


Figure A-44

FIELD/PERMANENT FORTIFICATIONS

Field/permanent fortifications include action to strengthen or fortify a unit position. Field fortifications may consist of log and earth bunkers, firing trenches, and dug-in positions for weapons. Permanent fortifications are more elaborate reinforced concrete structures.

Either type of fortification provides command posts, observation and fire direction centers, and covered protection for weapons to cover other obstacles such as minefield with direct or indirect fire. An example of this kind of fortification is covered in FM 5-103.

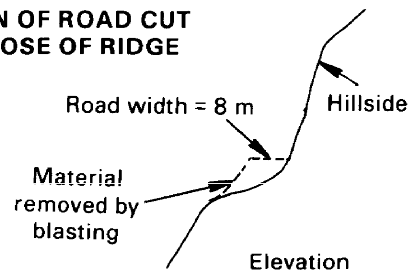
AREA WATER OBSTACLES

Inundated areas can be created deliberately by opening the floodgates of dams or dikes or by breaching with explosives, The area to be inundated is the natural floodplain. However, the exact boundaries will depend on the quantity of water released and its rate of flow. A lesser quantity will produce a smaller inundated area, but the effect of the obstacle will be prolonged.

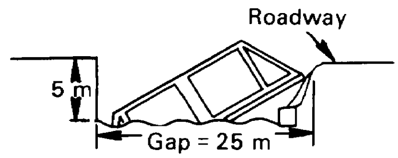
LINE OF COMMUNICATION (LOC) DEMOLITION

Demolitions of such structures as bridges, tunnels, culverts, and of the roadway itself at natural defiles can produce effective obstacles. Explosives have many apparent advantages in creating obstacles because they can be placed relatively quickly and the time of execution can be controlled. A large demolition project, however, is a major undertaking, and if not properly executed, can result in catastrophic failure such as the bungled German bridge demolition at Remagen in World War II. Properly handled, LOC demolitions can reinforce natural obstacles.

DEMOLITION OF ROAD CUT AROUND NOSE OF RIDGE



BRIDGE DEMOLITION



River/canal obstacle enhanced by bridge demolition mines emplaced around abutments.

TUNNEL DEMOLITION

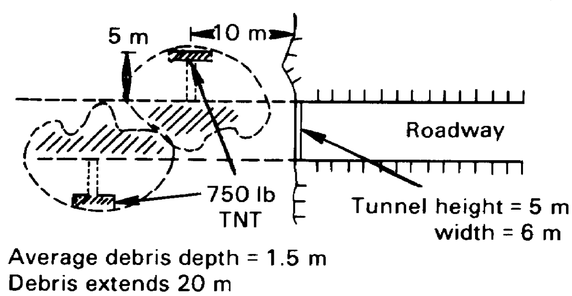


Figure A-45

URBAN RUBBLE

With the increased payloads of artillery, rockets and bombs, there would be a vast amount of damage and rubble created very quickly in areas with many artificial or constructed features. Nuclear weapons would be even more devastating. If nuclear weapons are employed against troop concentrations, there will be concurrent damage to the environment in the form of tree blowdown and the rubbling of buildings. This damage could occur on a greater scale than damage caused by conventional artillery and bombs.

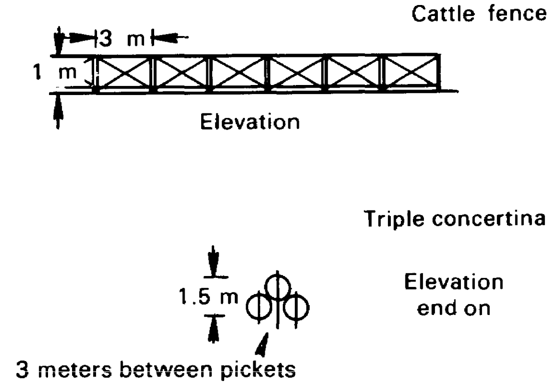
Figure A-46

NONEXPLOSIVE ANTIPERSONNEL OBSTACLES

Any obstacle that will stop a tank will also stop a wheeled vehicle. Special obstacles are required to slow down or stop personnel (figures A-47 and A-48). On the other hand, antipersonnel obstacles are generally worthless against tanks. Therefore, a defender might use a combination of antitank and antipersonnel obstacles in order to prevent easy neutralization by anyone component of the team.

ENTANGLEMENTS

Aside from antipersonnel mines, the most common antipersonnel obstacle is some form of barbed wire or barbed tape. This may be strung along fence posts or pegged along the ground as foot snare. The barbs are designed to snag the soldier's clothing and equipment, making it impossible for the soldier to move through quickly. Thereby, the soldier becomes an easier target. Like all other obstacles, the value of barbed wire/tape diminishes greatly unless it is covered by fire.



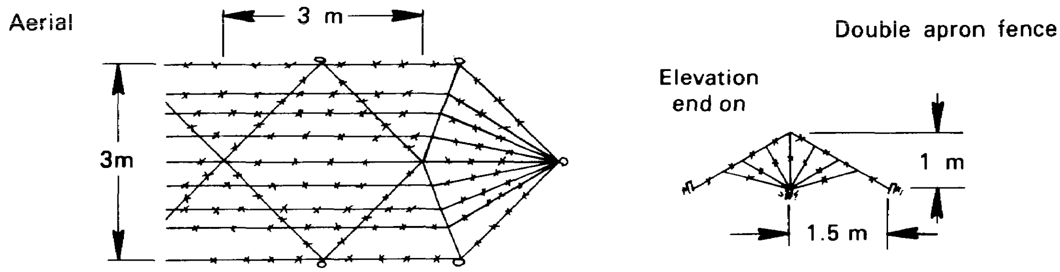
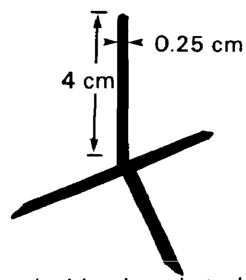


Figure A-47

CALTROPS

Caltrops are devices which consist of an arrangement of four sharpened metal prongs where one prong will always be vertical no matter how the caltrop lands. Caltrops can be dispensed by hand or from trucks or aircraft. Caltrops are designed to cause injury by penetrating the footgear of the person who steps on one. Serious injury will result if an individual quickly falls to the ground to avoid small arms or artillery fire.



Notes:
Caltrops can be employed with other obstacles or by themselves
With a density of 30-40/meter or front, caltrops are equivalent to triple concertina.

Figure A-48

Mobility:
US Equipment Reference Data

US COMBAT MOBILITY SUPPORT EQUIPMENT

OVERVIEW

This appendix describes the capabilities and limitations of selected equipment that can be employed for support of mobility activities (figures B-1 through B-18 and tables B-1 through B-10). Special consideration must be given to the operation of equipment on the winter battlefield, This includes the effectiveness of mine detection equipment and mine emplacement in snow and frozen ground, the effects of water and mud freezing on linkages and connectors, and the problem of equipment that becomes frozen in the ground. These are real problems in those areas above line B, figure 9-9 on page 9-15. This information will provide maneuver and engineer commanders (and their staffs) a means of estimating the following:

- Equipment required for support of mobility activities.
- Logistical and operational restrictions which apply to each mobilty support system.

MINE DETECTING SETS

The AN/PRS 7 and AN/PSS 11 are hand-held mine detectors. The AN/PRS 7 is capable of detecting metallic and nonmetallic land mines in any type of terrain or soil. The AN/PSS 11 is capable of detecting metallic land mines which are smaller and buried deeper. Each mine detector is issued to combat, combat support, and combat service support units throughout the US Army. The hand-held mine detector is operated by one soldier. To prevent fatigue, this operator should be rotated every 20 minutes. The AN/PRS 7 has been improved to increase detection rates and to reduce false alarms in arid environments. The new lithium battery for the AN/PRS 7 has increased operational life. The rate at which mines can be detected is dependent upon the terrain, proximity of the Threat, weather, and operator training. A path 7 feet (2.1 meters) wide by 492 feet (150 meters) can be swept in 41 minutes if the operator is not under fire and/or no mines are discovered during the operation. The improved AN/PRS 7 has been designated the AN/PRS 8.

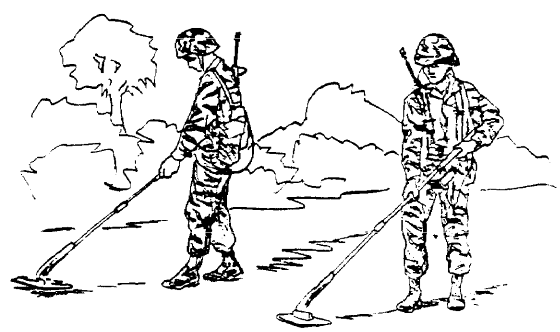
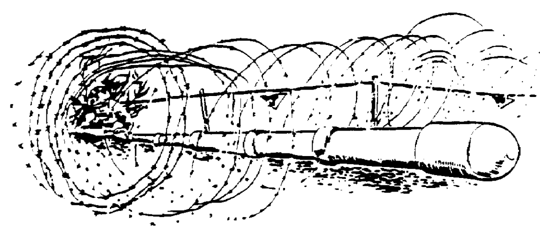


Figure B-1

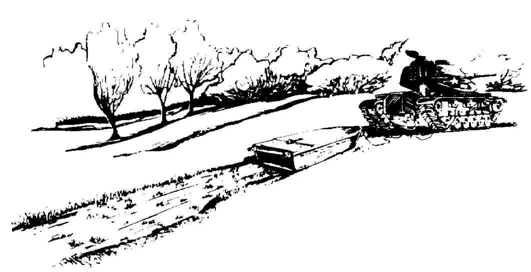
BANGALORE TORPEDO



The bangalore torpedo is a portable, antipersonnel mine-breaching device dating back to World War II. It is used by engineer troops or dismounted personnel for rapid minefield breaching and wire cutting. The bangalore torpedo is a class five item drawn, as required, for hasty minefield breaching. The bangalore torpedo kit consists of ten 1.5-meter/5-foot tubes, each containing 4 kilograms (9 pounds) of explosive and weighing 5.9 kilograms (13 pounds). It clears a path 0.6 meters (1.9 feet) long through antipersonnel mines only. It is not reliable for cutting high tensile-strength barbed wire obstacles. Detonation is accomplished by either electric or nonelectric blasting caps. When screened from enemy observation, one soldier can assemble and push one kit into a minefield in 26 to 34 minutes. One-hundred meters of bangalore torpedo would require 3.5 to 4.5 personnel-hours. For logistics planning, one 2 ½-ton truck can transport a maximum of 25 bangalore torpedo kits.

Figure B-2

M173 PROJECTED CHARGE DEMOLITION KIT



The projected charge demolition kit M173 is an antitank minefield-clearing device stored and transported in a boat-shaped container. It is designed to be towed to the edge of a minefield for rapid minefield breaching. The M173 contains 675 kilograms (1,500 pounds) of composition C-4, total weight 1,395 kilograms (3,100 pounds). It clears a path 4.6-meters (26.2 feet) wide and 70-meters (272.2 feet) long. Detonation is accomplished remotely from inside the towing vehicle, utilizing the 24-volt direct current (DC) electrical system. The M173 is a class five item, drawn as required. The device can be palletized or packaged to permit ready transport. Each kit can be towed over land or water by a land or amphibious vehicle. Each kit requires 0.5 personnel-hours for assembly. Both the assembler and components are vulnerable to small arms fire, indirect artillery fire, direct weapons fire, and NBC environment. For each M173 kit, one 2 ½-ton truck would be required for movement. Successive kits can be used for longer breaches. The charge can be fired from the back of a cargo truck.

Figure B-3

TRACK-WIDTH MINE-CLEARING ROLLER (TANK-MOUNTED)

This system provides armor units an organic capability to breach and proof lanes through minefields. The roller neutralizes single pulse, pressure-actuated mines in the track path of the pusher tank. A "dog-bone" and chain assembly clears tilt rod actuated mines between the roller banks. A quick disconnect feature is provided which allows the tank driver to disconnect the roller from within the tank. The tank crew, using the hand-winch assemblies, can mount the roller to the tank in 15 to 30 minutes during daylight. The mine roller consists of a roller assembly, mounting kit, and hand-winch kit. The roller assembly weighs approximately 20,000 pounds and consists of two push beams, mounted to the front of an M-1/M60 series tank. Each beam pushes a carriage assembly containing five roller wheels. The mounting kit contains a hydraulic pump, lines, a quick disconnect mechanism, and a mounting bracket. When not attached to a tank, the roller is transported on M172A1 lowboy trailers pulled by M818 tractors.

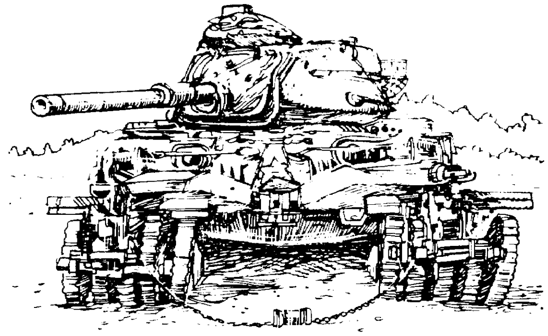


Figure B-4

M-728 COMBAT ENGINEER VEHICLE

The combat engineer vehicle (CEV) is a full tracked armored vehicle which can provide engineer support in the forward combat area while under fire. Although the CEV consists of a tank hull and a turret with a 165-millimeter demolition gun, its primary role is that of an assault weapon used to destroy bunkers and other fortified positions. It is not designed to be employed as a tank. The CEV's 165-millimeter ammunition is a high explosive plastic round made up of a composition charge. When employed in forward areas, the CEV requires protection by tanks or other armored assault vehicles. The CEV is equipped with a dozer blade and is effective in clearing rubble and obstructions. The CEV has a gas particulate filter system for removal of toxic gases and provides the occupants protection against nuclear attack roughly equivalent to a 4-foot deep defensive position with overhead cover.

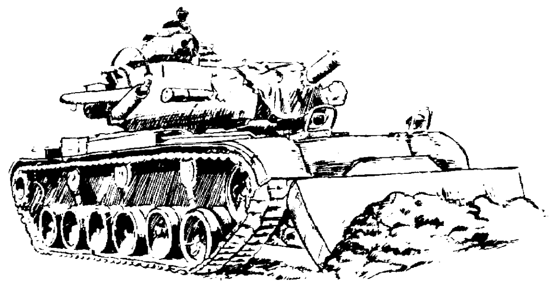


Figure B-5

M9 ARMORED COMBAT EARTHMOVER

The M9 armored combat earthmover (ACE) is capable of performing several battlefield mobility tasks. It can be employed to fill craters and prepare crossing sites at gaps. The ACE is also capable of removing obstacles such as roadblocks, trees, and rubble while maintaining combat roads and trails. The major vehicle systems are a scraper-dozer-hauling front-end and rear-end-installed winching system. The M9 provides light armor and chemical agent protection for the operator and key components. It is capable of 30 miles-per-hour (mph) road speeds on level terrain (when unballasted). The M9 also has an amphibious capability and can be air-transported by C-130, C-141, and C5A aircraft.

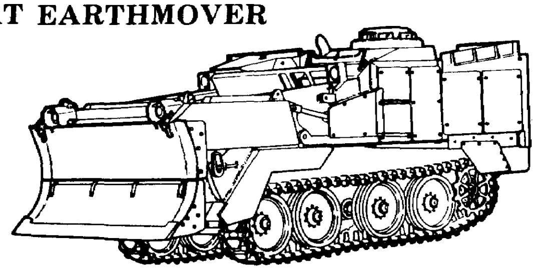
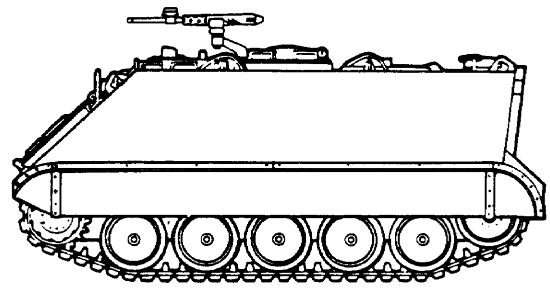


Figure B-6

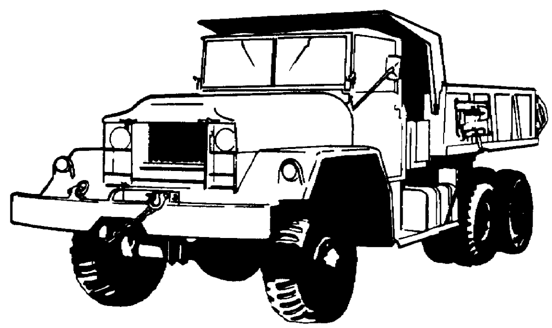
M-113A1 ARMORED PERSONNEL CARRIER



The M-113A1 armored personnel carrier (APC) is a full-tracked vehicle designed to transport troops or cargo. The APC is capable of amphibious operations, extended cross-country travel, and high-speed operation on roads and highways. Because of its low net weight, it is air-transportable and droppable. Each APC is capable of pulling a 1 ½-ton trailer containing engineer equipment and supplies. The APC replaces the 5-ton dump truck as the combat engineer squad vehicle in mechanized engineer units. The APC is equipped with a gas particulate filter unit designed to be used with the M25A1 tank protective mask. With its air filtration system and light armor protection, the APC has limited ability to operate in an NBC environment. Equipped with the 50-caliber machine gun, the APC can provide suppressive fire and a limited air defense capability.

Figure B-7

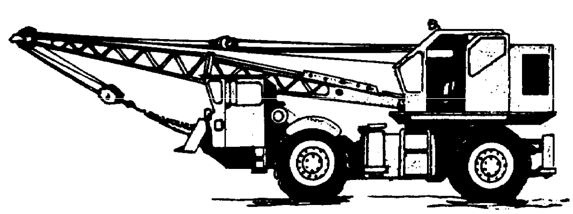
FIVE-TON DUMP TRUCK



The 5-ton dump truck is a wheeled vehicle designed for use over all types of roads and cross-country terrain. With its 5-cubic yard-capacity dump body, it provides earth and hauling capability for the engineer. It also can be used as a prime mover for several US Army trailers and is used as the squad vehicle in most nondivisional engineer companies to carry troops and tools. The 5-ton dump truck has no weapon system so it must operate with an armed co-operator or in proximity to armed units. Also, it has no air filtration system for occupants and offers no protection against NBC attack. If equipped with a winch, it can serve in small-vehicle recovery operations (including self-recovery) and in removal of obstacles or debris.

