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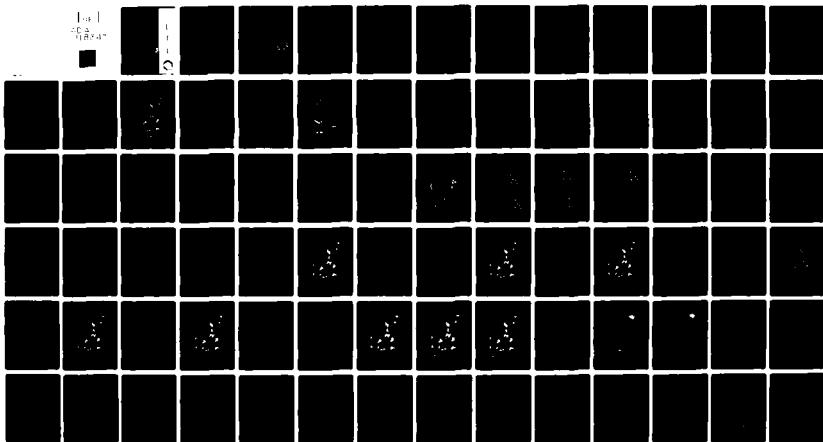
ARMY ENGINEER TOPOGRAPHIC LABS FORT BELVOIR VA  
SYNTHESIS GUIDE FOR OBSTACLE SITING (REPORT NUMBER 9 IN THE ETL--ETC(U)  
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Synthesis guide for obstacle siting

Robert A. Falls

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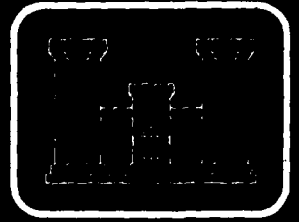
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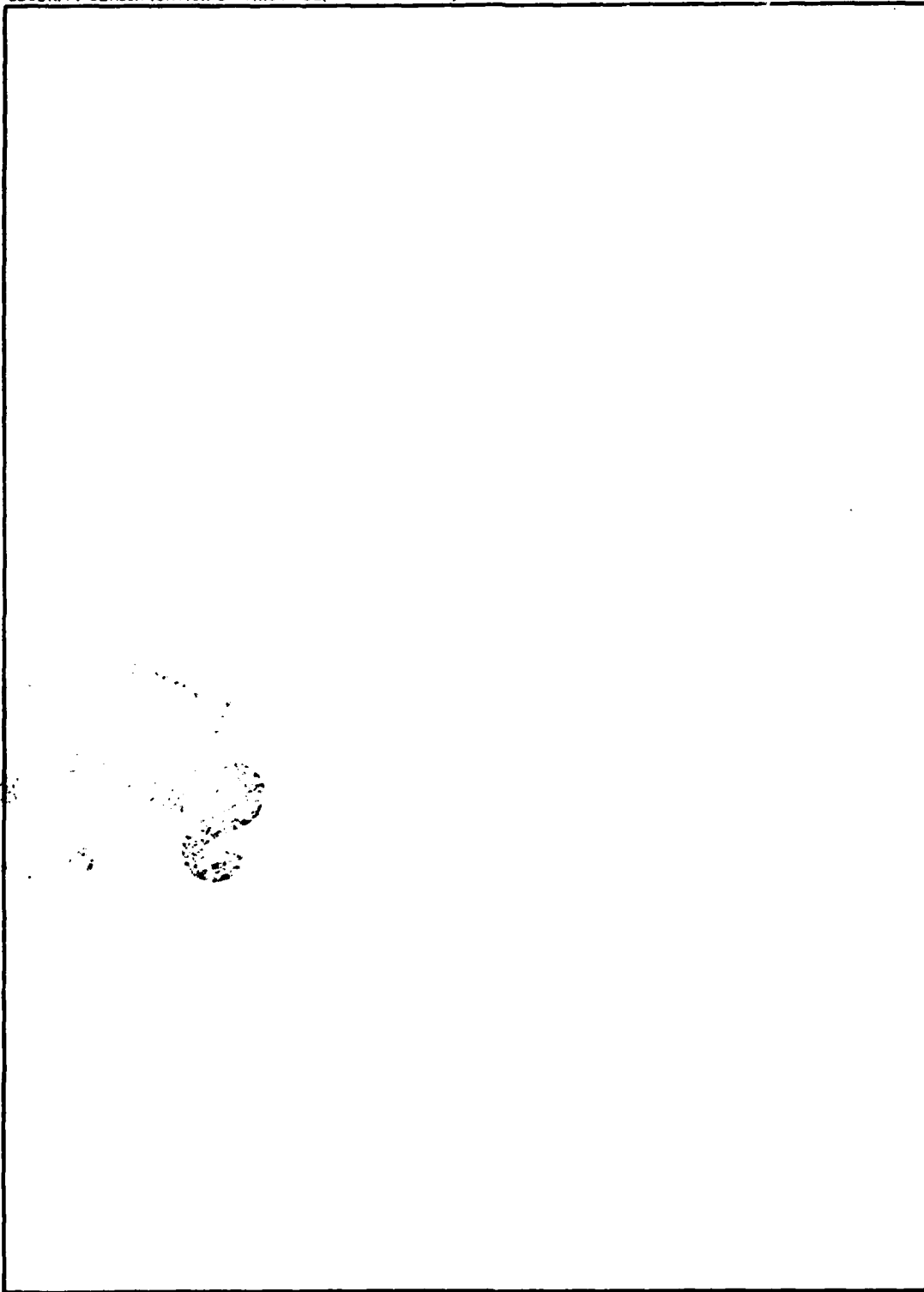
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## PREFACE

This guide for obstacle siting is one of a series of analysis and synthesis guides to be produced. After some modifications, the guides will be published as Department of Army manuals. For this reason, the author would appreciate critical comments and suggestions.

The published guides in this series are:

<u>Number</u>	<u>Authors</u>	<u>Title</u>	<u>AD Number</u>
ETL-0178	Jeffrey A. Messmore Theodore C. Vogel Alexander R. Pearson	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR VEGETATION (Report No. 1 in the ETL Series on Guides for Army Terrain Analysts)	AD-A068 715
ETL-0205	Theodore C. Vogel	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR ROADS AND RELATED STRUCTURES (Report No. 2 . . .)	AD-A080 021
ETL-0207	James Tazelaar	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR GEOLOGY (Report No. 3 . . .)	AD-A080 064
ETL-0220	Alexander R. Pearson Janet S. Wright	SYNTHESIS GUIDE FOR CROSS-COUNTRY MOVE- MENT (Report No. 4...)	AD-A084 007
ETL-0247	Roland J. Frodigh	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR CLIMATE (Report No. 5 . . .)	AD-A095 158
ETL-0254	Janet S. Wright Theodore C. Vogel Alexander R. Pearson Jeffrey A. Messmore	TERRAIN ANALYSIS PROCEDURAL GUIDE FOR SOIL (Report No. 6...)	AD-A107 048
ETL-0263	James Tazelaar	SYNTHESIS GUIDE FOR LINES OF COMMUNICATION (Report No. 7 . . .)	AD-A104 208

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This study was done under the supervision of A.C. Elser, Chief, MGI Data Processing and Products Division; and K.T. Yoritomo, Director, Geographic Sciences Laboratory.

Colonel Daniel L. Lycan, CE, and Colonel Edward K. Wintz, CE, were the Commanders and Directors, and Mr. Robert P. Macchia was Technical Director of the U.S. Army Engineer Topographic Laboratories during the report preparation.

CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI)  
UNITS OF MEASUREMENT

U.S. Customary Units of Measurement used in this report can be converted to metric (SI) as follows:

Multiply	BY	To Obtain
inches	25.4	millimeter
feet	30.48	centimeter
miles	0.6093	kilometer
acres	0.405	hectare
ounces	28.57	gram
gallons	3.785	liter
Fahrenheit degrees*	5/9	Celsius degrees, Kelvin

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\*To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula:

$$C = (5/9) (F-32)$$

To obtain Kelvin (K) readings, use formula:

$$K = (5/9) (F-32) + 273.15$$

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## SYNTHESIS GUIDE FOR OBSTACLE SITING

### I. INTRODUCTION

A. Purpose. The purpose of this report is to provide the terrain analyst with a step-by-step procedure for collecting and analyzing existing obstacles (natural and/or cultural) and reinforcing obstacles (conventional and/or dynamic) in order to develop obstacle-siting information and to record the results in the form of a graphic overlay. The ultimate objective is a graphic obstacle-siting product to assist in the decision making of the field tactical commander (figure 1).