Figure B-8

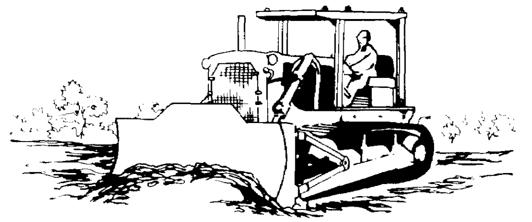
TWENTY-TON CRANE



The 20-ton rough terrain crane provides the engineer with lifting and loading capability. It is operated with the standard hook block, dragline, clamshell, and pile driver attachments. These attachments make it useful in all vertical construction missions. It is also used in removing rubble in built-up areas and to assist in construction of float and fixed bridges. During operations, the outrigger must be employed to prevent the crane from flipping over. The crane is not protected in a hostile environment. Both the operator and critical mechanical components are vulnerable to small arms fire, indirect artillery fire, and direct fire weapons. It has no capability for crew survival in an NBC environment.

Figure B-9

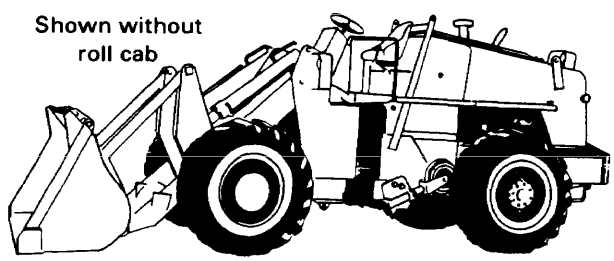
TRACTOR, D7/D8



The crawler tractor, commonly known as the bulldozer, is the engineer's basic earthmoving system. It is used for dozing, excavating, grading, land clearing, and a wide variety of construction and support operations. It is capable of working in adverse terrain conditions. The military model D7 and D8 tractors are equipped with a power shift transmission, a hydraulically-operated dozer blade, and a rear-mounted winch or ripper. The D7 tractor, with an operating weight of 50,000 pounds, 200-horsepower diesel engine, and drawbar pull of 39,000 pounds, is classified as a medium-size tractor. The D8 tractor, with an operating weight of 83,000 pounds with ripper, 300-horsepower diesel engine, and drawbar pull of 56,000 pounds, falls into the heavy class.

Figure B-10

SCOOP LOADERS

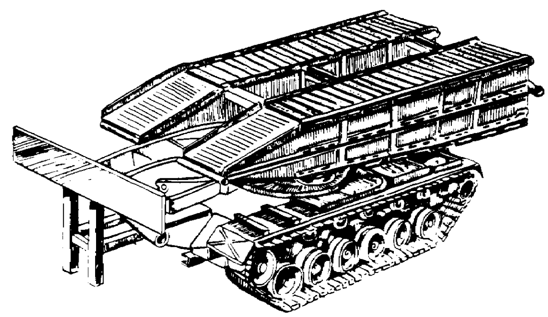


The scoop loader is a diesel engine self-contained unit mounted on large rubber tires. The hydraulically-operated scoop bucket is attached to the front of the loader by means of a push frame and lift arms. It may be used as a one piece general purpose bucket, a rock bucket, or a multisegment (hinged jaw) bucket. The multisegment bucket can be utilized as a clamshell, dozer, scraper, or scoop bucket. The current military engineer scoop loaders range from 2 ½- to 5-cubic yard rated capacity. They are employed in the majority of engineer organizations including airborne/airmobile (ABN/AMBL) unit and the combat heavy battalion.

Figure B-11

ARMORED VEHICLE LAUNCHED BRIDGE

The armored vehicle launched bridge (AVLB) is mounted on a full-tracked armored vehicle. It provides assault bridging capability for maneuvering tank and mechanized battalions. The AVLB is employed primarily in hasty crossings of short gaps by combined arms teams and is particularly suitable for spanning narrow streams, antitank ditches, craters, canals, partially blown bridges, and similar obstacles. The bridge may be placed over existing bridges or portions of existing bridges to increase the load-carrying capacity of these bridges. It may also be used with components of the M4T6 class 60 bridge to rapidly construct rafts. The bridge can be launched without exposing the crew to hostile fire and can be retrieved from either end. The carrier, based on an M60 tank chassis, has a gas particulate filter system designed to remove toxic gases that are present in contaminated NBC areas. The AVLB has no operable weapon system and therefore must operate in close proximity to the maneuver force for its protection. The AVLB has the following characteristics:



Transportation

- Bridge carried on launcher (modified M48 or M60 chassis)
- Maximum speed 43 kph/30 mph
- Spare bridge folded on low-bed trailer
- Twenty-ton crane transfers bridge (15 ton) to launcher in 20 to 30 minutes

Emplacement

- Launched in 2 to 5 minutes by 2-person crew
- Retrieval is possible from either end of bridge
- Crew must allow .9 m/3 ft bearing for unprepared abutment; .5m/1.5 feet for prepared and stable abutment (on each bank)

Capacity

- One class 60 vehicle crossing at a time
- Bridge span is 19.2 m (63 ft)
- 18.3 m (60 ft) using prepared abutments
- 17.4 m (57 ft) using unprepared abutments

Limitations

- Launch requires 10 m (32.8 ft) overhead clearance
- Maximum launch slope
- Uphill - 2.7 m/9 ft(15 percent)
- Downhill - 2.7 m/9 ft (15 percent)
- Sideslope - .3 m/1 ft (8 percent)

Figure B-12

LIGHT TACTICAL RAFT

The light tactical raft (LTR) is a hand-erectable, aluminum roadway supported by aluminum pontoons. The LTR is used in combat areas for wet gap crossing of light vehicles. It can also be erected into a float bridge providing the same support capability. Short fixed spans can be assembled from the LTR set to provide a means of crossing narrow streams or dry gaps with light vehicles and equipment. The maximum span length for fixed span configuration is 11.5 meters (38 feet). An LTR set consists of four pontoons and four deck bays. The entire set can be transported by two 2 ½-ton trucks with a pole trailer. Soldiers used in assembly and rafting operations will be vulnerable to small arms fire, indirect artillery fire, direct weapons fire, and an NBC environment.

MILITARY LOAD CLASS

CLEAR SPAN meters	(feet)	CLASS NORMAL		CAUTION		RISK	
6.1 -	(20)	(21)	17	(25)	19	(32)	23
6.7 -	(22)	(18)	15	(20)	17	(23)	19
7.3 -	(24)	(16)	13	(18)	15	(20)	17
7.9 -	(26)	(14)	12	(18)	14	(16)	16
8.5 -	(28)	(12)	11	(14)	13	(16)	15
9.1 -	(30)	(11)	10	(12)	12	(16)	14
9.7 -	(32)	(10)	9	(11)	11	(15)	13
10.3 -	(34)	(9)	8	(10)	10	(13)	12
10.9 -	(36)	(8)	7	(10)	9	(11)	12
11.5 -	(38)	(7)	7	(9)	9	(10)	11

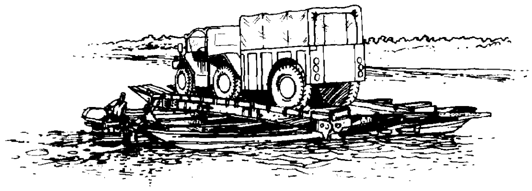


Figure B-13

Notes:
Figure in parentheses represents wheel load class.
Second figure represents tracked load class.

MILITARY LOAD CLASS

TYPE ASSEMBLY	TYPE CROSSING	CURRENT VELOCITY mps(fps) 1.5 (5)	2 (7)	2.5 (8)	2.75 (9)	3 (10)	3.5 (11)	ASSEMBLY TIME	LOADING SPACE
RAFT								30 min	9.15 m (30 ft)
4 pontoon/3 bay	N	12	12	12	8	4	0		
w articulators	R	14	14	14	12	8	4		
4 pontoon/3 bay	N	16	16	12	8	4	0	25 min	9.15 m (30 ft)
wo articulators	R	20	20	16	12	8	4		
4 pontoon/4 bay	N	10	10	10	6	2	0	35 min	12.5 m (41 ft)
w articulators	R	12	12	12	10	6	2		
5 pontoon/5 bay	N	9	9	9	8	5	2	40 min	15.84 m (52 ft)
w articulators	R	11	11	11	11	9	6		
5 pontoon/5 bay	N	16	14	11	8	5	2	35 min	15.85 m (52 ft)
wo articulators	R	19	17	15	12	9	6		
6 pontoon/4 bay	N	13	13	13	13	12	5	45 min	12.5 m (41 ft)
w articulators	R	15	15	15	15	15	11		
6 pontoon/4 bay	N	17	17	17	17	16	9	40 min	12.5 m (41 ft)
wo articulators	R	24	24	24	24	17	11		
6 pontoon/5 bay	N	18	18	18	18	12	6	45 min	15.85 m (52 ft)
wo articulators	R	22	22	22	22	17	11		
BRIDGE	C	18	15	12	9	6	3		
	N	16	13	11	8	5	2	60 min	45.7 m (150 ft)
	R	21	17	14	11	8	5		

Notes:
1. Type crossing legend: N = Normal, R = Risk, C = Caution.
2. Roadway width is 2.7 m (9 ft).
3. Assembly in wet gap must figure draft of erection boats: OBM = 0.6 m (2 ft) — BEB = 1 m (3.3 ft).

Table B-1

M4T6 FLOATING/FIXED BRIDGE

The M4T6 floating/fixed bridge is used in combat areas for wet/dry gap crossings of heavy vehicles. The M4T6 requires secure riverline assembly sites, exclusive combat engineer labor, and more time than newer systems. This system will normally supplement or provide backup for the ribbon bridge, mobile assault bridge, AVLB, and MGB which can be installed in less time. The M4T6 is a hand-erectable, air-transportable bridge system capable of carrying class 60 loads. The M4T6 features a pneumatic float with an aluminum roadway composed of interlocking pieces (balk). One set of M4T6 floating bridge is approximately 142 feet in length. Soldiers used in assembly and bridging and rafting operations will be vulnerable to small arms fire, indirect artillery fire, direct weapons fire, and an NBC environment.

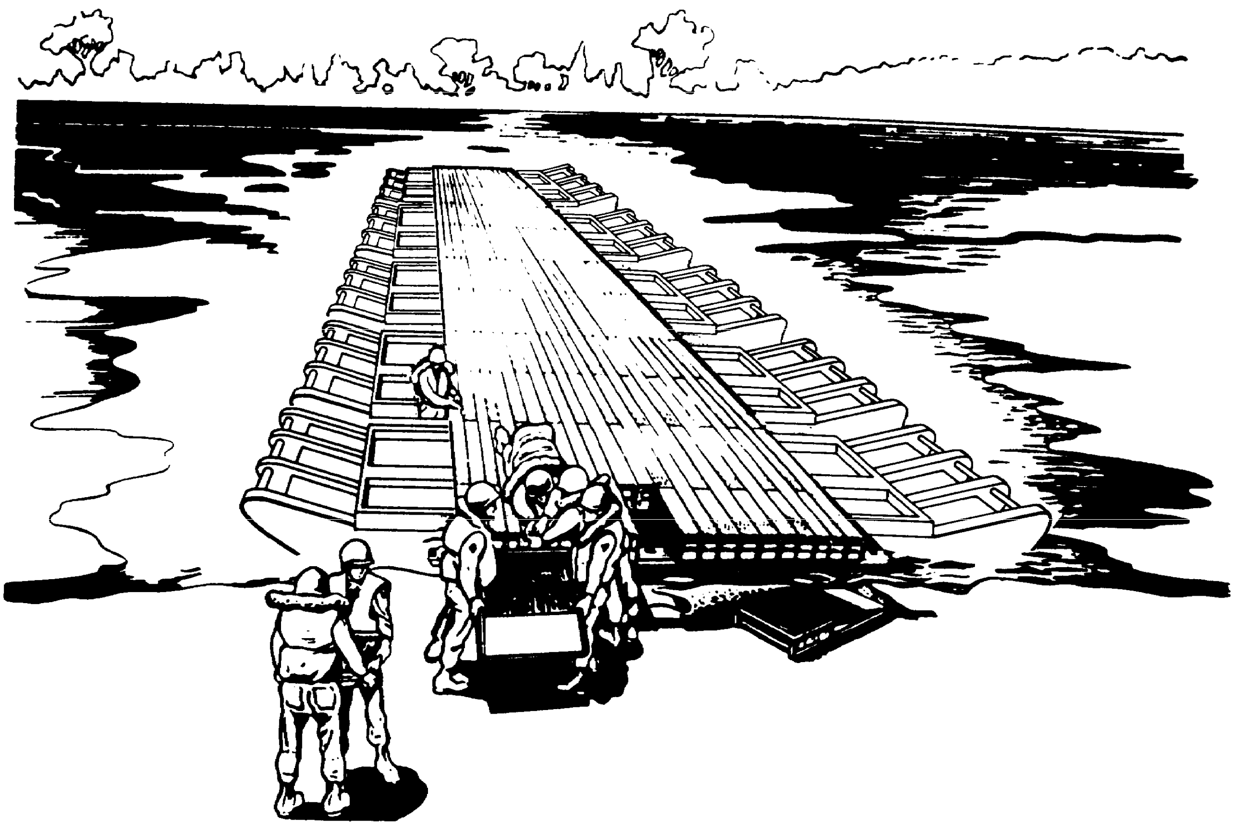


Figure B-14

CAPABILITIES

RAFT: One set makes:

- One 4-float normal raft (4N) AND one 5-float normal (5N) raft
- OR one 4-float reinf raft (4R) AND one 5-float reinf (5R) raft
- OR one 6-float reinf (6R) raft

ASSEMBLY CREW/TIME

1. Per 4 float raft:
   - 5 brg trks
   - 2 power boats (27 ft)
   - 1 plt, 2¼ hr
   - (When preassembled, 1¼ hr)
2. Per 5 float raft:
   - 6 brg trucks
   - 2 power boats (27 ft)
   - 1 plt, 3 hr
   - (When preassembled, 1½ hr)
3. Per 6 float raft:
   - 7 brg trucks
   - 2 power boats (27 ft)
   - 1 plt, 3¾ hr
   - (When preassembled, 1¾ hr)
4. All assembly times are estimated using trained troops in daylight with good weather conditions.

		CURRENT VELOCITY m/s (f/s)			
		1.5 (5)	2 (7)	2.5 (8)	3.5 (11)
RAFT	**LOAD SPACE**	**Capacity (MLC)**			
4N	15.7 m (51.6 ft)	50	45	40	30
		55	50	45	35
5N	20.3 m (66.6 ft)	55	50	45	35
		60	55	50	40
4R	11.6 m (38.3 ft)	50	50	45	35
		55	55	50	40
5R	15.2 m (50 ft)	60	60	55	45
		65	65	60	50
6R	16.2 m (53.3 ft)	65	65	65	45
		70	70	70	50

BRIDGE: One set makes 43.2 m (142′), normal construction, no of floats =

(Gap [m] + 2) + 10%
4.6

OR

(Gap [ft] + 2) + 10%
15

Reinforced construction, no of floats =

(Gap [m] + 2) + 10%
3

(Gap [ft] + 2) + 10%
10

RIVER WIDTH Length m (ft) (Normal assy)		**SUGGESTED UNIT SIZE**	**NUMBER OF ASSY SITES**	**TIME (Hours)**
45.5	(150)	1 company	2	4
61	(200)	1 company	2	5
76	(250)	1 company	2	6
91.5	(300)	2 companies	3	4
106.5	(350)	2 companies	3	5
122	(400)	2 companies	4	5½
152	(500)	2 companies	5	6
183	(600)	3 companies	6	4
213	(700)	3 companies	6	5-7
244	(800)	3 companies	6	6-8
305	(1,000)	3 companies	6	7-10
366	(1,200)	3 companies	6	8-12

NORMAL BRIDGE

45	40	35	35
55	50	45	30

REINFORCED BRIDGE

75	70	65	27
75	75	70	70

CROSSING RATE

200 vehicles per hour with 30 m (100 ft) spacing and 16 km/h (10 mph)

Notes:
1. Roadway is 4 m (13.2 ft) wide.
2. When assembled at river, 36 x 39.5 m (120 x 130 ft) area required.
3. Air compressor, 2 bridge erection boats (BEB), and crane needed per raft/bridge construction site.
4. Draft of raft/bridge 0.7 m (2 ft 5 in).
5. Draft of bridge erection boat = 1 m (3.3 ft).
6. Normal site preparation and anchorage concurrent with assembly time.

Table B-2

RIBBON BRIDGE/RAFT

The ribbon bridge is a modular, floating bridge/raft system made of aluminum alloy. A complete bridge set of 10 interior bays and 2 ramp bays will span a gap of 76.4 meters (252 feet). Each bay is transported, launched, and retrieved from a modified M812 5-ton truck. The ribbon bridge can be emplaced rapidly under all conditions of visibility. For increased mobility, the bays and ramps are designed for helicopter delivery. Soldiers used in assembly and bridge/rafting operations will be vulnerable to small arms fire, indirect artillery fire, direct weapons fire, and an NBC environment.

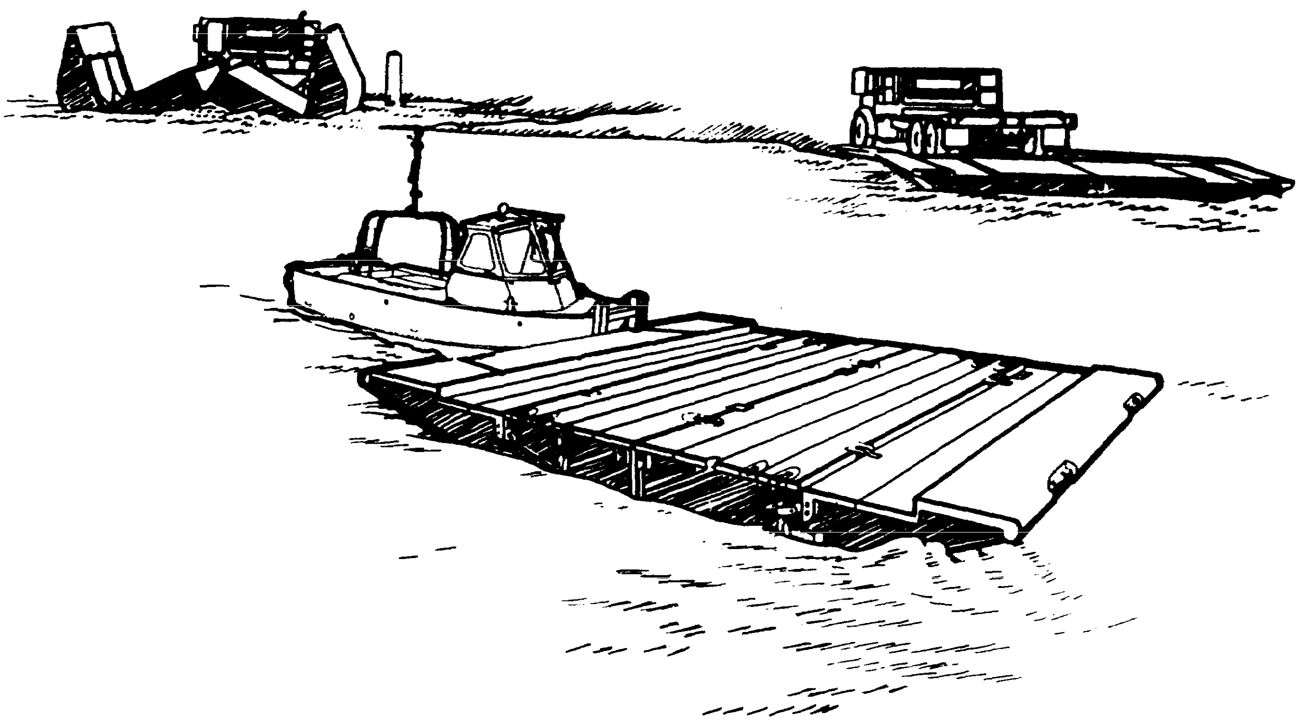


Figure B-15

CAPABILITIES	ASSEMBLY TIME	LOAD SPACE		CURRENT VELOCITY 0.9 / 0.3	1.2 / 4	1.5 / 5	1.75 / 6	2 / 7	2.5 / 8	2.7 / 8	3 m/s / 10 f/s
RAFT							LOAD CLASS				
3 bay	8 min	6.7 m (22 ft)	L	45	45	45	40	40	35	30	25
			C	45	45	35	25	15	10	0	
4 bay	12 min	13.4 m (44 ft)	L	70	70	70	60	60	60	55	45
			C	60	60	60	[4]55	[4]40	[4]30	[4]15	0
5 bay	15 min	20.1 m (66 ft)	L	75	75	75	70	70	70	60	60
			C	75	70	70	[4]70	[4]60	[4]50	[4]25	0
6 bay	20 min	26.8 m (88 ft)	L	W96/ T80	96/ 80	96/ 80	96/ 70	96/ 70	96/ 70	70/ 70	70/ 70
			C	W96/ T75	96/ 70	96/ 70	[4]70/ 70	[4]70/ 70	[4]55 55	[4]30/ 30	0

Notes:
1. L = Longitudinal C = Conventional
2. 3, 4, and 5 bay are wheeled or tracked rating; 6 bay as shown.
3. For longitudinal rafting, current velocity in loading areas must not exceed 1.5 m/s (5 f/s)
4. Use 3 BEBs for propulsion and 2 BEBs for all others.

BRIDGE

CAPABILITIES	ASSEMBLY TIME	0.9 / 0.3	1.2 / 4	1.5 / 5	1.75 / 6	2 / 7	2.5 / 8	2.7 / 8	3 m/s / 10 f/s
No of interior bays =	200 m/hr (600 ft/hr)	96/ 75	96/ 75	96/ 70	96/ 70	82/ 70	65/ 60	45/ 45	30/ 30

$\frac{\text{Gap (m)} - 14}{6.7}$

or

$\frac{\text{Gap (ft)} - 45}{22}$

All assembly times are estimated using trained troops in daylight with good weather conditions.

Notes:
1. Caution and risk values are available
2. Anchorage with 1 x BEB per 6 bays in currents up to 2.5 m/s (8 f/s).
3. Anchorage with 1 x BEB per 2 bays in currents of 2.7 m/s (9 f/s). Above 2.7 m/s (9 f/s) use bridle line 15 degrees vertical angle.
4. Vehicle spacing = 100 ft (front to back).
   Speed - Ramps = cl 0-40 - 15 mph
   over cl 40 - 5 mph
   Bridge = cl 0-40 - 25 mph
   over cl 40 - 15 mph

Notes:
1. Each bay transported on modified 5-ton truck.
2. Bridge erection boats transported on cradle on 5-ton truck.
3. MLC of loaded truck is 17.
4. Assembled by crew.
5. Loaded ribbon raft draft:
   Bay 0.6 m (24 in)
   Bridge boat (RREB) 1 m (40 in)
6. Adding pallet to off-loaded truck gives secondary cargo mission (pallet carries 6½ tons in tipping mode and 9½ tons as flatbed.)

Table B-3

MOBILE ASSAULT BRIDGE

The mobile assault bridge (MAB) is a self-propelled, amphibious unit that can be linked rapidly to form floating bridges or rafts of various sizes and capacities. The MAB provided the Army with its first "drive into the water" raft and bridging capability. All transporters have four-wheel drive and four-wheel steering. The MAB can travel on hard-surfaced roads at a maximum speed of 65 kilometers per hour and a maximum speed of 10 kilometers per hour off road. The MAB is used in the combat area for multiple river crossings to permit emplaced, high volume stream crossing of armor and supporting heavy tactical loads. It is replaced by standard floating or fixed bridges as soon as the tactical situation permits. During assembly or bridging/rafting operations, soldiers will be vulnerable to small arms fire, indirect artillery fire, direct weapons fire, and an NBC environment.

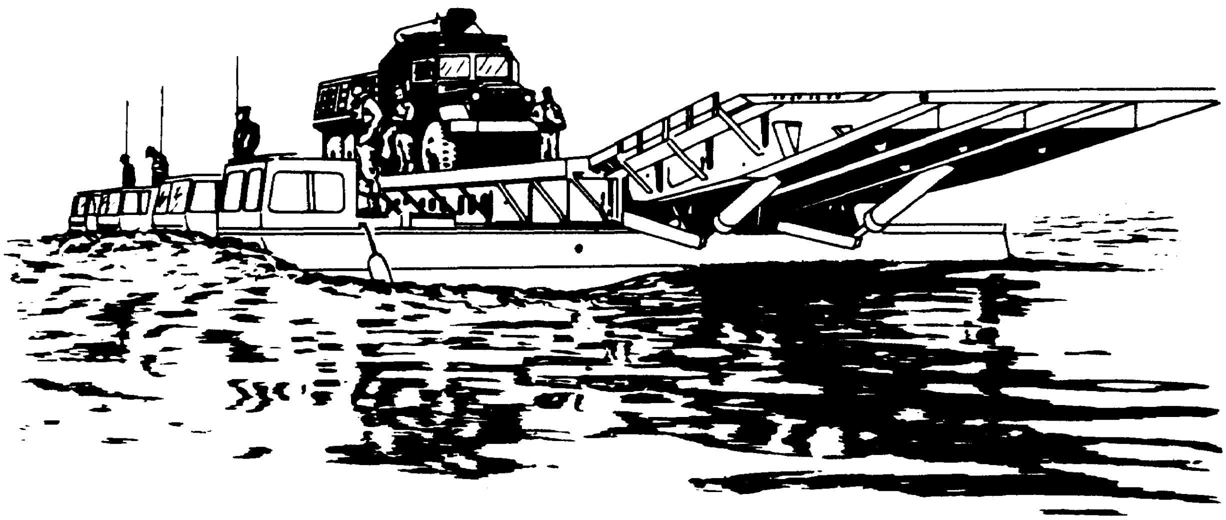
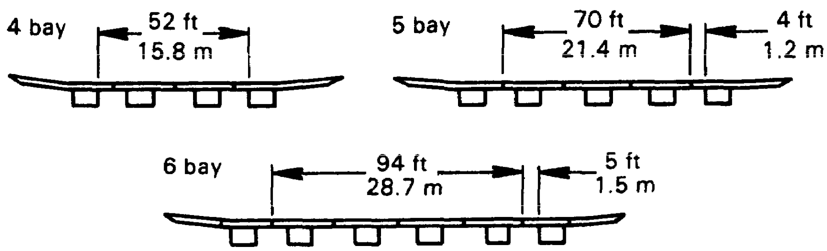


Figure B-16

CAPABILITIES	ASSY TIME	LOAD SPACE	CURRENT VELOCITY 0.9 / 3 N	1.5 / 5 N	2.0 / 7 N	2.5 / 8 N	2.8m/s / 9 f/s N
RAFT			LOAD CLASS				
a. 4 bays	10 min	15.8 m (52 ft)	54/ 62 (68*)	54/ 62 (68*)	52/ 58 (64*)	50/ 56 (62*)	48/ 54 (56*)
b. 5 bays	12 min	21.4 m (70 ft)	58/ 62 (78*)	58/ 62 (78*)	56/ 62 (74*)	56/ 62 (72*)	54/ 62 (64*)
c. 6 Bays	15 min	28.7 m (94 ft)	64/ 62 (108*)	64/ 62 (108*)	62/ 62 (108*)	60/ 62 (100*)	54/ 62 (90*)

Note:
Load capacities are maximum multiple vehicle loads. Heaviest vehicles are to be positioned first and at extremities of rafts.



BRIDGE

No of interior bays =	Average rate 200 m (600 ft) per hr	62	62	55	55	55

$\frac{\text{Gap (m)} - 20}{8}$

OR

$\frac{\text{Gap (ft)} - 66}{26}$

All assembly times are estimated using trained troops in daylight with good weather conditions.

1. Anchorage by prop/fluke anchor

2. Traffic rate up to 200 veh/hr at 16kph (10 mph) and 30m (100 ft) spacing.

Table B-4

MEDIUM GIRDER BRIDGE

The medium girder bridge (MGB) is a hand-erectable, heavy-duty bridge. The primary role of the MGB is for tactical bridging in the forward main battle area. As the situation permits, MGB would be removed and relocated forward to be replaced by other standard or nonstandard bridges. One MGB set contains enough equipment to construct 103 feet of double-story, class 60 bridge or three, 32-foot, single-story military load class 60 bridges. With the use of a link reinforcement kit and two bridge sets, a 163-foot-span bridge can be erected. It requires little, if any, site preparation. The key advantage of the MGB over other fixed bridges is its speed and ease of erection. During assembly, soldiers will be vulnerable to small arms fire, indirect artillery fire, direct weapons fire, and an NBC environment.

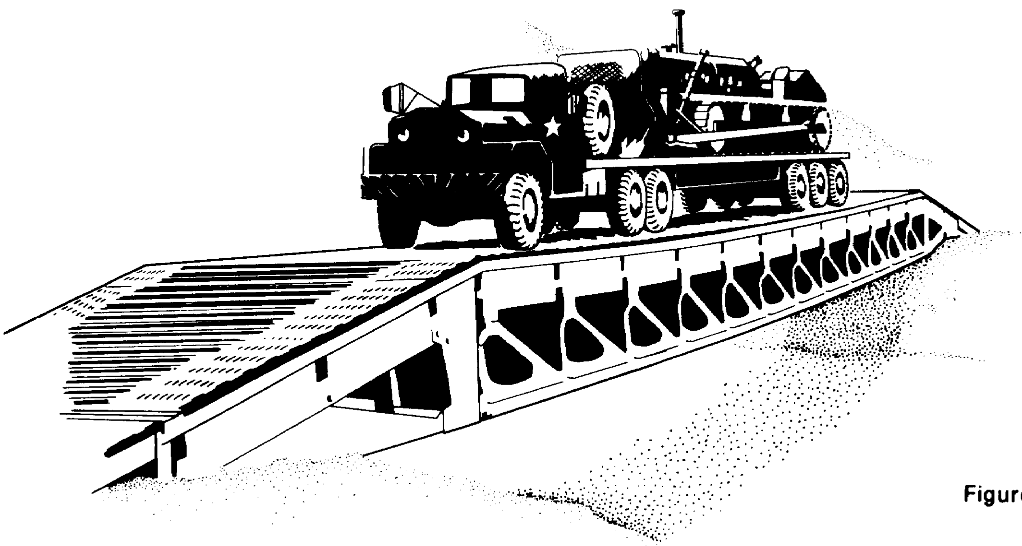


Figure B-17

CAPABILITIES	ASSEMBLY/CAPACITY			
	Length	Crew	Time	Class
1.83 m (6 ft) increments				
	Normal construction			
Numerous erection combinations	30.5 m	1 plt	2 hr	60
	with cable reinforcement			
Four 30.5 m (100 ft) bridges or Two 48.8 m (160 ft) bridges per MGB co or 129.4 m (32 ft) bridges	49.0 m	1 + plt	4 hr	60
	4 m (13.2 ft) roadway			

Notes:
1. 25 x 20 m assembly site required.
2. Only MGB co personnel required for assembly/disassembly.
3. All bridge components palletized.
4. DSMGB less than 12 bays (103 ft) will hold MLC 70.
5. Reinforced DSMGB less than 22 bays (163 ft) will hold MLC 70.

Table B-5

VEHICLE CLASSIFICATIONS

VEHICLE SYSTEMS

Table B-6 depicts the major vehicle systems that could be considered for mobility planning. Division 86 equipment is included.

NOMENCLATURE	HEIGHT (INCHES)	WIDTH (INCHES)	LENGTH (INCHES)	MLC: MILITARY LOAD CLASS	MAX SPEED (MPH)
Carrier, Cargo 6 ton, M548	116	110	248	16	43
Carrier, Command Post, M577A1	106	106	226.5	133	8
Carrier, Mortar; 81mm, M125A1	86.5	106	191.5	13	40
Carrier, Mortar; 107mm, M106A1	86.5	113	194	14	40
Carrier, Personnel, M113A2	86.5	106	191.5	13	40
Cavalry, Fighting Vehicle, M3	118	126	258	24	45
Howitzer 105mm (SP), M109A3	130	143	355	28	35
Howitzer 8 in (SP), M 110A1	135	140	392	32	32
Infantry Fighting Vehicle, M2	118	126	258	24	45
Improved Tow Vehicle, M2	132	106	180	13	42
Tank, Combat 105mm, M-1	118	145	332	60	45
Tank, Combat 105mm, M48A5	129.5	143	325	53	30
Tank, Combat 105mm, M60A1	129.5	143	325	52	30
Tank, Combat 105mm, M60A2	130.5	143	300.5	57	30
Tank, Combat 105mm, M60A3	130	143	325	52	30
Trailer, Water (400 gal), M149	76.5	82.5	83	-	-
Truck, Ambulance, ¼ ton, M713	77	71	143	3	65
Truck, Ambulance, 1½ ton, M792	91	84	227	5	55
Truck, Cargo 1¼ ton, M715	95	85	221	3	60
Truck, Cargo 2½ ton, M35A2	112	96	278.5	8	56
Truck, Cargo 5 ton 6x6, M54A2	116	97	315	10	54
Truck, Cargo 8 ton 4x4, M520	134	108	384	21	30
Truck, Fuel (2500 gal), M559	134	108	391	28	30
Truck, Utility ¼ ton, M151A2	71	64	133	3	65
Truck, Wrecker 5 ton 6x6, M816	114	98	356	18	52
Truck, Wrecker 10 ton 4x4, M553	134	108	401	25	30
Vehicle, Cmbt Engineer, M728	128	146	351	57	30
Vehicle, (light) Recovery, M578	130.5	124	250	25	37
Vehicle, (med) Recovery, M88A1	123.5	135	325.5	55	31
Vehicle, Cmbt Earth Mover, M9	90	150	246	30	30+

Table B-6

OBSTACLE-CROSSING CAPABILITIES

Obstacle Country/Vehicle	A Water Crossing (submerged) (M)	B Water Fording (M)	C Height To Clear (M)	D Width To Clear verse	E Max Gap Tra- (M)	F Ground Clear-ance	G Max Step (M)
US/M728 (CEV)	N/A	1.22	3.19	3.59	2.54	.41	.75
US/M113	N/A	Unlimited	2.13	2.68	1.6	.29	.64
US/M-2 & M-3	N/A	Unlimited	2.92	3.04	2.54	.45	.91
US/M60A1	4.11	1.22	3.26	3.63	2.66	.41	.91
US/M60A2	N/A	1.22	3.31	3.63	2.66	.46	.91
US/M48A5	2.43	1.22	3.12	3.63	2.59	.41	.91
US/MI	2.37	1.22	2.89	3.60	2.74	.48	1.24
FRG/LEOPARD2	4.00	2.25	2.93	3.71	3.00	.48	1.15
UK/Centurian	Unk	1.20	2.96	3.40	3.35	.51	.90
UK/Chieftian	4.57	1.07	2.90	3.66	3.15	.51	.91
FR/AMX30	4.00	2.00	2.86	3.10	2.90	.45	.93
US/M728 (CEV)	30	60	2.21	11.8	N/A		
US/M113	30	60	1.78	7.5	N/A		
US/M-2 & M-3	40	60	1.87	11.8	+30/-20 60/-10	(TOW) (25mm)	
US/M60A1	30	60	2.21	11.2	-9/+19		
US/M60A2	30	60	2.21	12.2	-10/+20		
US/M48A5	30	60	2.21	11.8	-9/+19		
US/MI	40	60	2.14	13.4	-10/+20		
FRG/LEOPARD2	30	60	2.15	12.2	-9/+20		
UK/Centurian	30	60	2.19	13.3	-10/+20		
UK/Chieftian	30	60	2.44	11.0	-10/+20		
FR/AMX	30	30	60	1.96	10.9	-8/+20	