B. Background. The first phase in the generation of military geographic information (MGI) is to collect data from a variety of sources, reduce the data to a standard format, and record it in the desired form. One practical method of producing this information is the factor overlay concept that preformats information for the data base. In figure 1, the factor overlay principle for formatting data is shown in the form of factor overlays that are eventually registered to military topographic maps, generally of the scale 1:50,000. Data is obtained from various source material such as maps, aerial photos, and literature, and is recorded on separate factor overlays such as slope, geology, vegetation, and roads and related structures.

The synthesis process means taking specific factor overlays out of the data base (figure 1), placing a sheet of frosted mylar on the overlays one at a time, and tracing selected map unit boundaries on the different overlay onto a single sheet of mylar. This sheet of mylar, called the Complex Overlay, will become the base from which the Obstacle-Siting Overlay will be made (figure 2). This overlay should indicate the most likely locations for obstacles listed in table 1.

#### C. The Obstacle Siting Concept.

##### 1. Existing and Reinforcing Obstacles

The factor overlay principle can be used to combine various terrain factors such as built-up areas, vegetation, and soil into a complex overlay that shows existing obstacles (natural and cultural). An obstacle is any obstruction that stops, delays, or restricts movement, and it can be either existing or reinforcing (conventional and dynamic). Rivers, swamps, marshes, forest, rock outcrops, wet soil, flooded areas are called natural obstacles; ditches, quarries, walls, buildings, canals, hedgerows are called cultural obstacles; tank traps, minefields, craters are called conventional reinforcing obstacles; and smoke is called a dynamic obstacle (table 1). Highly developed areas such as the northeastern United States and western Europe are dominated by cultural obstacles. The natural and cultural obstacles are already in place when the battle plans

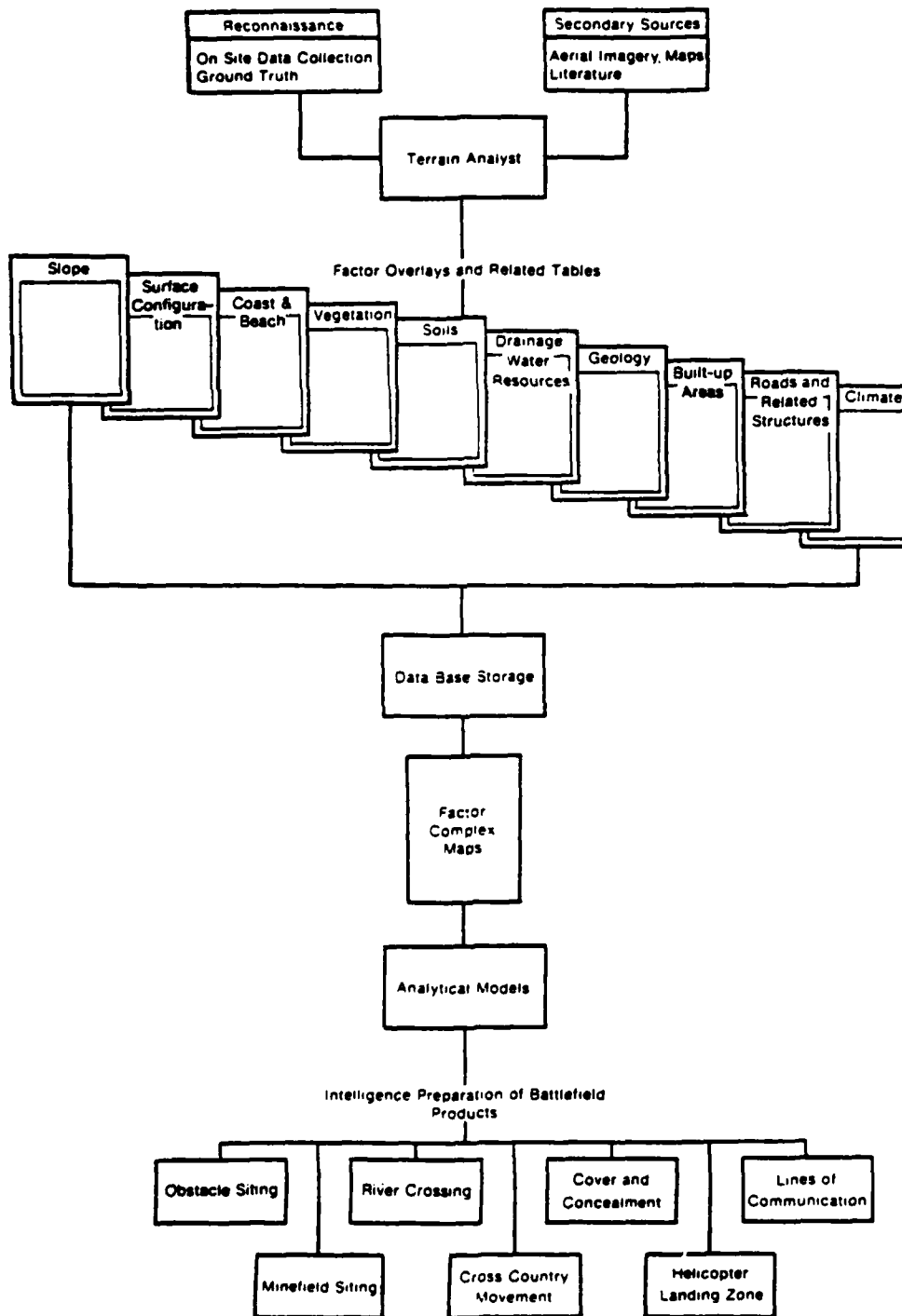


Figure 1. Production and Use of Factor Overlays and Data Tables.

1:50,000  
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**HOFFMAN**  
Obstacle Complex Overlay



Note: Roads Left Out for Simplicity

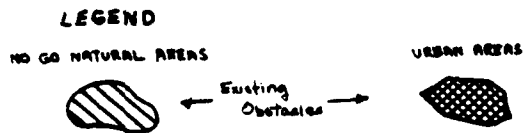
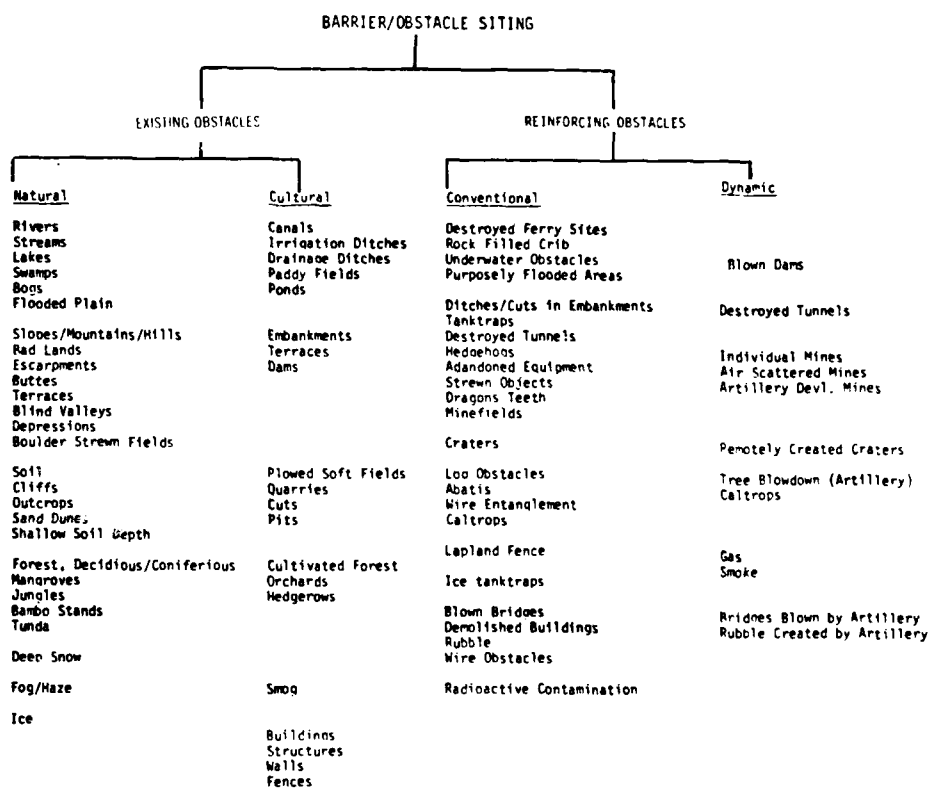


Figure 2. Sample Completed Obstacle Map.