Obstacle Country/Vehicle	H Max Tilt (%)	I Max Gradient (%)	J Max Strattle (M)	K Ground Pressure (PBI)	L Depression Elevation (degrees)	
US/M728 (CEV)	30	60	2.21	11.8	N/A	
US/M113	30	60	1.78	7.5	N/A	
US/M-2 & M-3	40	60	1.87	11.8	+30/-20	(TOW)
					+60/-10	(25mm)
US/M60A1	30	60	2.21	11.2	-9/+19	
US/M60A2	30	60	2.21	12.2	-10/+20	
US/M48A5	30	60	2.21	11.8	-9/+19	
US/MI	40	60	2.14	13.4	-10/+20	
FRG/LEOPARD2	30	60	2.15	12.2	-9/+20	
UK/Centurian	30	60	2.19	13.3	-10/+20	
UK/Chieftian	30	60	2.44	11.0	-10/+20	
FR/AMX30	30	60	1.96	10.9	-8/+20	

Table B-7

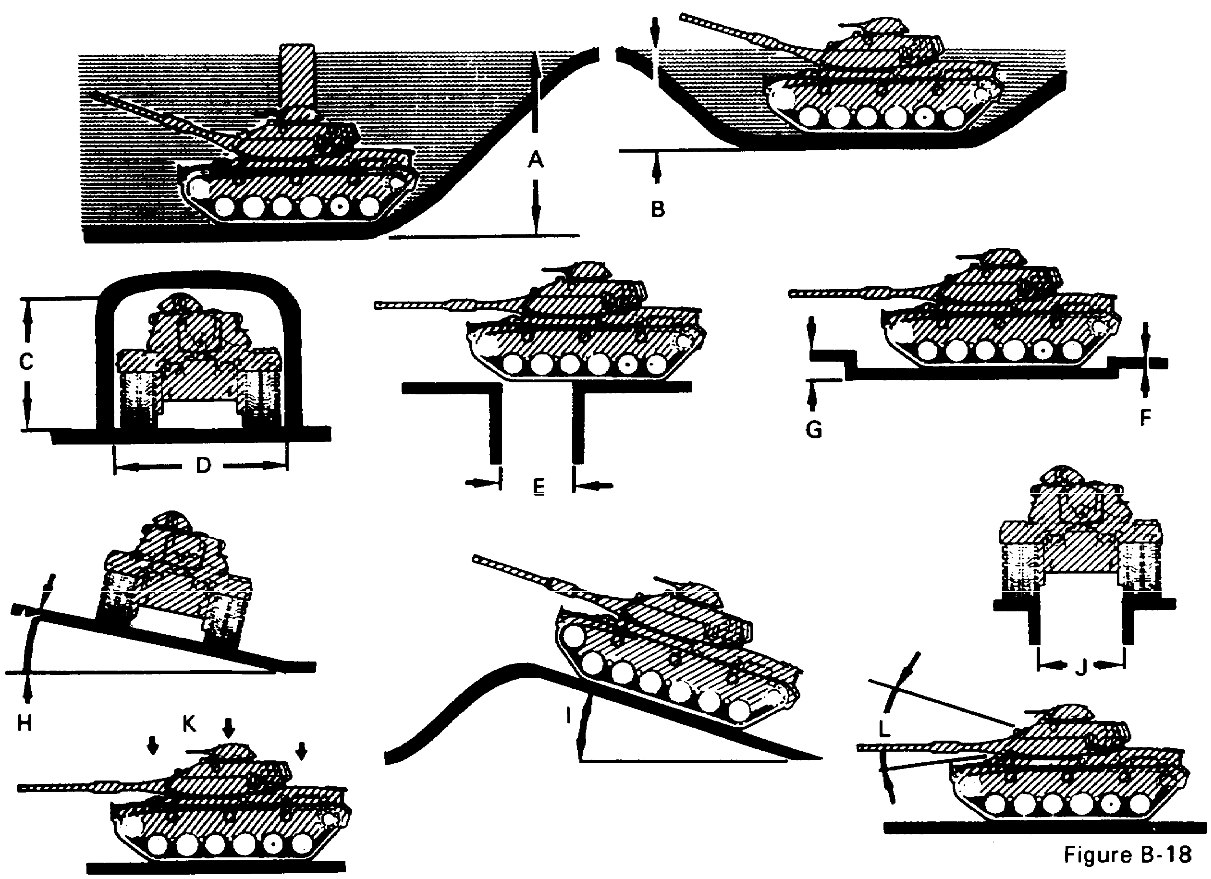


Figure B-18

ARMY AVIATION AND AIR FORCE EQUIPMENT CHARACTERISTICS

ARMY AVIATION

The Army aviation aircraft listed here could be expected to operate in the forward combat areas. The mobility requirements for such operations would include construction of combat landing zones and landing strips. Chapter 8 of this manual provides guidance on the planning and execution of such support. Design specifications are given in TM 5-330. Mobility support to specific types of Army aircraft, fixed wing and rotor, will depend on the tactical situation. Similarly, the location, distribution, and standards of construction will depend on the nature of aviation support and anticipated traffic.

ARMY HELICOPTERS

CHARACTERISTICS	OH-6A CAYEUSE	OH-58A KIOWA	UH-1H IROQUIS	AH-1G COBRA	UH-60 BLACK HAWK	CH-47C CHINOOK	CH-57B TAHRE
Length/fuselage	23.5 ft	32.2 ft	41.9 ft	44.5 ft	50.65 ft	51.0 ft	70.25 ft
Length-blades unfolded	30.3 ft	50.9 ft	57.1 ft	52.9 ft	64.10 ft	99.0 ft	88.4 ft
Width-blades folded	N/A	N/A	N/A	N/A	14.3 ft	12.5 ft	9.6 ft
Width thread	6.8 ft	6.3 ft	8.5 ft	7.3 ft	8.2 ft	10.5 ft	9.6 ft
Height-extreme	8.5 ft	9.5 ft	14.5 ft	11.6 ft	12.3 ft	18.6 ft	25.5 ft
Rescue-hoist capacity	N/A	N/A	600 lb	N/A	600 lb	600 lb	N/A
Winch capacity	N/A	N/A	N/A	N/A	8,000 lb	3,000 lb	25,000 lb
Troop capacity	2	2	11	0	14	33	(pod) 45
Litter capacity	0	2	6	0	6	24	(pod) 24
Maximum weight	2,400	3,000	9,500	9,500	20,250	46,000	47,000
Basic weight	1,163	1,700	4,900	8,404	11,000	19,772	21,000
Loiter time	2 hr 30 min	2 hr 10 min	1 hr 55 min	1 hr 50 min	2 hr 10 min	2 hr	1 hr 40 min

Table B-8

ARMY AIRCRAFT

CHARACTERISTICS	OV-1 MOHAWK	U-8F SEMINOLE	U-21A UTE	C-21A A20000
Length (ft)	41.0	33.3	35.8	43.8
Width (ft)	42.0	45.9	49.9	54.4
Height (ft)	13.0	14.2	14.2	15.4
Basic weight, kips	10.01	5.49	5.38	10.4
Takeoff (maximum weight, kips	14.82	7.2	9.5	12.6
Crew	2	1	2	2
Passenger capacity	0	5	6	10
Takeoff (hard surface sea-level ground run)	1440	1065	1500	1300
Takeoff (hard surface, zero wind, ft to clear 50-ft obstacle)	2330	1660	2000	1850

Table B-9

AIR FORCE EQUIPMENT

The aircraft and characteristics displayed in table B-10 would generally be used throughout the entire theater of operations. Forward aviation mobility support to specific types of aircraft will depend on the tactical situation. Similarly, the location, distribution, and standards of construction will depend on the Air Force mission and types of aircraft involved.

AIR FORCE AIRCRAFT

		DIMENSIONS			PERFORMANCE*	
AIRCRAFT DESIGNATION	NAME	WING SPAN (FT)	LENGTH (FT)	HEIGHT (FT)	TAKEOFF DISTANCE GROUND ROLL (FT)	LANDING DISTANCE GROUND ROLL (FT)
C-7	Caribou	95.6	72.6	31.8	725	825
C-47D	Sky Train	95.0	64.4	16.9	2,900	2,040
C-54G	Sky Master	117.5	93.5	27.8	2,780	1,918
C-123B	Provider	110.5	76.2	34.5	1,810	1,072
C-124A	Globemaster	174.1	130.0	48.6	5,520	3,200
C-124C	Globemaster	174.1	130.0	48.6	5,520	3,200
C-130A	Hercules	132.6	102.1	39.2	3,920	4,440
C-130E	Hercules	132.6	97.8	38.5	3,600	4,150
C-135A	Stratolifter	130.8	128.9	41.8	7,200	3,470
C-135B	Stratolifter	130.8	128.9	41.8	7,200	3,470
C-141B	Starlifter	160.0	168.3	39.25	4,100	3,900

*Ground run lengths indicated are for classification and can undergo changes depending on operating weight of aircraft, pressure, altitude correction, temperature correction, and local conditions.

Table B-10

APPENDIX C

Engineer Mobility Estimate

MISSION AND SITUATIONS

The mission is stated by the commander. References include maps, charts, or other documents.

Intelligence situation. This is based on information obtained from the intelligence officer and other sources. It is in the following three areas:

- Characteristics of the area of operations. This includes data on the weather and terrain information such as cross-country trafficability, infrastructure (routes and bridges), obstacles (existing and reinforcing), and choke points.
- Enemy strength and disposition. This includes data on the strength of enemy forces.
- Enemy capabilities. This includes data on enemy capabilities affecting the mission and affecting engineer activities.

Tactical situation. This is based on information obtained from the commander's planning guidance and from the operations order. It includes the—

- Present dispositions of major tactical elements.
- Possible courses of action to accomplish the mission. (These courses of action are carried throughout the remainder of the estimate.)
- Current operations.
- Projected operations.

Logistic situation. This is based on information obtained from the logistics officer. It includes the present disposition of logistic units supporting engineer operations, facilities (ammunition supply point, ammunition transfer point, and forward supply point), and engineer and obstacle materials (especially class five). It also includes projected developments within logistics likely to influence engineer operations.

Civil-military operations situation. This is based on information gathered from the civil-military officer and host nation support (HNS) engineer liaison personnel. It includes the present disposition of civil-military elements within engineer operations, as well as projected developments likely to influence engineer operations.

Engineer situation. This is based on information obtained from various engineer elements in the following four categories:

- Present disposition of personnel, equipment, and material. The commander should establish levels of effectiveness, identify problem areas (petroleum, oils, and lubricants; class five; personnel), and establish command and support relationships.
- Current engineer operations. The staff

engineer should list current employment for divisional units and nondivisional units, especially atomic demolition munitions and topographic.

- Projected engineer operations. The staff engineer should list projected employment for divisional and nondivisional units.

- Status of current engineer operations. The engineer should determine and list the present status of mobility-countermobility-survivability and general engineering tasks and the estimated time(s) to completion.

Assumptions. The engineer should list any assumptions required for initiating, planning, or preparing the estimate. Assumptions are modified to factual data once planning guidance is available.

ANALYSIS

The engineer should analyze all factors for each course of action and indicate problems and deficiencies. Resource requirements for each course of action should be identified and their impact on current and projected operations determined.

Sufficiency of area. The engineer should determine if the plan of maneuver minimizes engineer support requirements, thereby affording greater agility.

Sufficiency of resources. The available engineer personnel, equipment and material, and time should be considered, as well as the effectiveness of engineer units in current operations. The engineer should list deficiencies.

Impact on current operations. The engineer should determine how this mission will affect current operations.

Impact on projected operations. The engineer should determine how this mission will affect projected operations.

COMPARISON

The engineer should evaluate the situation and list the advantages and disadvantages with respect to accomplishing the mission. Advantages and disadvantages of each course of action should be discussed so that the cost (in terms of units, time, materials, and effect on current and projected operations) is known to the commander. Include methods of overcoming deficiencies or modifications required in each course of action.

CONCLUSION

In reaching a conclusion, the engineer should indicate whether the mission can be supported and which course(s) of action can best be supported, as well as list major deficiencies from the engineer perspective that must be brought to the commander's attention. These should include specific recommendations concerning methods for eliminating or reducing the effect of the deficiencies.

APPENDIX D

Bridge Classification Card*

GTA 5-7-7

MAY 1969

(THIS GTA, TOGETHER WITH GTA 5-7-6, OCT. 1968, SUPERSEDES GTA 5-7-5, JULY 1965)

BRIDGE CLASSIFICATION CARD

Bridges and vehicles are classified to prevent bridge failures due to overloading. If a vehicle class number is less than or equal to the bridge class number, the vehicle may cross without restrictions. Standard vehicles are assigned class numbers in FM 5-36. Refer to TM 5-312, *Military Fixed Bridges,* for a complete discussion of bridge classification procedures. The purpose of this card is to provide an expedient method of estimating the capacity of bridges in the field.

NOTATIONS

A—Area (in^2)
b—width of stringer (in)
d—total depth of stringer (in)
kip—1000 lbs
L—span length (ft)
L_e—effective span length (ft)
L_m—maximum span length (ft)
M_{DL}—dead load bending moment for entire span (kip-ft)
M_{LL}—live load bending moment per lane (kip-ft)
m—total bending moment per stringer (kip-ft)
m_{DL}—dead load bending moment per stringer (kip-ft)
m_{LL}—live load bending moment per stringer (kip-ft)
N_S—number of stringers
$N_{1,2}$—effective number of stringers
S_b—maximum spacing of bracing (ft)
S_S—center-to-center spacing for given stringer (ft)
V_{DL}—dead load shear for entire span (kips)
V_{LL}—live load shear per lane (kips)
v—total live load shear per stringer (kips)
v_{LL}—live load shear per stringer (kips)
v_{DL}—dead load shear per stringer (kips)
W_R—width of roadway from inside curb to inside curb (ft)
W_S—width of concrete slab (ft)

A. BRIDGE SIGNS

Class number signs are required on all classified vehicles and bridges in the theater of operations. Bridge signs are circular with a yellow background and black inscriptions. Signs are a minimum of 16 inches in diameter for one-lane bridges and a minimum of 20 inches in diameter for two-lane bridges. A two-lane bridge has two numbers on the bridge sign. The number on the left is the class of the bridge if two-lanes are used simultaneously. The number on the right (fig 1) indicates the class if the bridge is used for one-way traffic and the vehicles proceed along the centerline of the bridge. For a bridge with separate classifications for wheeled and tracked vehicles (dual classification), a special circular sign which indicates both classifications is used (fig. 2). Dual classification may be used for bridges greater than class 30. A separate rectangular sign is used if necessary to show bridge width limitations.

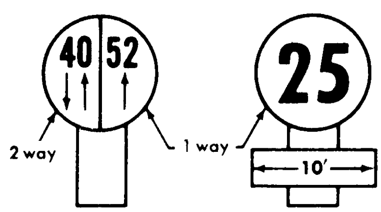


FIGURE 1

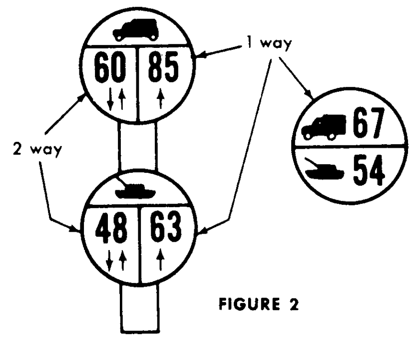


FIGURE 2

B. WIDTH AND HEIGHT REQUIREMENTS

Width and height requirements for bridges are listed in Table I. If a one-lane bridge does not meet the width requirement listed, post a rectangular warning sign under the class sign showing the actual clear width. For a two-lane bridge, downgrade the two way classification to the highest class for which it does qualify. The one-way class is not affected. If a bridge does not meet the minimum overhead clearance requirement, a telltale is used (fig. 3).

TABLE I

WIDTH REQUIREMENTS				
Bridge Class	4-12	13-30	31-60	61-100
One-Lane	9'-0"	11'-0"	13'-2"	14'-9"
Two-Lane	18'-0"	18'-0"	24'-0"	27'-0"

MINIMUM OVERHEAD CLEARANCE		
CLASS	4-70	71-Over
HEIGHT	14'-0"	15'-6"

C. HIGHWAY BRIDGE CLASSIFICATION, TIMBER STRINGERS

Classify the weakest span to obtain the bridge classification. If the weakest span is unknown use the following procedure for each span.

(1)

*A sample GTA 5-7-7, Bridge Classification Card, has been reproduced here, in its entirety, for your convenience.

1. Measure width and depth of stringers (measure diameter of stringer if circular), span length, and width of roadway. Count total number of stringers in the span. If overhead obstruction exists determine the amount of overhead clearance to the roadway.
2. Obtain total bending moment per stringer (m) from table II. Use the formula in figure 4 to obtain (m) for a concrete T-beam.
3. Read dead load per foot of bridge (W_{DL}) from figure 5, then divide by the total number of stringers to obtain w_{DL}.
4. Knowing w_{DL} and the span length determine the moment per stringer (m_{DL}) due to the dead load, from figure 7.
5. Calculate the total moment per stringer (m_{LL}) due to live load: $m_{LL} = m - m_{DL}$

NOTE: Check maximum span length (L_m) of stringer. If L_m obtained from table II is greater than span length (L) proceed to step 6. If the maximum span length (L_m) of the stringer is less than span length (L) reduce m_{LL} by the ratio L_m/L and proceed to step 6.

6. Compute stringer spacing (S_S).

$$S_S = \frac{W_R}{N_S - 1}$$

Read the effective number of stringers (N_1) for one-way traffic from figure 6. Compute effective number of stringers for two-way traffic (N_2).

$$N_2 = \frac{3}{8}N_S$$

where N_S equals the total number of stringers in the span. Compare N_1 and N_2. If N_2 is greater than N_1 the one- and two-way class will be the same and the value of N_1 is used to determine the class. If N_2 is less than N_1, N_2 will be used to determine the two-way class and N_1 will be used to determine the one-way class.