Table 1. List of Siting Obstacles.



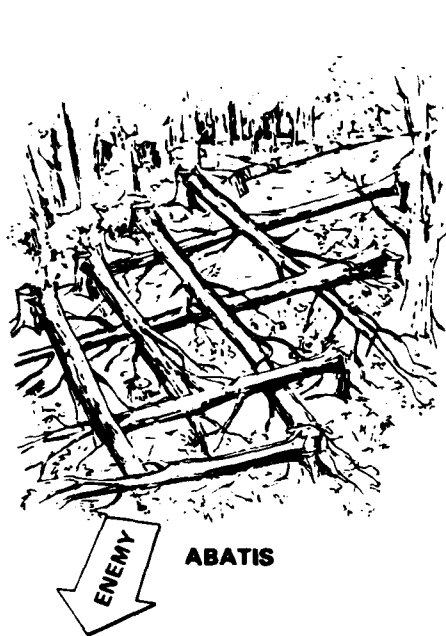
are drawn up. These existing obstacles form the basis upon which the military commander can build and anchor reinforcing obstacles (conventional and/or dynamic) to intensify the barrier system. It is in this way that the commander can enhance his defensive advantage.

Reinforcing obstacles (figure 3) are specifically constructed, emplaced, or created by detonation to serve in military action, either anticipated or already in progress. Existing obstacles (table 1) tend to be either linear (canals, rivers) or broad (forest, swamp) and are more accurately called obstacle areas. These existing obstacles frequently have gaps and lanes and consequently are highly variable in effectiveness. Existing obstacles, both natural and cultural, taken together constitute an obstacle matrix. Reinforcing obstacles must be added to the matrix to develop an integrated barrier system that will force the enemy to conform to the friendly forces' battle plan. Reinforcing obstacles are used to close the gaps and to block or destroy the lanes in the existing obstacle area, or to strengthen weak areas (figure 4). They are also used to extend existing obstacles or to develop obstacles in an obstacle-free area.

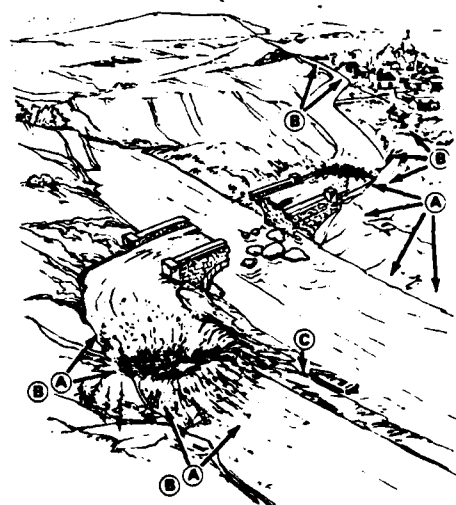
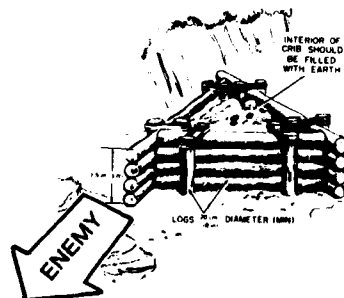
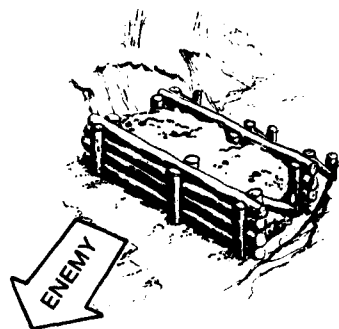
The combination of natural and cultural obstacles will in most cases leave gaps in the terrain suitable for exploitation by the enemy. These gaps are broadly termed "avenues of approach". An avenue of approach is a route by which a force may reach an objective or key terrain. To be considered an avenue of approach, a route must provide enough width for the mobility of the force for which the avenue is being considered. For example, intelligence officers above corps level consider avenues of approach adequate when they are able to handle a division. This designation is based on good fire observation, favorable ground, and good concealment and cover. The size of the avenue of approach should accommodate a force one echelon below defensive unit size. For example, the battalion-size defenders should identify company-size avenues of approach, and larger. The avenue of approach has all the characteristics of the mobility corridors developed in the cross-country movement (CCM) concept. The obstacle-siting overlay can be looked upon as the inverse of the cross-country movement. That is, the CCM map identifies mobility corridors, whereas, the barrier overlay identifies the areas not conducive to mobility and therefore identifies the gaps in the existing obstacles that require placement of reinforcing obstacles in order to develop an effective barrier system.

## 2. The Barrier System

a. Background. A barrier system is a coordinated series of strongpoints, defense areas, and obstacles that are generally placed in a linear fashion. The barrier is sited on the strongest tactical terrain features available. It is fashioned, designed, or used to canalize, direct, restrict, delay, or stop the movement of an opposing force and to impose



**DESTROYED CITY**



**A** Anti-personnel mines **B** Anti-tank mines **C** Booby traps

Use of mines in conjunction with demolitions (Point minefields).

Figure 3. Various Types of Reinforcing Obstacles.

additional losses of personnel, time, and equipment on that force. All of this must be accomplished without inhibiting the movement of friendly troops. Usually, several barriers are employed to create a barrier system. The barrier is the synthesis of such terrain factors as built-up areas, vegetation, slope, etc., and reveals the existing (natural and/or cultural obstacle) framework within which reinforcing obstacles are woven to develop the barrier system. Finally, care is given to placement of covering fire and concealment of weapons. A brief discussion on (a) how barrier plans originate, (b) types of barriers, and (c) deployment of barriers at various echelons will follow.

b. Origin. Barrier plan and development at various echelons are as follows:

(1) The Department of the Army prepares very broad barrier studies of large geographical areas. These studies develop general barrier systems as well as broad planning factors for material, logistics, and manpower requirements. The studies may suggest tactical concepts for areas within the barrier systems. In addition, the Army conducts feasibility studies of the barrier system that take into consideration the armed forces and materials available.

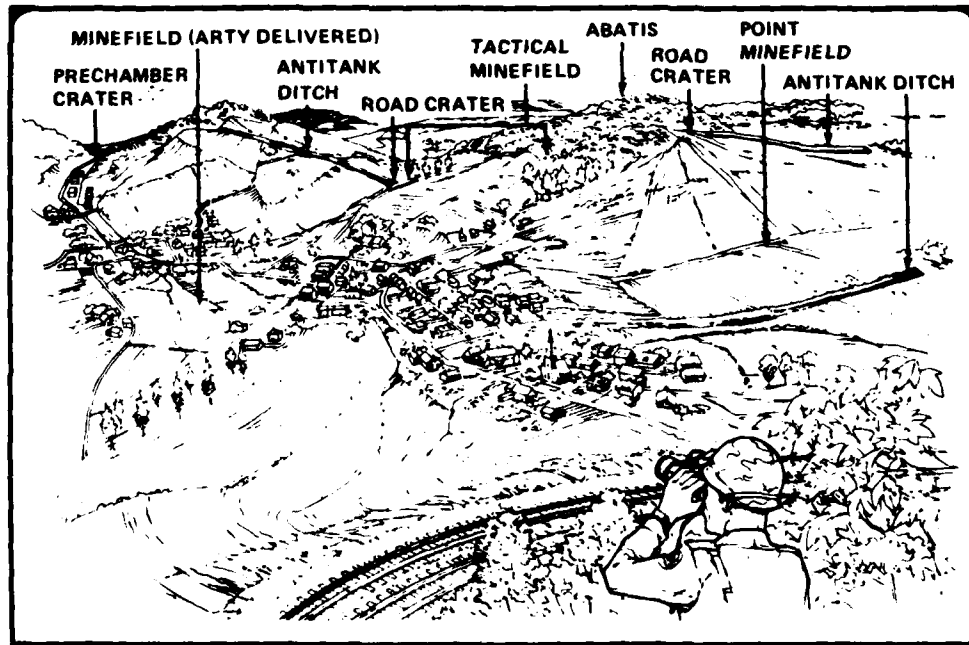


Figure 4. Variety of Reinforcing Obstacles Used in a Terrain Setting.

(2) At a lower level, formally known as the theater of operations level, the barrier study and geographic area are still broad in scope. However, it is here that the first indication of using general reconnaissance, terrain studies, maps, and aerial photographs appears. Broad concepts in logistics are suggested to assist the theater commander in obtaining the material, equipment, and facilities required.

(3) At still lower level, formally known as the army group level, barrier studies are normally conducted in long-range planning that has operational missions. These studies have a tendency to shape tactical concepts and to provide a framework for obstacle plans at the field army level.

(4) The field army barrier plan is not so detailed as to show all the individual obstacles in the field army area of responsibility. It is used as a framework to be passed down to corps and division levels. The plan will contain the following: (a) Portions of the Department of the Army barrier study pertaining to this section. (b) Identification of vital specific barriers. (c) The general location of the barriers by barrier trace symbols (figure 5). Depending on ground and aerial reconnaissance intelligence, subordinate commanders will determine the exact location of these obstacles. (d) Identification of areas of responsibility for barriers. (e) Location of minefields of major tactical importance. (f) Development of a code-numbering system for obstacles. (g) Completion time for a portion or all of a barrier system. (h) Identification of gaps or routes through the barriers. (i) Restriction on using certain obstacles. (j) Responsibility for coordination of subordinate units' barrier tie-points. (k) Instructions regarding the submission of detailed obstacle plans from corps level.

Theater of operations, army group, and field army are terms that have recently been discarded. These military units are now identified by the term "Echelons above Corps" (EAC). Barrier plans and the systems generated from them are semicontinental in size. When these plans and developed systems are passed below EAC, the name is changed to obstacle plans and obstacles.

(5) The corps obstacle plan is based on the EAC plan and the corps tactical plan. It is more detailed because it is based on more knowledge of the area and on detailed terrain analysis, maps, and aerial photographs. At this level, obstacles are fairly well defined (figure 6). The corps specifies a large number of reinforcing obstacles by location and type as compared to the EAC plan. The corps obstacle plan includes overprinted maps or overlays in sufficient detail so that the division level can understand the type of obstacles that are to be installed. The corps also coordinates the detailed planning of subordinate units, including use of supporting weapons to cover obstacles with fire.

LEGEND

- \*\*\*\* EAC
- \*\*\* Corps
- \*\* Division
- Barrier Trace.  
Used on plans  
above Corps  
level.
- ⊙ Forward edge of  
battlefield.

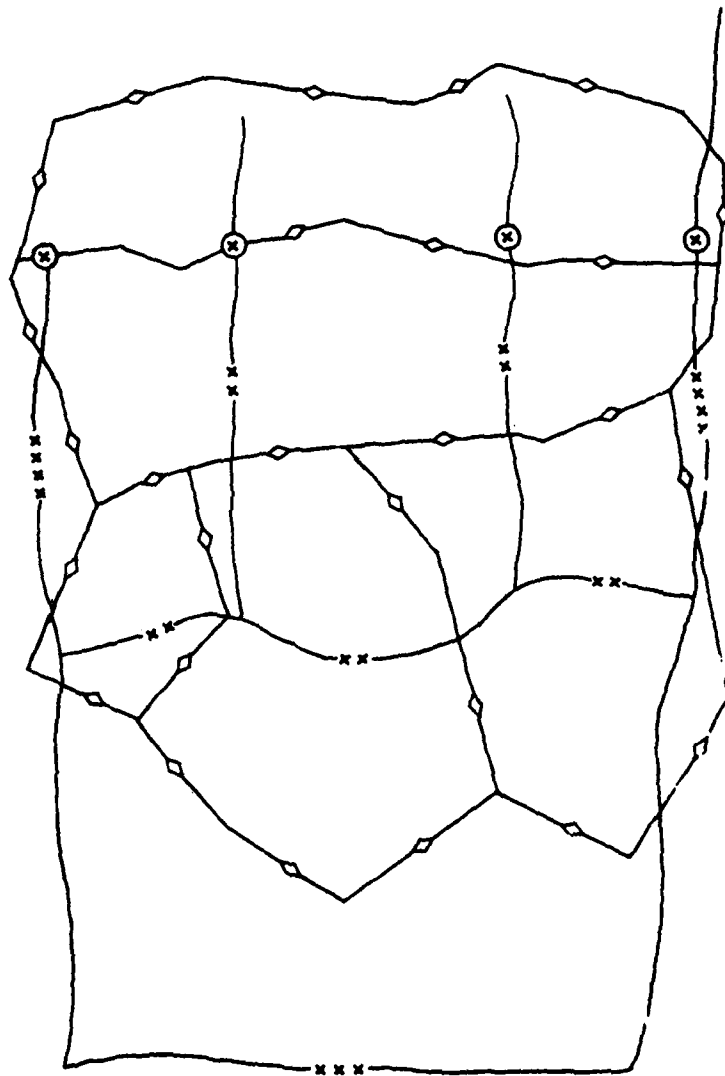


Figure 5. The Barrier Trace Delineation.

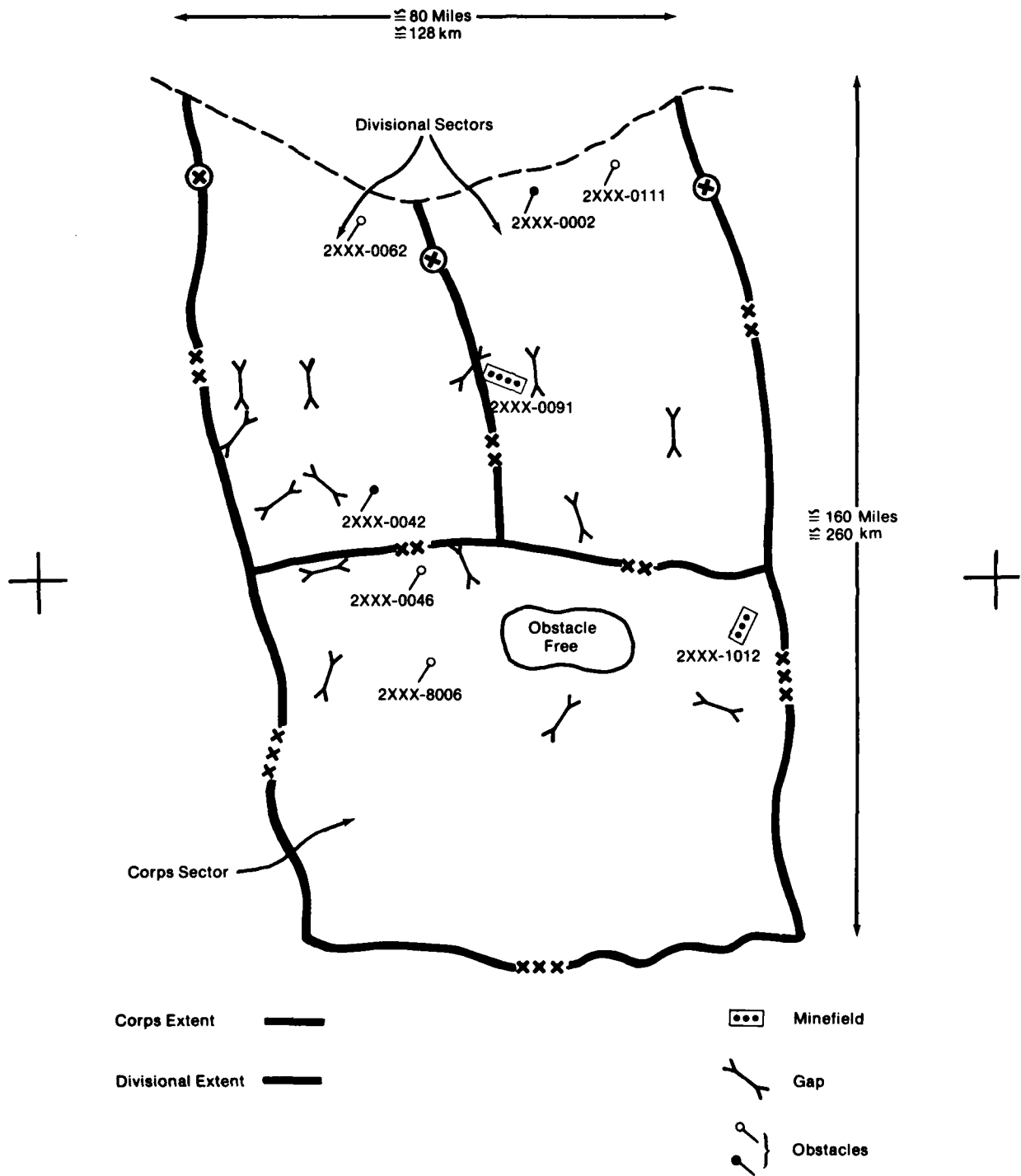


Figure 6. Corps Obstacle Plan and Reinforcing Obstacle Symbolgy.