7. Determine the live load moment per lane (M_{LL}) by entering figure 8 with the value of m_{LL} obtained from step 5 and either N_1 or N_2 as obtained in step 6.
8. Determine the classification of the bridge based on bending moment by entering figure 10 (moment graph) with M_{LL} as obtained from step 7 and the span length as measured.
9. Obtain total shear per stringer (v) from table II. (See figure 4 for concrete T-beam section.)
10. Knowing w_{DL} from step 3 and the span length, determine dead load shear per stringer (v_{DL}) from figure 7.
11. Knowing the total shear per stringer (v) from step 9 and the dead load shear per stringer (v_{DL}) from step 10, calculate the live load shear per stringer (v_{LL}) from: $v_{LL} = v - v_{DL}$
12. Determine the live load shear per lane (V_{LL}) by entering figure 9 with v_{LL} and either N_1 or N_2 as determined in step 6.
13. Determine the bridge classification based on shear by entering the shear graph (fig. 11) with the value for V_{LL} obtained in step 12 and the measured span length.
14. Compare the classifications obtained in step 8 for bending moment and in step 13 for shear. The lower of the two classifications obtained will govern.
15. Check the width and clearance restrictions (table I) and downgrade the two-way class or post a width restriction sign for one-way class.
16. Check chart (fig. 12) based on deck thickness and stringer spacing. Downgrade the classification if the deck thickness controls.
17. Check lateral bracing. Lateral braces are required as indicated in table II. If necessary add bracing as required before posting bridge classification.

EXAMPLE 1

Given: Two lane timber stringer bridge having no overhead obstructions. Span 20 feet; 10 stringers, each 10" x 18" actual dimensions; roadway width (W_R) 24 feet; timber decking 5 inches thick; no lateral braces.

1. Make field measurements to determine above information.
2. m = 108.0 kip-ft.
3. $w_{DL} = \frac{1.12 \text{ kips}}{10} = 0.112$ kips per foot of span.
4. $m_{DL} = 6.0$ kip-ft.
5. $m_{LL} = 108.0 - 6.0 = 102$ kip-ft.
   L_M for 10 × 18 = 21.5 ft. > 20 ft. ∴ OK.
6. Stringer spacing $(S_S) = \frac{W_R}{N_S - 1} \quad \frac{24}{10 - 1} = 2.67$ ft.

   $N_1 = 2.9$; $N_2 = \frac{3}{8}(10) = 3.75$

   N_2 is greater than N_1, therefore one- and two-way class will be the same. Use N_1 to determine both one- and two-way class.
7. $M_{LL} = 290$ kip-ft.
8. Class based on moment from figure 10 is:
   Wheel – 60
   Track – 40
9. v = 18 kips (from table II).
10. $v_{DL} = 1.1$ kips (from fig. 7).
11. $v_{LL} = 18.0 - 1.1 = 16.9$ kips.
12. $V_{LL} = 63$ kips from fig. 9.

(2)

13. Class based on shear from fig. 11 is:
    Wheel – 60
    Track – 48
14. Comparing classifications obtained from moment and shear (steps 8 and 13) one- and two-way Classification is:
    Wheel – 60
    Track – 40
15. There are no width or height (clearance) restrictions.
16. Deck thickness is 5 inches with stringer spacing of 32 inches yields class 40 from fig. 12, so deck thickness controls and classification is:
    Wheel – 40
    Track – 40
17. No lateral bracing is required.

D. HIGHWAY BRIDGE CLASSIFICATION WITH STEEL STRINGERS

Classify the weakest span to obtain bridge classification. If weakest span is unknown use the following procedure for each span.

1. Measure stringer dimensions to obtain information required by tables III and measure span length and width of roadway. Count total number of stringers in one span. If overhead obstruction is present, measure the overhead clearance.
2. Same as step C-2 for timber bridges except use table III.
3. Same as step C-3 for timber bridges.
4. Same as step C-4 for timber bridges.
5. Calculate the total live load moment per stringer (m_{LL}) knowing m from step 2 and m_{DL} from step 4.

$$m_{LL} = \frac{m - m_{DL}}{1.15}$$

NOTE: Check L_M as in step 5 for timber stringers.

6. Same as step C-6 for timber bridges.
7. Same as step C-7 for timber bridges.
8. Same as step C-8 for timber bridges.
9. Same as step C-9 for timber bridges except use table III.
10. Same as step C-10 for timber bridges.
11. Same as step C-11 for timber bridges.
12. Determine live load shear per lane, (V_{LL}): $V_{LL} = \frac{2 v_{LL}}{1.15}$
13. Same as C-13 for timber bridges.
14. Same as C-14 for timber bridges.
15. Same as C-15 for timber bridges.
16. Same as C-16 for timber bridges.
17. Same as C-17 for timber bridges except use $N_{L} = \frac{L}{S_{L}} + 1$ to calculate number of lateral braces. S_L is the maximum bracing spacing for a given steel stringer and is found in table III.

EXAMPLE 2

Given: 10-10WF25 stringers, 5-inch timber deck span length is 20 ft., W_R = 24 feet. There are no overhead obstructions and no lateral braces.

1. The given data shown is usually obtained by field measurements.
2. m = 59 kip-ft for 10WF25 beam from table III.
3. W_{DL} = 1.05 kip-ft. from fig. 5 for 20 ft. span.

$$w_{DL} = \frac{W_{DL}}{N_S} = \frac{1.05}{10} = 0.105 \text{ kip/ft.}$$

4. m_{DL} = 5.3 kip-ft from fig. 7.
5. $m_{LL} = \frac{m - m_{DL}}{1.15} = \frac{59 - 5.3}{1.15} = 46.7$ kip-ft.
   L_M = 25 (from table III) > 20 ∴ OK
6. $S_S = \frac{W_R}{N_S - 1} = \frac{24}{10 - 1} = 2.67$ ft.
   N_1 = 2.9 ft. from fig. 6.
   $N_2 = \frac{3}{8} N_S = \frac{3}{8} \times 10 = 3.75$
   Since N_2 is larger than N_1 one- and two-way class will be the same. Use N_1 to obtain both one- and two-way class.
7. M_{LL} = 140 kip-ft.
8. Class based on moment from fig. 10 is:
   Class 18 for both wheel and track vehicles.
9. v = 38 kips from table III for 10WF25 beam.
10. v_{DL} = 1.1 kips.
11. $v_{LL} = v - v_{DL} = 38 - 1.1 = 36.9$ kips.
12. $V_{LL} = \frac{2 v_{LL}}{1.15} = \frac{(2)(36.9)}{1.15} = 64.2$ kips.

③

13. Class based on shear from fig. 11 is: Wheel – 58 Track – 46
14. Class 18 obtained from bending moment (step 8) will govern.
15. No width or clearance restrictions.
16. Deck thickness of 5 inches with stringer spacing of 32 inches yields class 40 from fig. 12.
17. Class of bridge must be based on class of the weakest span. Therefore, the moment class of the steel stringer span governs and the bridge classification is: 18.
18. Number of braces, $N_L = \frac{L}{S_L} + 1 = \frac{20}{8} + 1 = 3.5$ ∴ 4 braces must be added.

E. REINFORCED CONCRETE BRIDGE

Due to wide variations in design criteria, it is not possible to calculate the exact capacity of a reinforced concrete bridge based only on the measureable external dimensions. Therefore, when information is available pertaining to the design loading or civil load rating for the bridge (from a local agency or from intelligence reports), the class will be obtained by correlation if charts are available relating civilian design load to the military class for various span lengths. Such charts are available in TM 5-312 for many United States and foreign civilian design loads, or they may be developed within certain army areas. When the necessary information is not available for classification by correlation, the expedient methods shown below may be used.

SLAB BRIDGES: Measure the span length from center-to-center of supports in feet, the roadway width (W_R) in feet, the slab width (W_S) in feet, and the depth (D) of the concrete slab, (fig. 13) exclusive of any wearing surface or fill, in inches. Enter fig. 14 with the span length, drawing a vertical line until it intersects the curve representing the depth (D) of the slab, estimating when necessary where this point should be. From this intersection draw a horizontal line to read the value of m_{LL} on the left hand axis. Depending on one or two way classification, use one or both of the following formulas to determine the effective roadway width:

One-way $W_1 = \dfrac{L}{\frac{3}{4} + \frac{L}{W_S}}$ Two-way $W_2 = \dfrac{L}{\frac{1}{4} + \frac{2L}{W_S}}$

Find M for one-way or two-way traffic using W_1 or W_2 respectively:

$$M_{1,2} = W_{1,2}\, m_{LL}$$

Enter fig. 10 with this value of $M_{1,2}$ and the span length to obtain the class of the bridge. Check width and height restrictions for the class bridge obtained.

EXAMPLE 3

Given: Two-lane concrete slab bridge; span length = 20′; D = 14″; roadway width (W_R) = 28′; slab width (W_S) = 31′. To find Bridge Class:—Enter fig. 14 with span length on the horizontal scale and move vertically until it intersects curve for D = 14″ and read across to 20 kip-ft. on the vertical scale.

(1) One-way class: $W_1 = \dfrac{L}{\frac{3}{4} + \frac{L}{W_S}} = \dfrac{20}{\frac{3}{4} + \frac{20}{31}} = 14.3'$

(2) Two-way class: $W_2 = \dfrac{L}{\frac{1}{4} + \frac{2L}{W_S}} = \dfrac{20}{\frac{1}{4} + \frac{40}{31}} = 13.0'$

(3) M_1 = 20 (14.3) = 286 kip-ft. yields class 60 wheel, 40 track from moment graph (fig. 10).

(4) M_2 = 20 (13.0′) = 260 kip-ft. yields class 52 wheel, 34 track.

(5) Bridge Class is:

	One-way	Two-way
a. wheel	60	52
b. track	40	34

T-BEAM BRIDGES: Make the necessary measurements as shown in fig. 15, and find L, the span length from center-to-center of supports. All dimensions are in inches except L and W, which are in feet. Calculate "M" by the formula:

$$M = N\,[(158 + D\,(1.07T + 0.34L + 0.027S + 0.77b - 24.1)] + 0.08L^2$$

Enter the graph on fig. 10 with this value of "M" and the span length to obtain the class of the bridge.

EXAMPLE 4.

Given: Two-lane concrete T-Beam bridge; 32′ span length; 7 T-Beams, S = 48″, D = 30″, b 12″, T = 6″; 24′ roadway.

To find Bridge Class: Roadway width limits two-way classes 4 to 60. Number of stringers per lane = 3.5

$M = 3.5\,[158 + 30(1.07\,(6) + 0.34\,(32) + 0.027\,(48) + 0.77\,(12) - 24.1)] + 0.08\,(32)^2$

$M = 3.5\,[158 + 30(6.42 + 10.88 + 1.30 + 9.24 - 24.1)] + 82$

$M = 3.5\,[158 + 30(3.74)] + 82 = 3.5(158 + 112.2) + 82 = 1028$

With this value of "M" and the span length, obtain the class from the moment graph (fig. 10).

Two-way Class: Bridge is class 60 wheeled as limited by roadway width and class 50 tracked.

One-way Class:

Effective No. of Str. $= \dfrac{15}{\text{roadway width in feet}} \times$ No. of Str.

$= \dfrac{15}{24} \times 7 = 4.375$

$M = 4.375\,[158 + 112.2] + 82 = 1264$

Bridge is class 95 wheeled and class 63 tracked.

④

TABLE II
PROPERTIES OF TIMBER STRINGERS

Actual size (bxd) (in)	(a) Moment capacity m (kip-ft)	(b) Shear capacity v (kips)	(c) Maximum span Length (L_m) (ft)	Actual size (bxd) (in)	(a) Moment capacity m (kip-ft)	(b) Shear capacity v (kips)	(c) Maximum span Length (L_m) (ft)
4x8	8.53	3.2	9.5	12x20	160.0	24.0	23.8
*4x10	13.33	4.0	11.9	12x22	193.6	26.4	26.2
*4x12	19.20	4.8	14.3	12x24	230	28.8	28.6
6x8	12.80	4.8	79.5	14x14	91.5	19.6	16.7
6x10	20.0	6.0	11.9	14x16	119.5	22.4	19.1
6x12	28.8	7.2	14.3	14x18	151.2	25.2	21.5
*6x14	39.2	8.4	16.7	14x20	186.7	28.0	23.8
*6x16	51.2	9.6	19.1	14x22	226	30.8	26.2
*6x18	64.8	10.8	21.5	14x24	269	33.6	28.6
8x8	17.07	6.4	79.5	16x16	136.5	25.6	19.1
8x10	26.7	8.0	11.9	16x18	172.8	28.8	21.5
8x12	38.4	9.6	14.3	16x20	213	32.0	23.8
8x14	52.3	11.2	16.7	16x22	258	35.2	26.2
8x16	68.3	12.8	19.1	16x24	307	38.4	28.6
*8x18	86.4	14.4	21.5	18x18	194.4	32.4	21.5
*8x20	106.7	16.4	23.8	18x20	240	36.0	23.8
*8x22	129.1	17.6	26.2	18x22	290	39.6	26.2
*8x24	153.6	19.2	28.6	18x24	346	43.2	28.6
10x10	33.3	10.0	11.9	8φ	10.05	5.7	9.5
10x12	48.0	12.0	14.3	9φ	14.31	7.2	10.7
10x14	65.3	14.0	16.7	10φ	19.63	8.8	11.9
10x16	85.3	16.0	19.1	11φ	26.1	10.6	13.1
10x18	108.0	18.0	21.5	12φ	33.9	12.7	14.3
10x20	133.3	20.0	23.8	13φ	43.1	15.0	15.5
*10x22	161.3	22.0	26.2	14φ	53.9	17.4	16.7
*10x24	192.0	24.0	28.6	16φ	80.4	22.6	19.1
12x12	57.6	14.4	14.3	18φ	114.5	28.6	21.5
12x24	78.4	16.8	16.7	20φ	157.1	35.4	23.8
12x16	102.4	19.2	19.1	22φ	209	42.7	26.2
12x18	129.6	21.6	21.5	24φ	271	50.8	28.6

Key to symbols:

φ Diameter

* Lateral bracing required at mid-point and ends of span.

(a) For rectangular stringer not listed, $m = \frac{bd^2}{30}$

For a round stringer not listed, $m = .02d^2$

(b) For rectangular stringer not listed, $v = \frac{bd}{10}$

For a round stringer not listed, $v = .09d^2$

(c) For stringer not listed, $L_m = 1.19d$

TABLE III
PROPERTIES OF STEEL STRINGERS

Nominal size	Actual depth (d) (in)	Actual width (b) (in)	Flange thick-ness (t_f) (in)	Web thick-ness (t_w) (in)	Moment capacity m (kip-ft)	Shear capacity v (kips)	Max Span Length (L_m) (ft)	Max Bracing Spacing (S_b) (ft)
51BU278	51-1/4	14	1-5/8	3/4	3067	594	133	15
*39WF211	39-1/4	11-3/4	1-7/16	3/4	1770	450	100	15
*37WF206	37-1/4	11-3/4	1-7/16	3/4	1656	425	95	15
36WF300	36-3/4	16-5/8	1-11/16	15/16	2486	520	94	25.5
36WF194	36-1/2	12-1/8	1-1/4	13/16	1492	431	93	14
36WF182	36-3/8	12-1/8	1-3/16	3/4	1397	406	93	13
36WF170	36-1/8	12	1-1/8	1-1/16	1302	381	92	12
36WF160	36	12	1	11/16	1217	365	92	11.5
36WF230	35-7/8	16-1/2	1-1/4	3/4	1879	421	91	19.5
36WF150	35-7/8	12	15/16	5/8	1131	350	91	10.5
*36WF201	35-3/8	11-3/4	1-7/16	3/4	1545	402	90	16
*33WF196	33-3/8	11-3/4	1-7/16	3/4	1433	377	85	17
33WF220	33-1/4	15-3/4	1-1/4	13/16	1661	392	85	20

⑤

TABLE III
PROPERTIES OF STEEL STRINGERS (Cont'd)