(6) The division plan is developed in greater detail than the EAC or corps plans. At this level of command, a detailed reconnaissance of its area is made (figure 7). The division determines the exact trace of each barrier, the location and type of reinforcing obstacle best suited to the terrain, the location of gaps and lanes, and the requirements for materials, time, and labor. The division determines whether or not the location and type of obstacle suit the tactical plan of maneuver and the overall fire support plan. If a conflict occurs concerning the location of the exact obstacles, the fire support plan, and the tactical scheme of maneuver, then each or all are adjusted to bring them into harmony in order to provide the maximum defense. The G-2 generates the intelligence estimate of enemy intent, and in analyzing this information, the G-3 develops a tactical plan that portrays division staff functions.

The lowest levels, such as brigades and regiments, provide much of the detail for an obstacle plan, which can include performing terrain reconnaissance and locating the actual obstacles on the ground. Brigades and lower units are not allowed to see complete obstacle plans for the corps, since they are not carried any lower than division level.

At each descending level of command, the scale of the topographic map employed becomes larger until at the command level between the division and brigade, it approaches the 1:50,000 scale. This is the map scale to which the U.S. Army Engineer Topographic Laboratories Terrain Analysis and Synthesis Procedural Guides are primarily addressed. The barrier location at upper levels of command may be only a trace on a small or medium scale map (1:1,000,000 or 1:250,000).

#### c. Types

The types of barriers are covering barriers,\* forward barriers,\* intermediate barriers,\* rear barriers\* and flank barriers.\*

##### (1) Covering Barrier

A covering barrier is located forward of the battle area and is emplaced when units are not in actual contact with the enemy and when units are withdrawing to a defense area to the rear. It is selected by a field army, corps, or division to assist the delaying actions of covering forces. It consists of obstacles designed to slow the initial enemy thrust, to separate tanks from infantry, and to deceive the enemy about the location of the main battle area.

\* Terms used above corps level.

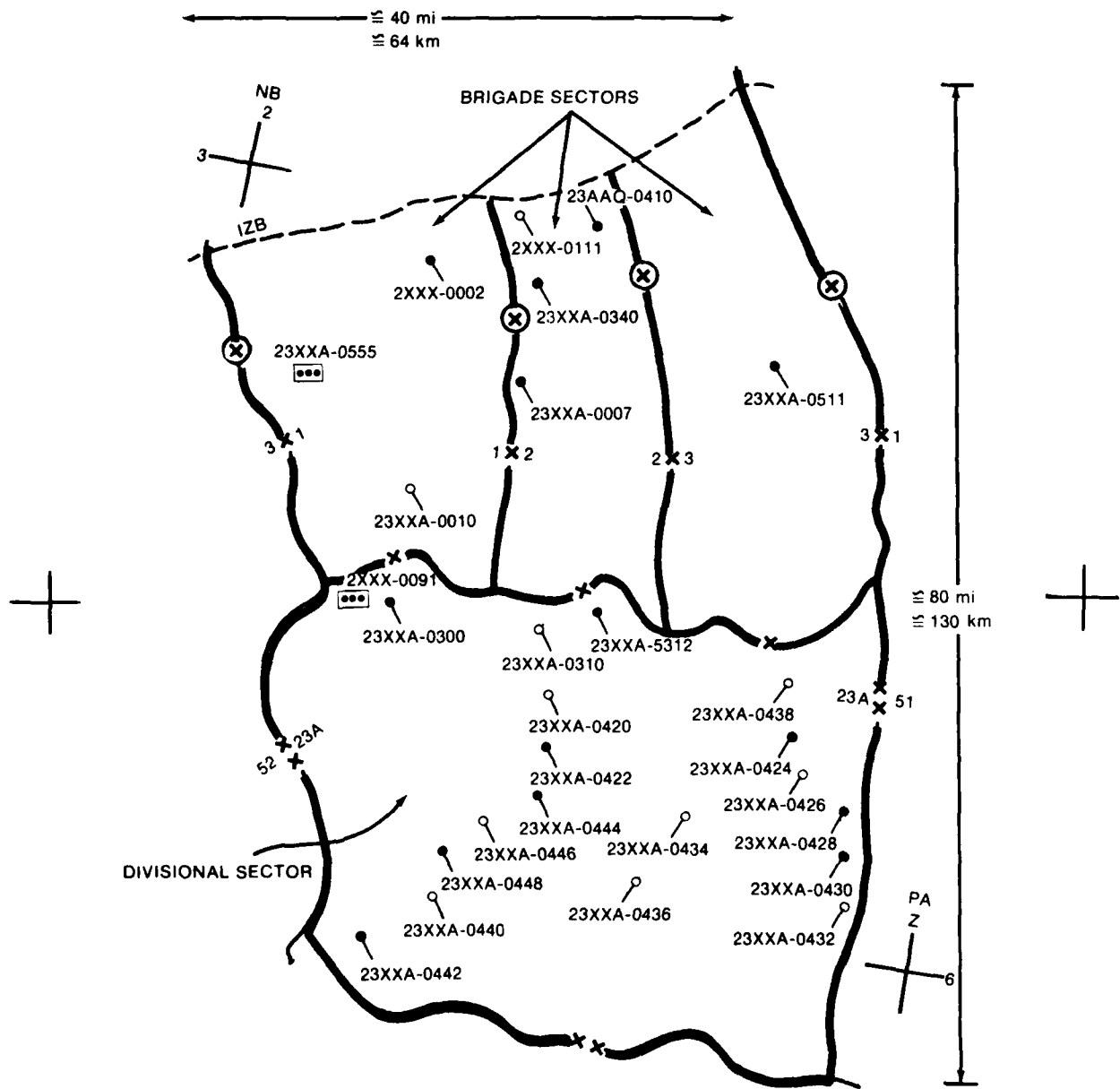


Figure 7. Division and Brigade Obstacle Plan and Reinforcing Obstacle Numbering System

Covering barriers are not necessarily continuous, but may consist of groups of coordinated obstacles in depth across the enemy's major avenues of approach. Because of the limited time available to construct covering barriers, as well as the limited size of the security forces, emphasis is placed on the use of natural obstacles reinforced with artificial obstacles that can be quickly and easily constructed, such as demolitions, nuisance mining, hasty roadblocks of all types, and abatis. Covering barriers may be employed along international borders to provide early warning and to delay an invading force that is capable of striking without either warning or declaration of war.

### (2) Forward Barriers

A forward barrier is located generally along a forward division's initial battle position. It consists of the defense areas and strong points in depth, coordinated fire of all weapons, and artificial and natural obstacles employed in depth for close-in projection and defense. It is not necessarily a continuous field of antitank and antipersonnel mines, but it combines all types of obstacles, both natural and artificial, and the fire of all weapons. It is sited on the strongest terrain features available and is the backbone of the defense. Depth to the forward barrier can be achieved by using a series of obstacles on the dangerous avenues of approach. These obstacles are covered by forces along the forward edge of the battle area (FEBA). In establishing a forward barrier, units analyze the terrain to determine those areas that prevent the movement of tanks, or permit their passage only with great difficulty. Although each defense area is founded on the strongest combination of terrain features available, all areas may not be equally strong. When portions of the forward barriers are located on vulnerable terrain, the natural vulnerability of the terrain is reduced by using all types of artificial obstacles and coordinated defensive fire.

### (3) Intermediate Barriers

Intermediate barriers are located between the forward and rear barriers, or between units that are smaller than division size. They are developed initially by construction of narrow minefields, by abatis, by road craters, by bridge demolition, and by other obstacles at random, as time, labor, materials, and transportation become available. Individual obstacles are sited where natural obstacles (such as forest, unfordable streams, swamps, and escarpments) prevent easy bypassing. In time, these individual obstacles are connected as intermediate barriers to form a rough cellular pattern. Intermediate barriers permit penetration of the forward barrier without jeopardizing entire battle areas, and they assist in canalizing enemy forces into preselected target areas.

#### (4) Rear Barriers

Corps, field army, or higher commands select rear barriers. Their purpose is to assist in organizing a rear battle area and slowing or preventing deep enemy penetrations or wide envelopments. The principles for locating and constructing rear barriers are the same as those used for locating and constructing forward barriers. Artificial obstacles are used more extensively in the construction of rear barriers, since time, materials, transportation, equipment, and specially trained personnel are more readily available in rear areas.

#### (5) Flank Barriers

A flank barrier is located to protect the side of a division or larger unit and to slow or prevent penetrations and envelopments. The principles for locating and constructing intermediate obstacles and barriers are applicable to flank barriers.

#### (6) Barrier Depth

Barriers must be employed in depth if they are to withstand a determined enemy assault. The destructive power of nuclear weapons makes it possible for an enemy to penetrate any single barrier and defense. The maintenance of strong defense garrisons in the rear portion of the combat zone to prevent the enemy from exploiting breakthroughs is usually not practicable. Successive barriers in a cellular pattern, combined with intermediate obstacles in depth, will slow or limit enemy penetration, permit greater freedom of maneuver by friendly forces, and provide time for the defenders to regroup and counterattack. Successive barriers require the enemy to expend strength and time at each barrier and may compel him to concentrate and thus offer, lucrative targets for massed artillery fire or nuclear weapons. The width and depth of a specific barrier are not fixed, but are based on the purpose of the barrier, the tactical situation, and the resources available. The distance between barriers is an important consideration. If barriers are located too close together, they become one barrier rather than two. If located too far apart, they permit the enemy to consolidate his gains before assaulting the next barrier. Although the specific locations of barriers depend on terrain, as a general rule they should be far enough apart to give the reserves time and space to counterattack. Figure 8 shows the barrier system trace superimposed on corps size military concentration.

#### (7) Deployment

The deployment of reinforcing obstacles starts with the commander and his division or brigade staff (G3/S3, G2/S2) discussing the terrain (Complex Barrier Overlay) and barrier construction, the enemy, the weather, and the logistics of resources to develop a successful tactical operation. Developing a successful barrier concept

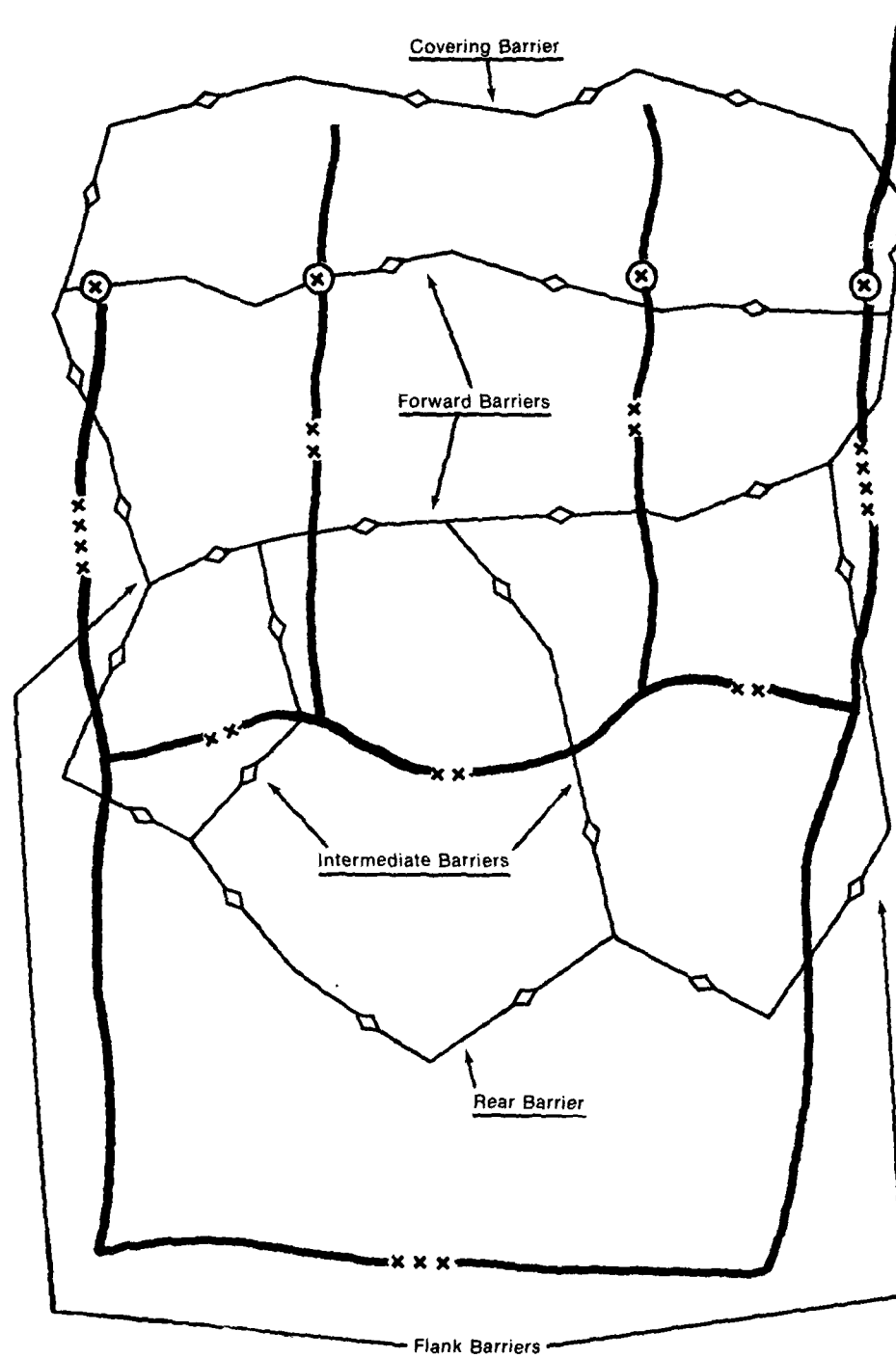
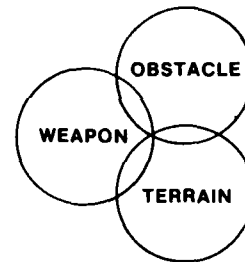
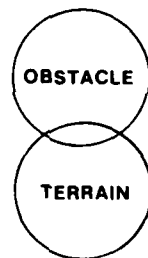
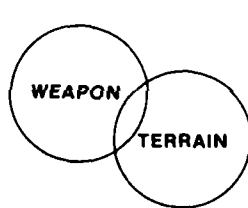
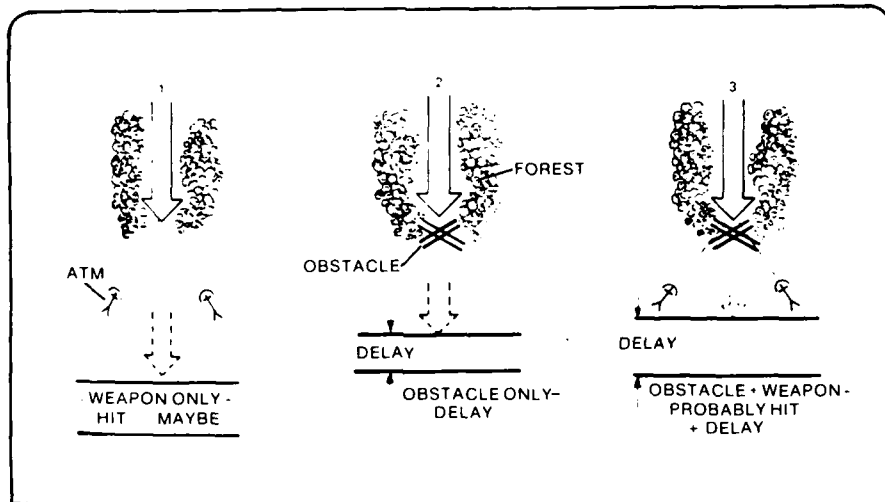


Figure 8. The Barrier System Trace Superimposed on Corps and Division Boundaries.

based on G3/S3, G2/S2, inputs can be complicated unless a systematic procedure is used. The initial phase of the analysis should focus on the terrain as viewed from a threat perspective, keeping in mind that the enemy may elect to strike from a direction not considered. The following procedure for analysis is generally used with maps or actual ground reconnaissance: (1) Determine the enemy's objective(s); (2) Decide on enemy avenues of approach; (3) Determine enemy order of battle; (4) Identify key terrain; (5) Select tentative defense positions based on the barrier complex overlay; (6) Select tentative observation posts; (7) Decide on fields of fire, taking into consideration barrier overlay and weapons; (8) Decide on tentative positions for cover and concealment; (9) Decide the position for reinforcing obstacles that will enhance or increase the obstacle value of the existing obstacles, the reinforcing obstacles, and the type of weapons; (10) Estimate the time of contact with the enemy; and (11) Allocate weapon systems to the best terrain position.