Nominal size	Actual depth (d) (in)	Actual width (b) (in)	Flange thick-ness (t_f) (in)	Web thick-ness (t_w) (in)	Moment capacity m (kip-ft)	Shear capacity v (kips)	Max Span Length (L_m) (ft)	Max Bracing Spacing (S_b) (ft)
33WF141	33-1/4	11-1/2	15/16	5/8	1005	313	85	11
33WF130	33-1/8	11-1/2	7/8	9/16	911	300	85	10
33WF200	33	15-3/4	1-1/8	3/4	1506	362	84	18.5
*31WF180	31-1/2	11-3/4	1-5/16	11/16	1327	327	80	16.5
30WF124	30-1/8	10-1/2	15/16	5/8	797	273	77	11
30WF116	30	10-1/2	7/8	9/16	738	263	76	10
30WF108	29-7/8	10-1/2	3/4	9/16	672	255	76	9
*30WF175	29-1/2	11-3/4	1-5/16	11/16	1156	304	75	17.5
*27WF171	27-1/2	11-3/4	1-5/16	11/16	1059	282	70	18.5
27WF102	27-1/8	10	13/16	1/2	599	217	69	10
27WF94	26-7/8	10	3/4	1/2	546	205	68	9
*26WF157	25-1/2	11-3/4	1-1/4	5/8	915	237	65	19
24WF94	24-1/4	9	7/8	1/2	497	191	62	11
24WF84	24-1/8	9	3/4	1/2	442	174	61	9.5
24WF100	24	12	3/4	1/2	560	173	61	13
24I120	24	8	1-1/8	1-3/16	564	286	61	12.5
24I106	24	7-7/8	1-1/8	5/8	527	224	61	12
24I80	24	7	7/8	1/2	391	183	61	8.5
24WF76	23-7/8	9	11/16	7/16	394	163	61	8.5
*24WF153	23-5/8	11-3/4	1-1/4	5/8	828	217	60	20.5
*24I134	23-5/8	8-1/2	1-1/4	13/16	634	283	60	15
*22I75	22	7	13/16	1/2	308	168	56	8.5
*21WF139	21-5/8	11-3/4	1-3/16	5/8	699	198	55	24.5
*21I112	21-5/8	7-7/8	1-3/16	3/4	495	238	55	14.5
21WF73	21-1/4	8-1/4	3/4	1/2	338	148	54	9.5
21WF68	21-1/8	8-1/4	11/16	7/16	315	140	54	9
21WF62	21	8-1/4	5/8	3/8	284	130	53	8
20I85	20	7-1/8	15/16	11/16	337	195	51	11
*20I65	20	6-1/2	13/16	7/16	245	132	51	9
*20WF134	19-5/8	11-3/4	1-3/16	5/8	621	177	50	23.5
18WF60	18-1/4	7-1/2	11/16	7/16	243	115	46	9.5
*18I88	18-1/4	7	1	11/16	326	184	46	13
18WF55	18-1/8	7-1/2	5/8	3/8	220	108	46	8.5
*18I80	18	8	15/16	1/2	292	133	46	14
18WF50	18	7-1/2	9/16	3/8	200	99	46	8
18I55	18	6	11/16	1/2	199	126	46	7.5
*18WF122	17-3/4	11-3/4	1-1/16	9/16	648	145	45	23.5
*18I62	17-3/4	6-7/8	3/4	3/8	238	100	45	9.5
*18I77	17-3/4	6-5/8	15/16	5/8	281	163	45	11.5
16WF112	16-3/4	11-3/4	1	9/16	450	136	42	23.5
*16I70	16-3/4	6-1/2	15/16	5/8	238	146	42	12
16WF50	16-1/4	7-1/8	5/8	3/8	181	94	41	9
16WF45	16-1/8	7	9/16	3/8	163	85	41	8
16WF64	16	8-1/2	11/16	7/16	234	106	40	12.5
16WF40	16	7	1/2	5/16	145	75	40	7.5
*16I50	16	6	11/16	7/16	155	105	40	8.5
16WF36	15-7/8	7	7/16	5/16	127	74	40	6.5
*16WF110	15-3/4	11-3/4	1	9/16	345	127	40	25
*16I62	15-3/4	6-1/8	7/8	9/16	200	129	40	11.5
*16I45	15-3/4	5-5/8	5/8	7/16	150	104	40	7.5
*15WF103	15	11-3/4	15/16	9/16	369	121	38	24.5
15I56	15	5-7/8	13/16	1/2	173	110	38	10.5
15I43	15	5-1/2	5/8	7/16	132	93	38	7.5
*14WP101	14-1/4	11-3/4	15/16	9/16	344	114	36	26
*14I40	14-1/4	5-3/8	3/8	3/8	119	83	36	8
14I51	14-1/8	5-5/8	3/4	1/2	150	104	36	10
14I70	14	8	15/16	7/16	204	87	35	18
*14I57	14	6	7/8	1/2	153	101	35	12.5
*14I40	14	5-1/2	5/8	3/8	121	78	35	8
14WF34	14	6-3/4	7/16	5/16	109	61	35	7.5
14WF30	13-7/8	6-3/4	3/8	1/4	94	58	35	6

(6)

TABLE III
PROPERTIES OF STEEL STRINGERS (Cont'd)

Nominal size	Actual depth (d) (in)	Actual width (b) (in)	Flange thick-ness (t_f) (in)	Web thick-ness (t_w) (in)	Moment capacity m (kip-ft)	Shear capacity v (kips)	Max Span Length (L) (ft)	Max Bracing Spacing (S) (ft)
*14WF92	13-3/8	11-3/4	7/8	1/2	297	96	34	25.5
*14146	13-3/8	5-3/8	11/16	1/2	126	99	34	9
*13135	13	5	5/8	3/8	85	72	33	8
*13141	12-5/8	5-1/8	11/16	9/16	108	104	32	9.5
12WF36	12-1/4	6-5/8	9/16	5/16	103	56	31	9.5
*12165	12	8	15/16	7/16	182	73	30	21
12WF27	12	6-1/2	3/8	1/4	76	44	30	7
12150	12	5-1/2	11/16	11/16	113	120	30	10
12132	12	5	9/16	3/8	81	62	30	7.5
*12134	11-1/4	4-3/4	5/8	7/16	81	72	28	8.5
*11WF76	11	11	13/16	1/2	202	77	28	27
*10129	10-5/8	4-3/4	9/16	5/16	67	48	27	8.5
10WF25	10-1/8	5-3/4	7/16	1/4	59	38	25	8
*10140	10	6	11/16	3/8	92	53	25	14
10135	10	5	1/2	5/8	65	88	25	8
10125	10	4-5/8	1/2	5/16	55	46	25	7.5
10WF21	9-7/8	5-3/4	5/16	1/4	48	36	25	6.5
*10WF59	9-1/4	9-1/2	11/16	7/16	132	56	23	23
*9125	9-1/2	4-1/2	1/2	5/16	51	43	24	8
*9150	9	7	13/16	3/8	103	45	23	21
*8135	8	6	5/8	5/16	65	34	20	15.5
*8128	8	5	9/16	5/16	49	35	20	11.5
8WF31	8	8	7/16	5/16	61	33	20	14.5
*8WF44	7-7/8	7-7/8	5/8	3/8	81	40	20	21
*7WF35	7-1/8	7-1/8	9/16	3/8	58	37	18	18.5
*6WF31	6-1/4	6-1/4	9/16	3/8	45	31	16	18.5

* These nominal sizes have no U.S. equivalent.

(a) For a stringer not listed $m = d_1 (bt_f + \frac{d_1 t_w}{6}) (2.25)$.

(b) For a stringer not listed, $v = 16.5 (d_1 \times t_w)$.

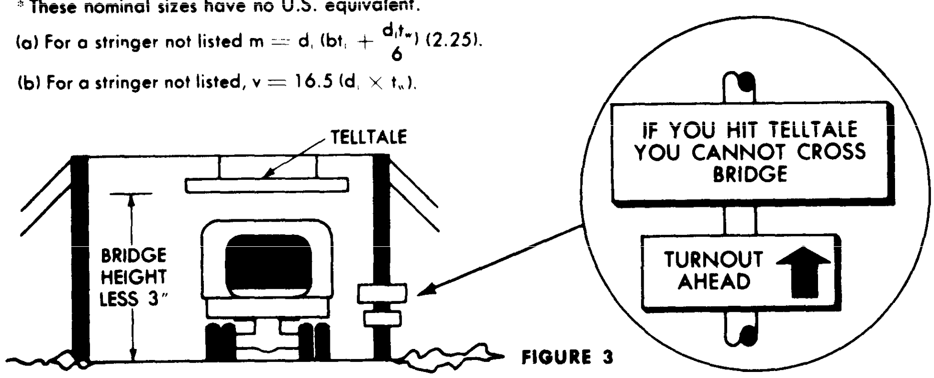
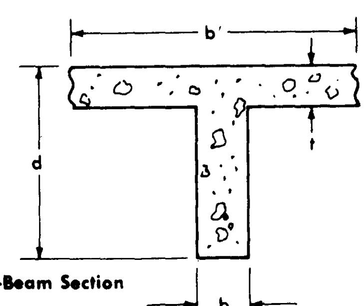


FIGURE 3



Concrete T-Beam Section

FIGURE 4

$m = 0.585\ b'\ td$

b' in inches
t in inches
d in feet
m in kip ft

NOTE: Shear is not critical in Concrete T-Beams

⑦

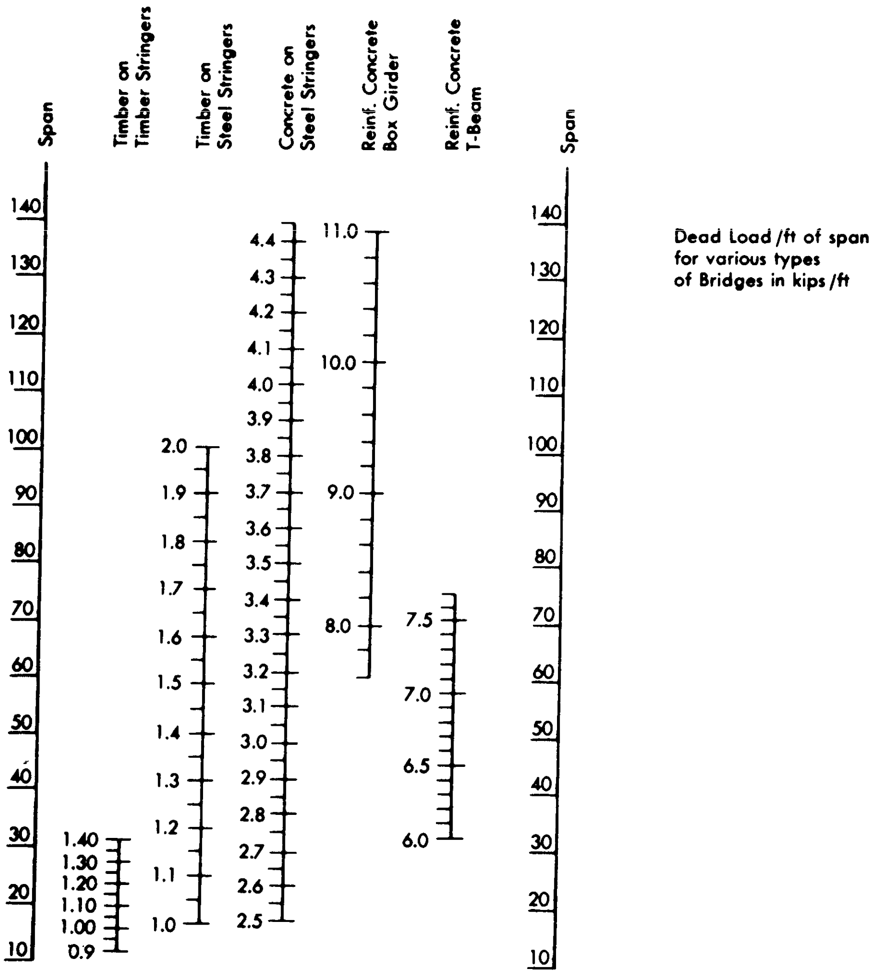


FIGURE 5

Notes:
1. Span is center to center of supports in feet.
2. All dead load weights are in kips /ft of bridge.
3. Weights are for a 24' roadway. If roadway width is different multiply by, $\frac{x}{24'}$, where x is actual roadway width.

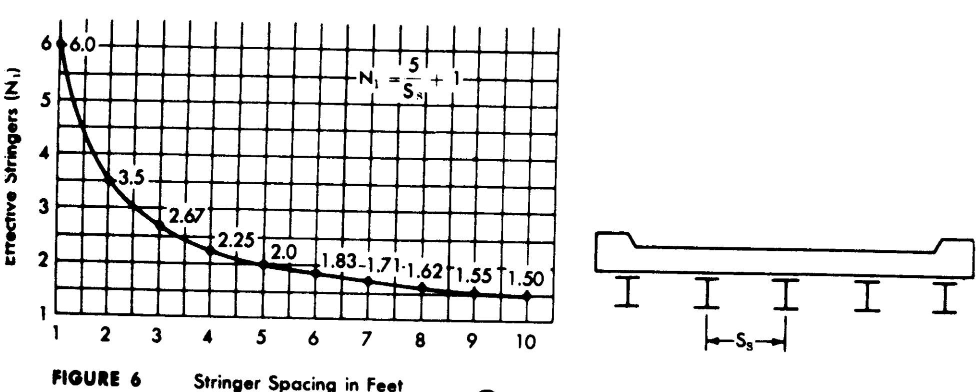
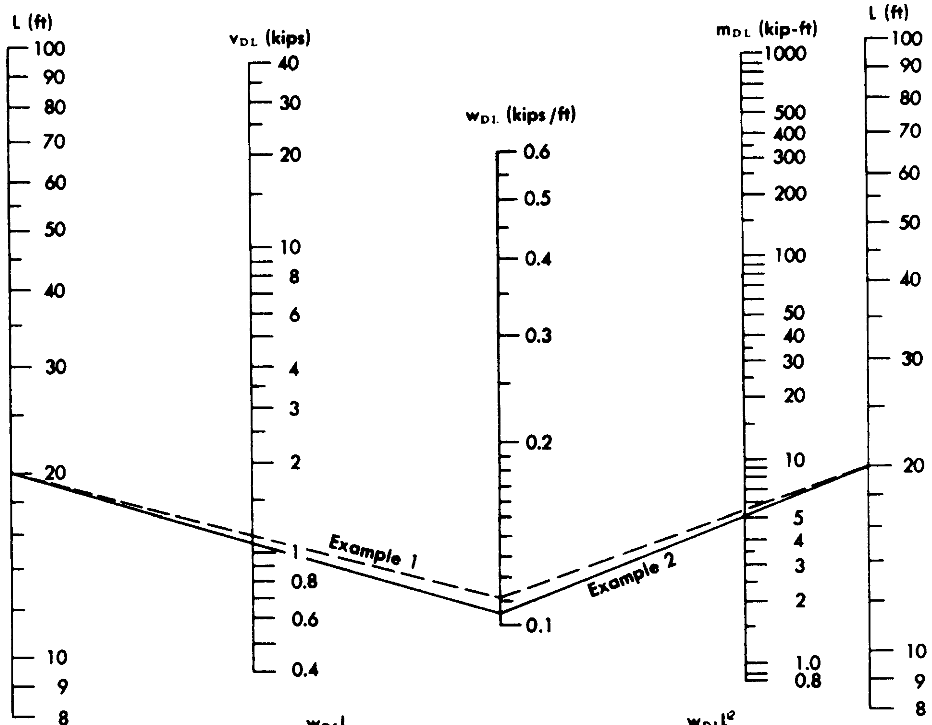


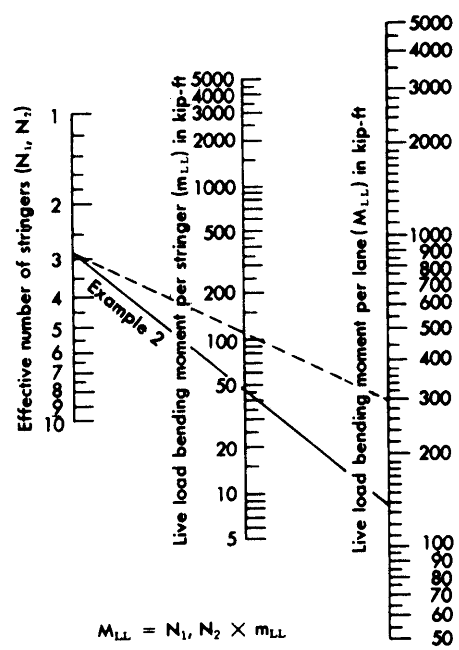
FIGURE 6 Stringer Spacing in Feet

⑧



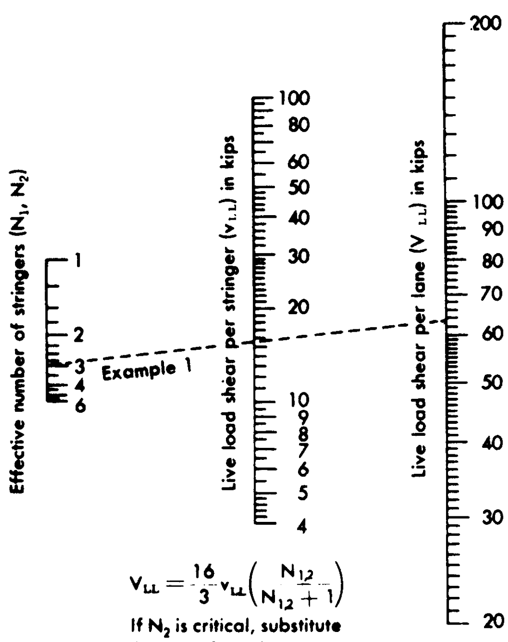
$v_{DL} = \frac{w_{DL}L}{2}$ $m_{DL} = \frac{w_{DL}L^2}{8}$

FIGURE 7



$M_{LL} = N_1, N_2 \times m_{LL}$

FIGURE 8



$V_{LL} = \frac{16}{3} v_{LL} \left(\frac{N_{1,2}}{N_{1,2} + 1} \right)$

If N_2 is critical, substitute for N_1 in formula

FIGURE 9

(9)