Properly used obstacles are combat multipliers. They significantly enhance the relative value of weapons, especially antiarmor weapons. This enhancement results from siting reinforcing obstacles to take advantage of the following factors: (1) The probability of a hit is greater if the target is moving slowly or stopped; (2) Attacking enemy armored vehicles are clearly visible to direct-fire, antitank weapons while crossing "terrain windows" during their approach. In coordination with the siting of antitank weapons, the commander sites obstacles to take advantages of these factors (figure 9). The obstacle slows or stops the attacking armored vehicle, thus turning a rapidly moving target into a slow or stationary one. At the same instant, the obstacle holds the attacker in a favorable, known position at a known range. Proper use of the obstacle thus integrates the reinforcing obstacle with the existing terrain obstacles and weapons.



LEGEND

 CRATERED ROAD


 ATM

Figure 9. Improvement of Obstacle Siting by Correct Use of Weapons, Terrain, and Obstacle.

## II. SOURCE MATERIAL

No single source is capable of providing all the data required for the Obstacle-Siting overlay. The analyst must use different sources for different geographic areas. In some cases - foreign areas mostly - there will be areas for which no sources of information are available. When this happens, an effort should be made to develop a data base by initiating ground and aerial reconnaissance missions. The principal source materials that should be used in developing the Obstacle-Siting overlay are maps, literature, factor overlays, and aerial imagery. These source materials should be studied especially for the following subdivisions of what is the barrier-siting concept, i.e. the factors affecting obstacles, cross-country movement, lines of communication, and cover and concealment.

A. Factor Overlays. A factor overlay is a graphic illustration of the result of terrain analysis. Preformatted data in the form of factor overlays can be registered to standard 1:50,000-scale topographic maps. Under this concept, data is extracted from various source materials and recorded on factor overlays. These overlays are stable, translucent sheets of material. Separate overlays are prepared for each map sheet and for each major terrain subject, e.g. built-up areas, slope, vegetation, water-courses and water bodies, surface roughness, soil, and roads. Factor overlays are intermediate data base products intended primarily as tools for the terrain analyst, and they are not customarily distributed outside of the topographic and intelligence community.

Factor overlays are used in various combinations to generate factor complex graphics, which become the manuscripts for special purpose maps.

B. Maps. Most information pertaining to the compilation of cultural obstacles onto a single overlay can be obtained from topographic maps and existing factor overlays. The extent and type (deciduous, evergreen, or mixed) of forest cover is all that generally can be expected from topographic maps. More detailed information on the forest would require special vegetation maps or other sources of information. Drainage and waterbody information also can be obtained from 1:50,000 scale maps. These maps, however, will not reveal water depth information, and therefore maps of larger scale or the geographic literature of the region have to be researched.

C. Aerial Imagery. As used in this guide, aerial imagery includes imagery obtained with any of the following remote sensor systems: thermal infrared scanners, radar, and aerial cameras. Reconnaissance photography, including vertical and oblique aerial photographs, is an excellent source of information, particularly when ground access is denied and map sources are known to be out of date. The accuracy and amount of detail that can be obtained will depend on the type and scale of the imagery as well as the skill and knowledge of the analyst.

D. Literature. Literature pertaining to obstacle siting as an exact title will not generally be found. However, much insight can be obtained on obstacle site selection under key words such as (1) natural and cultural obstacles, (2) reinforcing obstacles, (3) slope, (4) surface roughness, (5) geology, (6) terrain analysis, and (7) climate. Materials maintained by federal and state governments are useful. The analyst will find the following sources suitable as background information:

PS/3AA/101 "Defense Mapping Agency Production Specifications for 1:50,000 scale Topographic Maps of Foreign Areas," First Edition, July 1980.

TM S-1, "Specifications for Military Maps," Defense Mapping Agency, Topographic Center, Vol. I and II, 1973.

TM 5-330, "Planning and Design of Roads, Airbases, and Heliports."

TM 5-248, "Foreign Maps," Headquarters, Department of the Army, 1963.

TM 5-818-2, "Soils and Geology."

TM 30-245, "Image Interpretation Handbook," Vol. I, Departments of Army, Navy, and Air Force, 1967.

FM 5-36, "Route Reconnaissance and Classification," Headquarters, Department of the Army, 1970.

FM 21-26, "Map Reading," Headquarters, Department of the Army, 1969.

FM 90-7, "Obstacles," U.S. Army Engineer School, Fort Belvoir, VA, (Final Approved Draft), December 1977.

FM 21-33, "Terrain Analysis," Headquarters, Department of the Army, 1978.

FM 30-10, "Military Geographic Intelligence (Terrain)," Headquarters, Department of the Army, 1972.

FM 90-10, "Military Operations on Urbanized Terrain," August 1979.

FM 21-31, "Topographic Symbols," Headquarters, Department of the Army, 1961.

EM 1110-2-1906, "Laboratory Soils Testing."

Interpretation of Aerial Photographs, 2nd Edition, T. E. Avery, Burgess Publishing Company, Minneapolis, Minnesota, 1968.

ST 23-3-1, "Antiarmor Tactics and Techniques for Mechanized Infantry,"  
U.S. Infantry School, Fort Benning, GA.

and Publications such as "The Engineer," "Infantry," and "Armor."

Terrain Analysis Procedural Guide for Vegetation, ETL-0178, March 1979.  
U.S. Army Corps of Engineers, Engineer Topographic Laboratories, Fort  
Belvoir, VA 22060, AD-A068 715.

Terrain Analysis Procedural Guide for Roads and Related Structures,  
ETL-0205, October 1979, U.S. Army Corps of Engineers, Engineer Topographic  
Laboratories, Fort Belvoir, VA 22060, AD-A080 021.

Terrain Analysis Procedural Guide for Geology, ETL-0207, November 1979,  
U.S. Army Corps of Engineers, Engineer Topographic Laboratories, Fort  
Belvoir, VA 22060, AD-A080-064

Synthesis Guide for Cross-Country Movement, ETL-0220, February 1980,  
U.S. Army Corps of Engineers, Engineer Topographic Laboratories, Fort  
Belvoir, VA 22060, AD-A084 007.

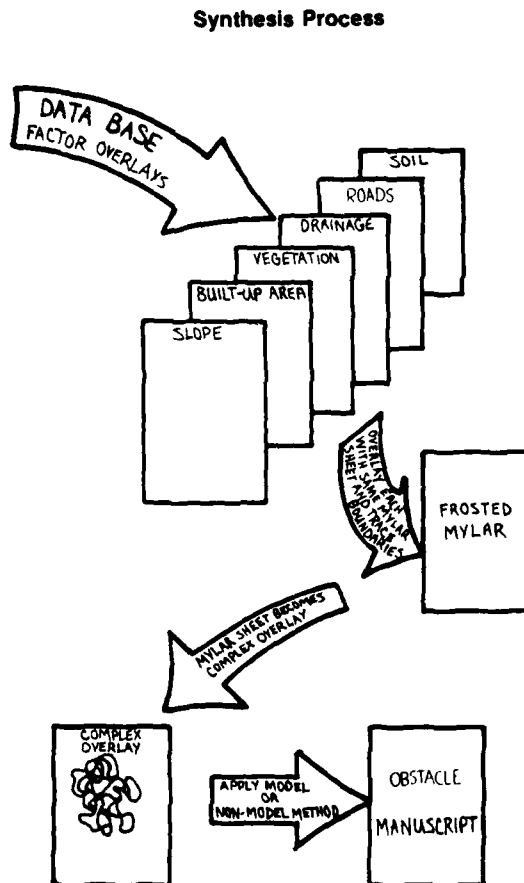
Terrain Analysis Guide for Surface Configuration, U.S. Army Corps  
of Engineers, Engineer Topographic Laboratories, Fort Belvoir, VA 22060,  
Report in progress.

### III. PROCEDURAL OUTLINE

A. Preparatory Steps for Obstacle-Siting Synthesis. This section provides an overview of the step-by-step procedures required to perform a complete obstacle synthesis. The outline is presented as a schematic flow diagram showing what steps are required and the sequence in which they are normally performed. The diagram indicates what is to be done; how it is done is explained in the Analysis Procedures section.