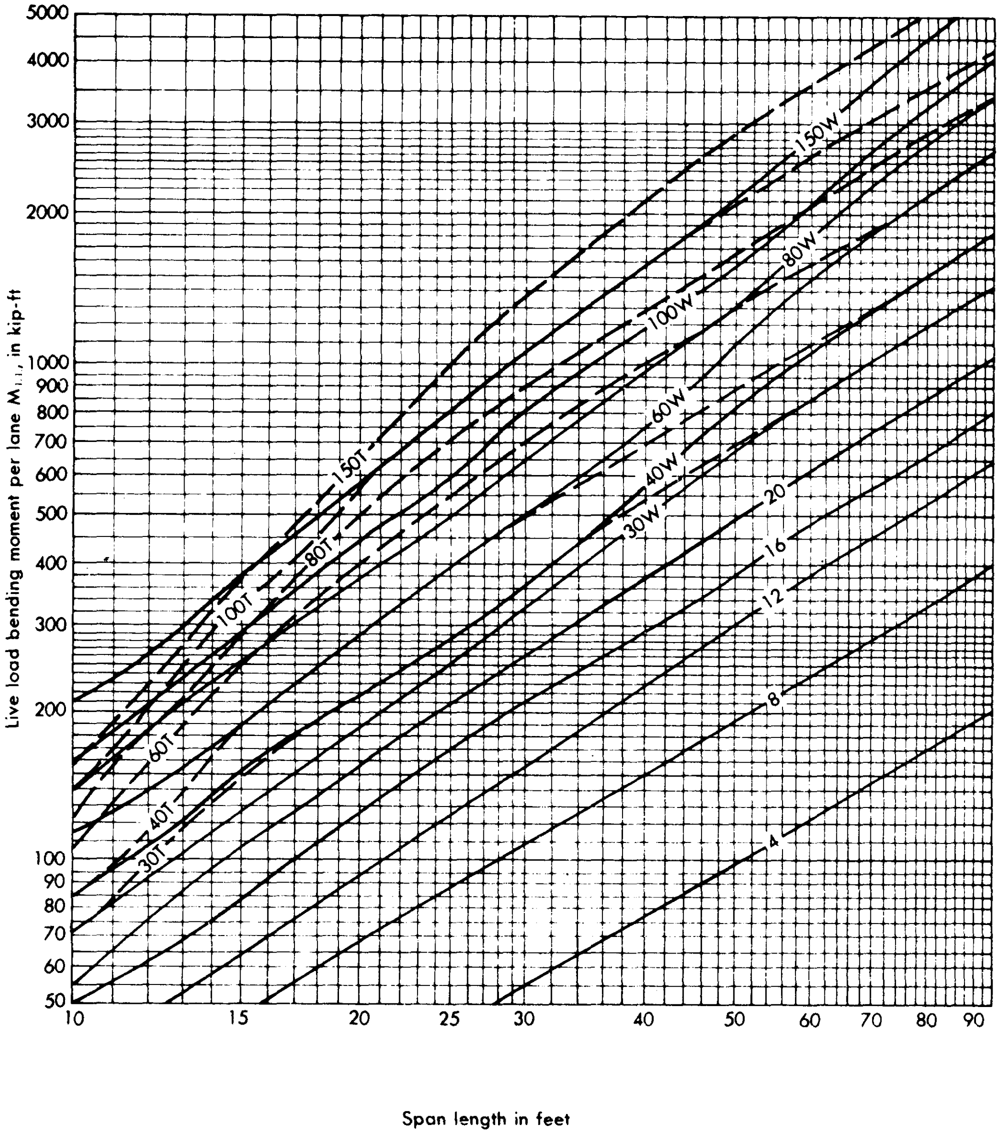


FIGURE 10. MOMENT GRAPH

⑩

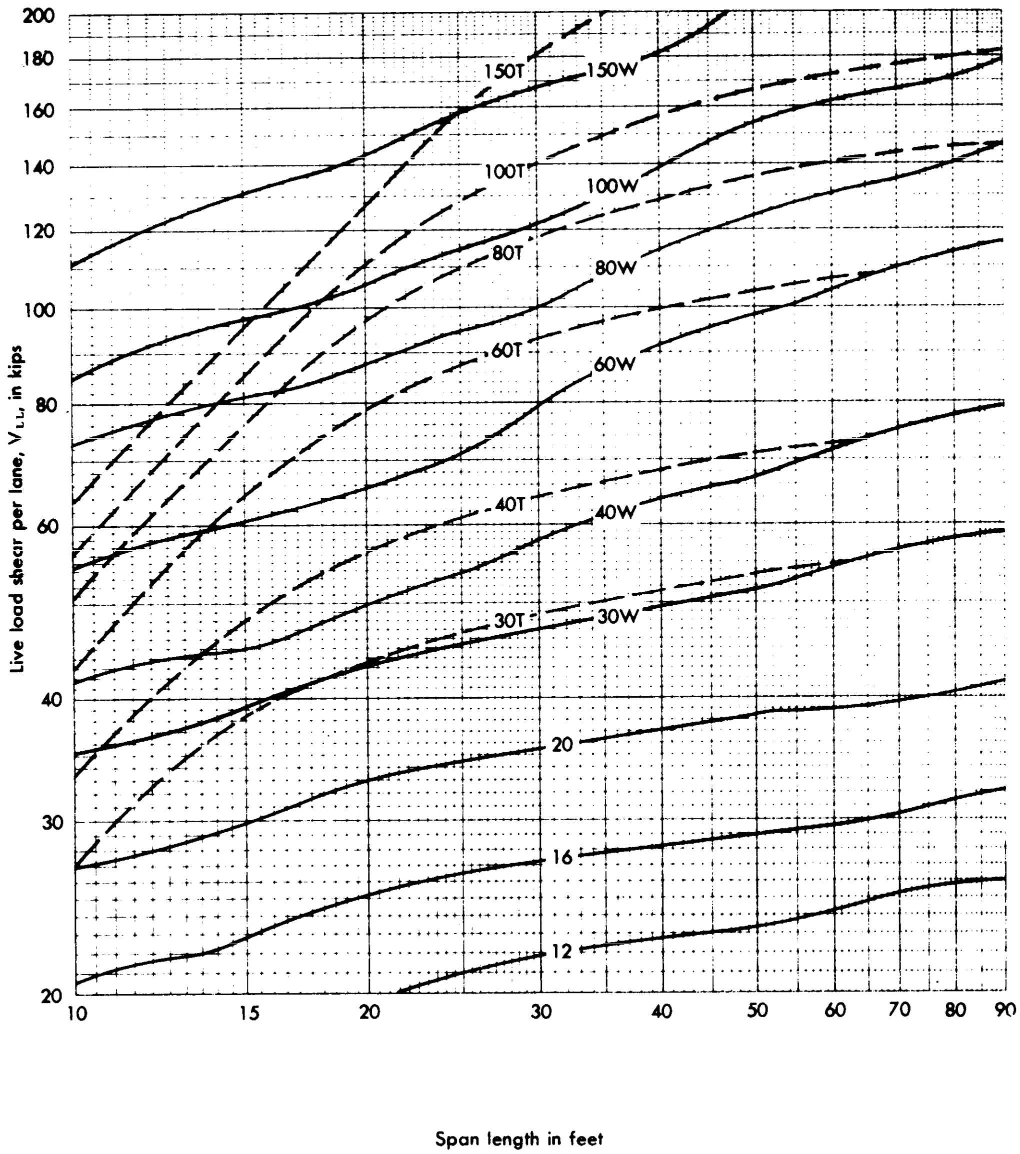
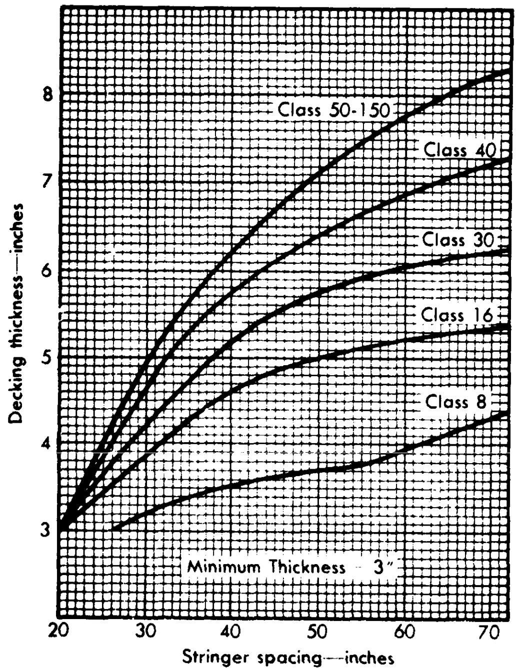


FIGURE 11. SHEAR GRAPH

(11)



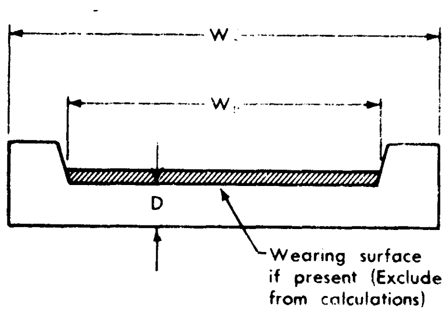


FIGURE 13. CONCRETE SLAB BRIDGE

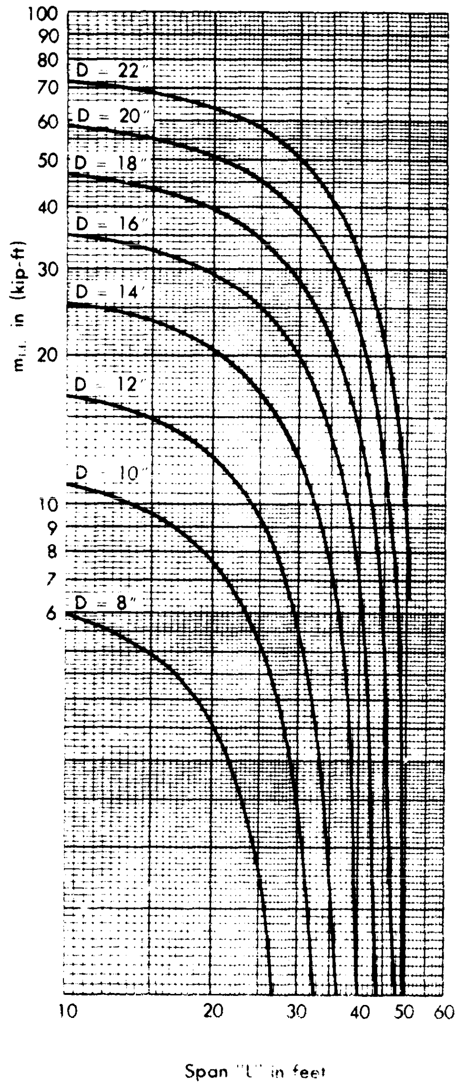


FIGURE 14. LIVE LOAD MOMENT FOR A 12" INCH STRIP OF REINFORCED CONCRETE.

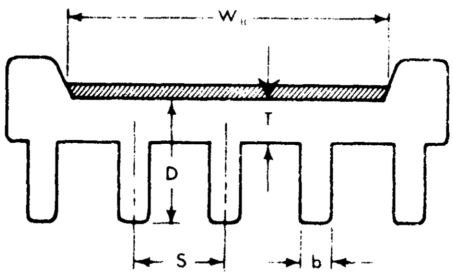


FIGURE 15. CONCRETE T-BEAM BRIDGE

(12)

F. MASONRY ARCH BRIDGE CLASSIFICATION

To obtain the bridge classification number for a masonry arch bridge, a provisional class number based on the crown thickness and span length is determined, this provisional class number is then adjusted by applying factors based on the materials and the condition of the bridge.

PROVISIONAL CLASS NUMBER

1. Mark span length (S in fig. 16) on Col. A of chart 1.
2. Mark total crown thickness (t - D in fig. 16) on Col. B of chart 1.
3. Draw a straight line through the points marked in steps 1 and 2 and where this line intersects Col. C, read the provisional class number.

PROFILE FACTOR

4. Divide span length (S in fig. 16) by the rise (R in fig. 16) and mark the result at the bottom of chart 2. If the result is 4 or less, profile factor is 1. Otherwise .....
5. Draw a vertical line from the mark made in step 4 and mark the point where it intersects the curved line.
6. Draw a horizontal line from the mark made in step 5 to the left edge of chart 2 and read the profile factor at this point.

OTHER FACTORS (See table IV)

7. Select the material, joint, deformation, crack, abutment size, and abutment fault factors from the table. Use only those factors which apply.

ACTUAL CLASS NUMBER

8. Multiply the provisional class number by each of the various factors found above. The result is the bridge classification number.

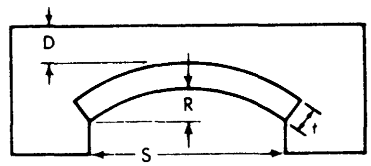


FIGURE 16 MASONRY ARCH BRIDGE

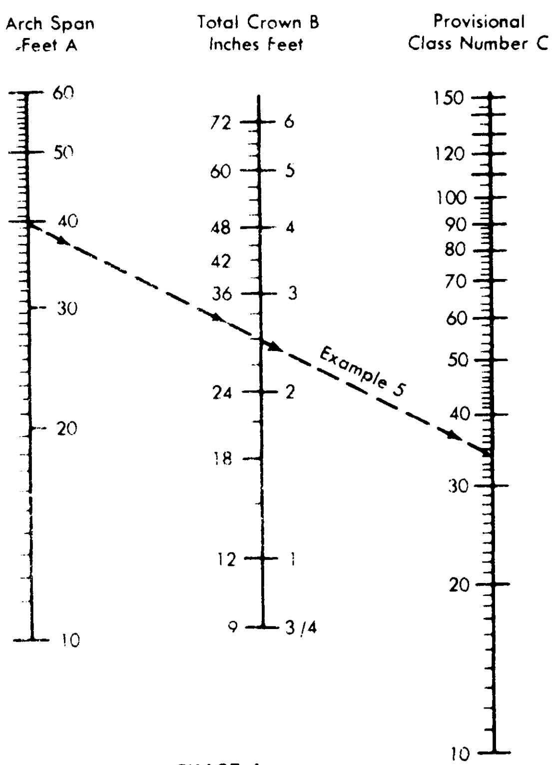
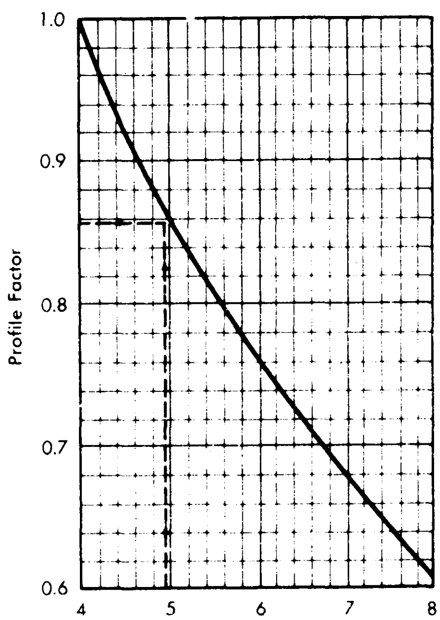


CHART 1

CHART FOR DETERMINING PROVISIONAL LOAD CLASS OF ARCH BRIDGES



SPAN/RISE RATIO

CHART 2

PROFILE FACTORS FOR ARCH BRIDGES

⑬

EXAMPLE 5

GIVEN: Masonry arch bridge; span (S) 40 ft; rise (R) 8 ft, arch ring thickness (t) 18 in; depth of fill at crown (D) 12 in; roadway width 15 ft; material-limestone in good condition; joints—mortar, some deterioration, small voids, close joints; cracks—large longitudinal crack in arch under one parapet wall; abutments—one approach up a narrow embankment.

Find Bridge Class—Solution: Roadway width limits bridge to one lane. Total crown thickness (t + D, see fig.16) = 18 in + 12 in = 2.5 ft. Using chart 1 line up straight edge at span of 40 ft (Col. A) and total crown thickness of 2.5 ft (Col. B). At the intersection of straight edge and Col. C, read provisional class number, 34.

Determine the profile factor. Span / rise ratio = S/R = 40/8 = 5. Enter the bottom of chart 2 with the span-rise ratio and draw a vertical line. At the intersection of this vertical line and the curved line on the chart, pivot (going horizontally) to the left edge of the chart. Read the profile factor as 0.86.

Material factor for limestone in good condition is 1.0. Joint factor is between 0.80 and 0.70, say 0.75. Crack factor for one crack at the edge of the ring is 0.90. Abutment factor for one unsatisfactory abutment is 0.95.

Determine actual class number by multiplying provisional class number by factors found above.

Actual Class Number = 34 × 0.86 × 1.0 × 0.75 × 0.90 × 0.95 = Class 19.

TABLE IV Arch Factors

MATERIAL FACTOR

1.	Granite, whitestone and built-in-course masonry	1.5
2.	Concrete or blue engineering bricks	1.2
3.	Good limestone masonry and building bricks	1.0
4.	Poor masonry or brickwood (of any kind)	0.7 to 0.5

JOINT FACTORS

1.	Thin joints, 1/10″ or less in width	1.25
2.	Normal joints, with width up to 1/4″	1.00
3.	Ditto, but with mortar unpainted	0.90
4.	Joint over 1/4″ wide, irregular good mortar	0.80
5.	Ditto, but with mortar containing voids deeper than one-tenth of the ring thickness	0.70
6.	Joints 1/2″ or more wide, poor mortar	0.50

DEFORMATION FACTORS

1.	The rise over the affected portion is always positive.	— Apply span-rise ratio of affected portion to the whole arch.
2.	Flat section of profile.	— Maximum: 12
3.	A portion of the ring is sagging.	— Maximum class: 5; if fill at crown exceeds 18″

CRACK FACTORS

1.	Small transverse cracks within 2 ft. of the edge	1.0
2.	Large transverse cracks within 2 ft. of the edge	1.0
3.	Longitudinal cracks in center third of bridge	0.9 to 0.7
	One small crack	1.0
	One large crack or several narrow cracks	0.5
4.	Small lateral and diagonal cracks	1.0
5.	Large lateral and diagonal cracks—Maximum Class: 12; or the figure derived by using the other factors.	
6.	Cracks between the arch ring and parapet wall due to lateral spread of the fill	0.9
7.	Cracks between the ring and spandrel, due to a dropped ring—Reclassify from the nomograph, on the assumption that the crown thickness is that of the ring alone.	

ABUTMENT SIZE FACTORS

1.	Both abutments satisfactory	1.00
2.	One unsatisfactory abutment	0.95
3.	Both abutments unsatisfactory	0.90
4.	Both abutments massive, clay fill suspected	0.70
5.	Arch supported on one abutment and one pier	0.90
6.	Arch supported on two piers	0.80

ABUTMENT FAULT FACTORS

1.	Inward movement of one abutment	0.75 to 0.50
2.	Outward spread of abutments	1.00 to 0.50
3.	Vertical settlement of one abutment	0.90 to 0.50

GENERAL NOTES

1. Bridge classification using this card is based on the class of the superstructure only, since this is considered to be the controlling feature in bridge classification. The theoretical substructure design for the given superstructure can be determined using the Bridge Design Card (GTA 5-7-6) and then compared with the substructure in place as a basis of determining whether or not the bridge classification should be lowered.

2. The condition of both Superstructure and Substructure components should be examined closely for damage or deterioration and the probable effect on the bridge classification.

Distribution: *Active Army:*

ACSI (2); DCSPER (2); DCSLOG (2); DCSOPS (2); CORC (2); CRD (1); COA (1); CINFO (1); TIG (1); CofEngrs (10); TJAGSA (1); USCONARC (5); CNGB (2); ARADCOM (2); ARADCOM Rgn (1); USACDC (2); Armies (5); Corps (3); Div (2); Div Arty (1); Inf Div (5); Armor Div (5); Engr Div (5); Inf Bde (5); Armor Bde (5); Engr Bde (5); Inf Regt (5); Armor Regt (5); Engr Regt (5); Inf Gp/BG (5); Armor Gp/BG (5); Engr Gp/BG (5); Engr Bn (5); Inf Bn (5); Armor Bn (5); Inf Co/Btry (5); Armor Co/Btry (5); Engr Co (5) except TOE 5-77G (25), TOE 5-78G (25), TOE 5-148G (25); Log Comd (1); Bde (2); OS Maj Comd (15); Instl (10); Engr Cen (20); Engr Dep (25); Gen Dep (20); Army Dep (5); PMS Sr Div Units (1); Svc Colleges (5); Br Svc Sch (5); AMS (5); USATC (2); MDW (1).

NG: State AG (3); Units - Same as Active Army except allowance is one (1) copy for each unit.

USAR: Same as Active Army except allowance is one (1) copy for each unit.

For explanation of abbreviations used, see AR 320-50.

(14)

APPENDIX E

Sample Road Reconnaissance Report

ROAD RECONNAISSANCE REPORT
For use of this form, see FM 5-36, proponent agency is TRADOC.

DATE: 1 June '84

TO: (Headquarters ordering reconnaissance)	FROM: (Name, grade and unit of officer or NCO making reconnaissance)
Commanding Officer, ATTN: S2; 21st ENGR BN (21st INF DIV)	Wm. Behring (signature) Wm. Behring 1/LT CO A 21st ENGR BN

1. MAPS	a. COUNTRY	b. SCALE	c. SHEET NUMBER OF MAPS	2. DATE/TIME GROUP (Of signature)
	Quantico	1:5Ø,ØØØ	5561-III	Ø1 18ØØ JUN 64

SECTION I - GENERAL ROAD INFORMATION

3. ROAD GRID REFERENCE FROM	TO	4. ROAD MARKING (Civilian or Military number of road)	5. LENGTH OF ROAD (Miles or kilometers, specify)
UT 122864	UT Ø97899	Virginia 617	16.Ø Km

6. WIDTH OF ROADWAY (Feet or meters, specify)	8. WEATHER DURING RECONNAISSANCE (Include last rainfall, if known)
6.7 - 9.3 meters	CLEAR - TEMP. 84° Last rainfall - approx 28 May '84

7. RECONNAISSANCE DATE	TIME
1 Jun 64	1ØØØ HRS

SECTION II - DETAILED ROAD INFORMATION *(When circumstances permit more detailed information will be shown in an overlay or on the mileage chart on the reverse side of this form. Standard symbols will be used.)*

	9. ALINEMENT (Check one ONLY)		10. DRAINAGE (Check one ONLY)
	(1) FLAT GRADIENTS AND EASY CURVES		(1) ADEQUATE DITCHES, CROWN/CAMBER WITH ADEQUATE CULVERTS IN GOOD CONDITION
	(2) STEEP GRADIENTS (Excess of 7 in 100)	✓	(2) INADEQUATE DITCHES, CROWN/CAMBER OR CULVERTS. ITS CULVERTS OR DITCHES ARE BLOCKED OR OTHERWISE IN POOR CONDITION
	(3) SHARP CURVES (Radius less than 100 ft (30m))		
✓	(4) STEEP GRADIENTS AND SHARP CURVES		

	11. FOUNDATION (Check one ONLY)		
✓	(1) STABILIZED COMPACT MATERIAL OF GOOD QUALITY		(2) UNSTABLE, LOOSE OR EASILY DISPLACED MATERIAL

12. SURFACE DESCRIPTION *(Complete items 12a and b)*

	a. THE SURFACE IS (Check one ONLY)		
	(1) FREE OF POTHOLES, BUMPS, OR RUTS LIKELY TO REDUCE CONVOY SPEED	✓	(2) BUMPY, RUTTED OR POTHOLED TO AN EXTENT LIKELY TO REDUCE CONVOY SPEED

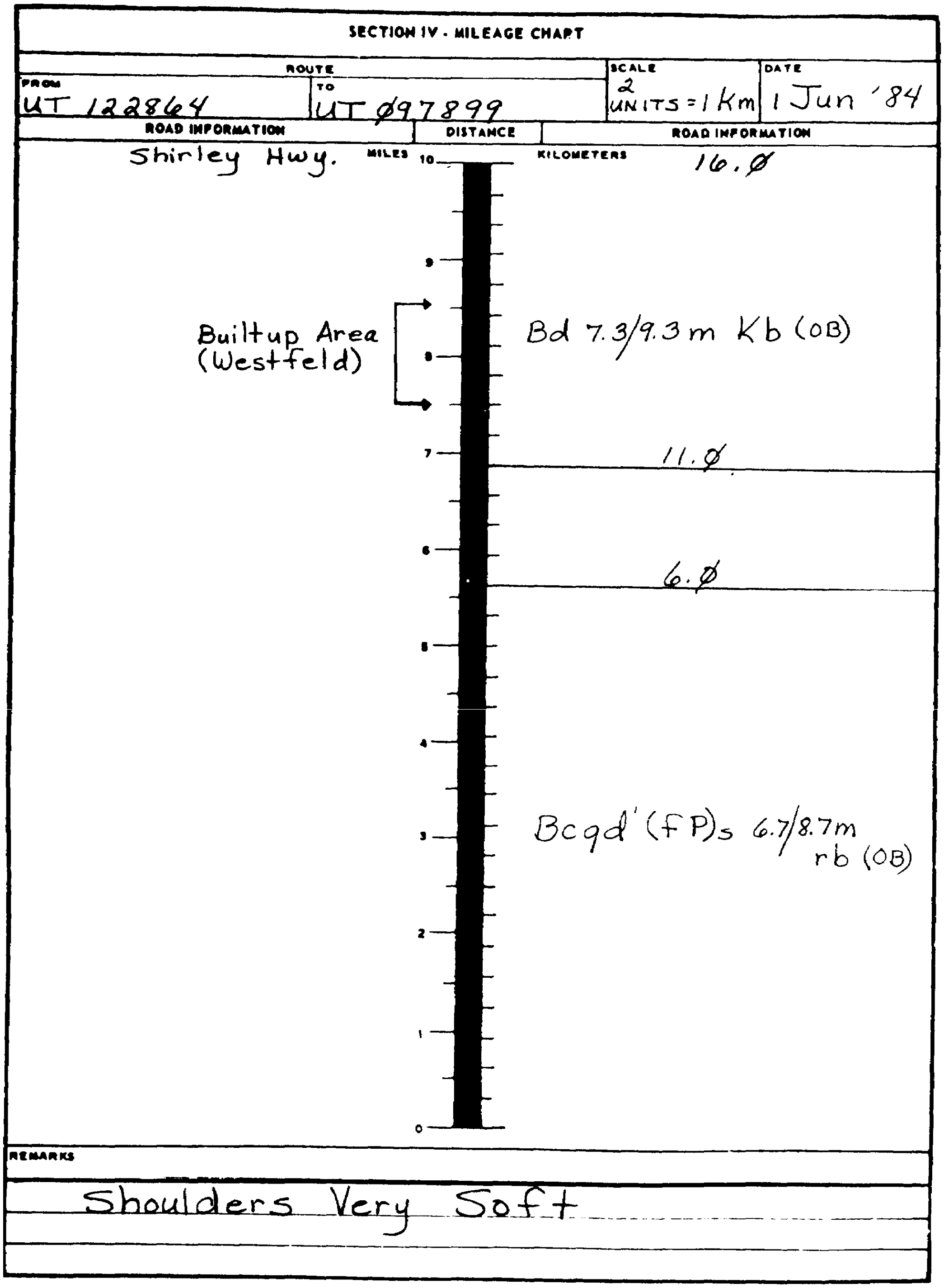
	b. TYPE OF SURFACE (Check one ONLY)		
	(1) CONCRETE		(6) WATERBOUND MACADAM
✓	(2) BITUMINOUS (Specify type where known): check chart		(7) GRAVEL
			(8) LIGHTLY METALLED
			(9) NATURAL OR STABILIZED SOIL, SAND CLAY, SHELL, CINDERS, DISINTEGRATED GRANITE, OR OTHER SELECTED MATERIAL
	(3) BRICK (Pave)		(10) OTHER (Describe):
	(4) STONE (Pave)		
	(5) CRUSHED ROCK OR CORAL		

SECTION III - OBSTRUCTIONS *(List in the columns below particulars of the following obstructions which affect the traffic capacity of a road. If information of any factor cannot be ascertained, insert "NOT KNOWN")*

(a) Overhead obstructions, less than 14 feet or 4.25 meters, such as tunnels, bridges, overhead wires and overhanging buildings.
(b) Reductions in road widths which limit the traffic capacity, such as craters, narrow bridges, archways, and buildings.
(c) Excessive gradients (Above 7 in 100)
(d) Curves less than 100 feet (30 meters) in radius)
(e) Fords

SERIAL NUMBER a	PARTICULARS b	GRID REFERENCE c	REMARKS d
1	sharp curve - radius 27.5 m	UT 122869	see overlay
2	steep grade - 8% - uphill East	UT 115875	Length 3ØØ m
3	narrow bridge - traveledway 5.Øm	UT 109879	see Bridge Rpt. #1
4	underpass - V.C. 4.Ø5 m	UT 1Ø2883	see overlay
5	Road crater - Lgt. 7.5 m	UT 1Ø1884	See Recon RPt. #1
6	FORD - Lgt. 7.3 m - width 8.2 m	UT 1ØØ886	See FORD Rpt. #1
	Bottom Gravel - depth - 0.5 m		

DA FORM 1 JUL 60 1248 PREVIOUS EDITION OF THIS FORM IS OBSOLETE.


SECTION IV - MILEAGE CHART

ROUTE FROM	ROUTE TO	SCALE	DATE
UT 122864	UT Ø97899	2 UNITS = 1 Km	1 Jun '84

ROAD INFORMATION | DISTANCE | ROAD INFORMATION

Shirley Hwy. — MILES 10 — KILOMETERS 16.Ø

Builtup Area (Westfeld) — Bd 7.3/9.3 m Kb (OB)

11.Ø

6.Ø

Bcqd' (FP)s 6.7/8.7m rb (OB)

MILES: 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0

REMARKS

Shoulders Very Soft

GLOSSARY

Abbreviations and Acronyms

abn/ambl	airborne/airmobile
ACE	armored combat earthmover
ADA	air defense artillery
ADE	assistant division engineer
AFCENT	Allied Forces, Central Europe
AFNORTH	Allied Forces, Northern Europe
AFSOUTH	Allied Forces, Southern Europe
APC	armored personnel carrier
apers	antipersonnel
assy	assembly
at	antitank
ATGM	antitank guided missile
AVLB	armored vehicle launched bridge
bdes	brigades
BEB	bridge erection boats
BHD	breast-high diameter
brg trks	bridge trucks
C^3	command, control, and communications
CCM	cross-country movement
CENTCOM	Central Command
CEV	combat engineer vehicle
cm	centimeter
cmbt	combat
co	company
CP	command post
CSR	controlled supply rate
DAO	division ammunition officer
DC	direct current
DS	direct support
DSMGB	double story medium girder bridge
EENT	early evening nautical twilight
engr	engineer
ERP	engineer release point
EW	electronic warfare
F	Fahrenheit
FACE	forward aviation combat engineering
FARP	forward arming and refueling points
FEBA	forward edge of battle area
FLOT	forward line of own troops
f/s	foot (feet) per second
FR	France
FRG	Federal Republic of Germany
ft	foot (feet)
ft /hr	cubic foot (feet) per hour
FTZ	full touch zone
gal	gallon(s)
g	gram(s)
GS	general support
G2/S2	intelligence staff
G3/S3	operations staff
G4/S4	logistics/supply staff
G5/S5	civil affairs staff
GSP	tracked folding ferry (Soviet)
HF	high frequency
HNS	host nation support
in	inch(es)

IPB	intelligence preparation of the battlefield
IRD	Inzhenerny Razvedyvatel'ny Dozor (engineer reconnaissance patrol)
km	kilometer(s)
km/h	kilometer(s) per hour
kg	kilogram(s)
LAPES	low altitude parachute extraction system
LD/LC	line of departure/ line of coordination
LOCs	lines of communication
LTR	light tactical raft
LZ/DZ	landing zone/drop zone
m	meter(s)
MAB	mobile assault bridge
M-CM-S	mobility-countermobility-survivability
METT-T	mission, enemy, terrain and weather, time and troops
MGB	medium girder bridge
m³/h	cubic meter(s) per hour
MICLIC	mine clearing line charge (M58A1/M58A2)
MLC	military load class
mm	millimeter(s)
MOPP	mission oriented protective posture
mph	mile(s) per hour
m/s	meter(s) per second
MRD	motorized rifle division
NATO	North Atlantic Treaty Organization
NBC	nuclear, biological, and chemical
NTZ	nontouch zone
obj	objective
OBM	outboard motor
OCOKA	Observation and fields of fire, cover and concealment, obstacles, key terrain, and avenues of approach
OPCON	operational control
OPSEC	operations security
PACOM	Pacific Command
PL	phase line
plt	platoon
POL	petroleum, oils, and lubricants
POZ	Podvizhnoy Otriad Zagrazhdeniya (mobile obstacle detachment)
psi	pounds per square inch
RACO	rear area combat operations
RDJTF	rapid deployment joint task force
recon	reconnaissance, reconnoiter
reinf	reinforced
RREB	ribbon raft erection boat
RSR	required supply rate
SLAR	side looking airborne radar
SOP	standing operating procedure
SP	self-propelled
STANAG	Standardization Agreement
TACGAP	European tactical gap study
TD	tank division
TNT	Trinitrotoluene
US	United States
VCI	vehicle cone index
vel	velocity
VHF	very high frequency
w	with
wo	without

References

REQUIRED PUBLICATIONS

Required publications are sources that users must read in order to understand or to comply with this publication.

FIELD MANUALS (FMs)

5-25	Explosives and Demolitions
5-30	Engineer Intelligence
5-34	Engineer Field Data
5-36	Route Reconnaissance and Classification
5-100 (HTF)	Engineer Combat Operations (How to Fight)
20-32	Mine/Countermine Operations at the Company Level
90-13 (HTF)	River Crossing Operations (How to Fight)

TECHNICAL MANUALS (TMs)

5-220	Passage of Obstacles other than Mine Fields
5-280	Foreign Mine Warfare Equipment
5-330	Planning and Design of Roads, Airbases, and Heliports in the Theater of Operations
5-530	Materials Testing
5-545	Geology

RELATED PUBLICATIONS

Related publications are sources of additional information. They are not required in order to understand this publication.

DEPARTMENT OF THE ARMY FORMS (DA) FORMS

1248	Road Reconnaissance Report
2028	Recommended Changes to Publications and Blank Forms

FIELD MANUALS (FMs)

5-35	Engineer's Reference and Logistical Data
5-146	Engineer Topographic Units

FIELD MANUALS (continued)

21-32	Topographic Support
24-1 (HTF)	Combat Communications (How to Fight)
31-71	Northern Operations
71-2 (HTF)	The Tank and Mechanized Infantry Battalion Task Force (How to Fight)
90-2 (HTF)	Tactical Deception (How to Fight)
90-3 (HTF)	Desert Operations (How to Fight)
90-4 (HTF)	Airmobile Operations (How to Fight)
90-5 (HTF)	Jungle Operations (How to Fight)
90-6 (HTF)	Mountain Operations (How to Fight)
90-10 (HTF)	Military Operations on Urbanized Terrain (MOUT) (How to Fight)
100-2-3	Soviet Army Troops Organization and Equipment
100-5 (HTF)	Operations (How to Fight)
101-5	Staff Officers' Field Manual: Staff Organization and Procedure

TECHNICAL MANUALS (TMs)

5-331A	Utilization of Engineer Construction Equipment: Volume A; Earthmoving, Compaction, Grading, and Ditching Equipment
5-331B	Utilization of Engineer Construction Equipment: Volume B; Lifting, Loading, and Handling Equipment
5-331C	Utilization of Engineer Construction Equipment: Volume C; Rock Crushers, Air Compressors, and Pneumatic Tools
5-331D	Utilization of Engineer Construction Equipment: Volume D-1; Asphalt and Concrete Equipment
5-331E	Utilization of Engineer Construction Equipment: Volume E; Engineer Special Purpose and Expedient Equipment
5-337	Paving and Surfacing Operations

GRAPHIC TRAINING AID (GTA)

5-7-7	Bridge Classification Card (May 1969)

STANDARDIZATION AGREEMENTS (STANAGs)

STANAGs are available, upon request, from Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2002	Warning Signs for the Marking of Contaminated or Dangerous Land Areas, Complete Equipments, Supplies and Stores
2079	Rear Area Security and Rear Area Damage Control
2101	Principles and Procedures for Establishing Liaison
2103	Reporting Nuclear Detonations, Biological and Chemical Attacks, and Predicting and Warning of Associated Hazards and Hazard Areas
2144	Call for Fire Procedures
2174	Military Routes and Route/Road Networks
2205	Use of Identical Maps by NATO Armed Forces Operating on Land
2269	Engineer Resources
2818	Characteristics of Demolition Accessories to Determine Their Operational Interchangeability
2929	Airfield Damage Repair
2933	Land Forces Explosives and Demolition Accessories Interchangeability Catalogue

PROJECTED PUBLICATIONS

Projected publications are sources of additional information that are scheduled for printing but not yet available. Upon print, they will be distributed automatically by a pinpoint distribution and will not be available for requisition from the United States Army Adjutant General Publications Center, Baltimore, MD, until indexed in DA Pamphlet 310-1.

FIELD MANUALS (FMs)

5-102	Countermobility
5-103	Survivability

INDEX

FM 5-101

23 JANUARY 1985

By Order of the Secretary of the Army:

JOHN A. WICKHAM, JR.
General, United States Army
Chief of Staff

Official:

DONALD J. DELANDRO
Brigadier General, United States Army
The Adjutant General

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