Although the diagram illustrates many separate steps for clarity, it will often be more practical to combine two or more of the steps into a single operation.

#### 1. Sequence of steps for Obstacle-Siting Synthesis.



2. Map analysis for several elements considered in developing factor overlays for Obstacle-Siting Map (figure 10).

# OBSTACLE SITING CONCEPT

DATA SOURCE

ANALYSIS  
FACTOR  
OVERLAYS

Built-Up Areas

Vegetation

Watercourses and  
Waterbodies

Slope

Soil

Others Such As:  
Road/Related  
Structures and  
Climate.

SYNTHESIS  
PREDICTION  
COMPILATION.  
OUTPUT

Complex  
Overlay

Prediction  
Model

Topic  
Graphic

USER

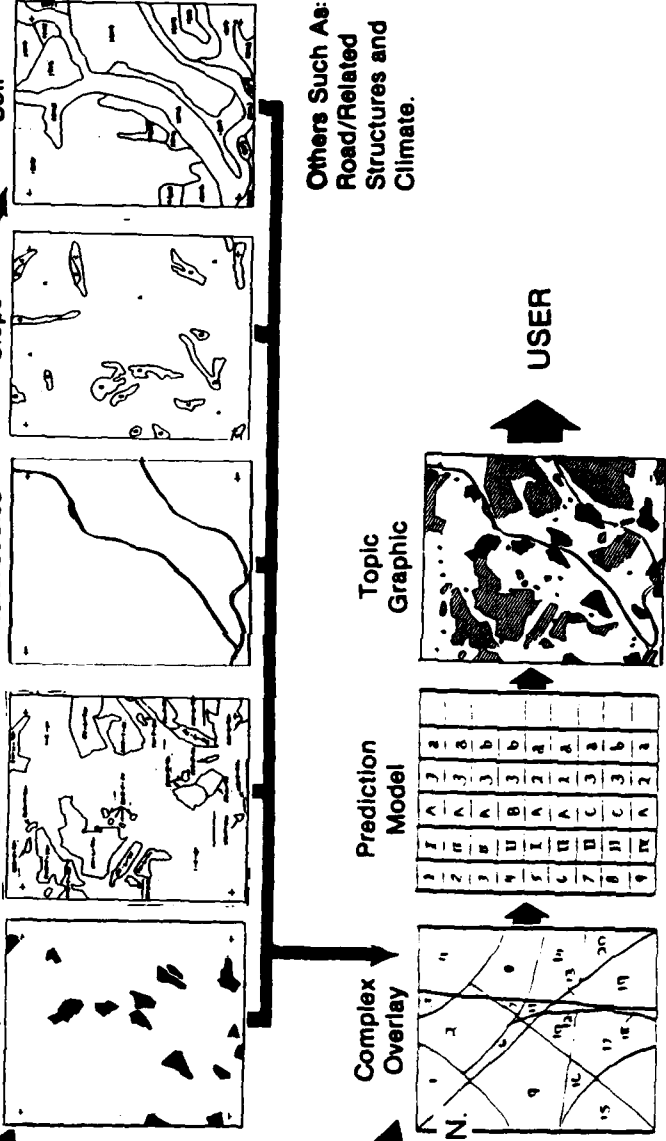
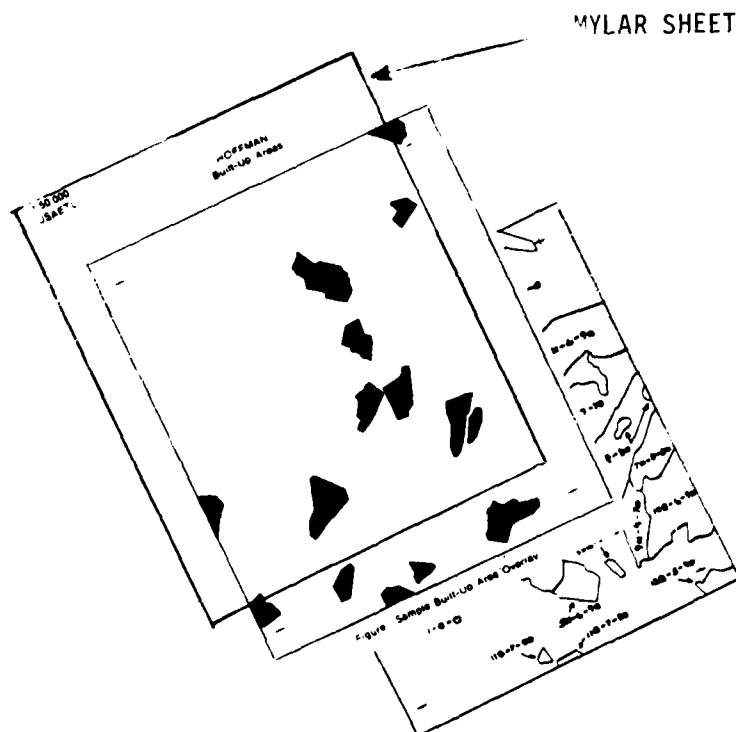


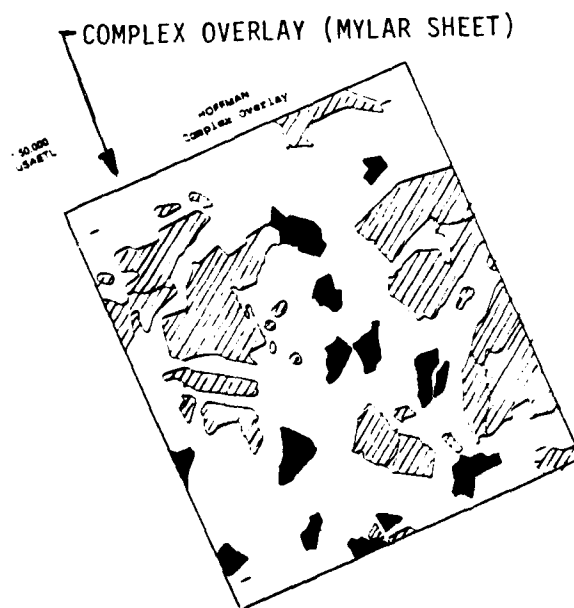
Figure 10. Operational Concept of the Military Geographic Intelligence Subsystem.

## B. Map Analysis

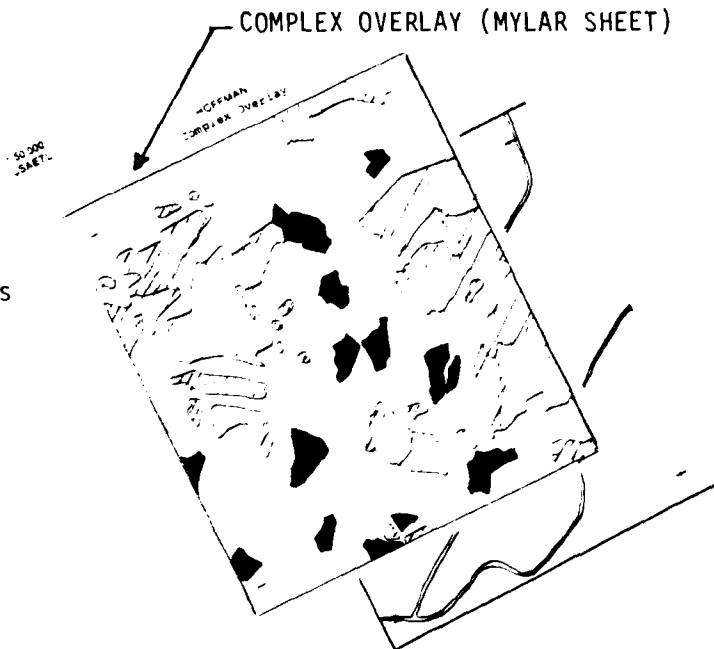
1. Pull the Built-up Areas and Vegetation Factor Overlays\* out of the data base and register the overlays. Place a clean frosted mylar sheet over the two factor overlays and register the mylar. Look through the mylar and redraw on the mylar the built-up areas and vegetation which are obstacles to T-72 Tank movement.



2. The mylar sheet now is a complex overlay of the built-up areas and vegetation obstacles.



3. The complex overlay (mylar sheet) is lifted from the Built-up Areas\* and Vegetation factor overlay. Pull the Watercourse and Water Bodies\* factor overlay out of the data base. Place the complex mylar sheet over the Watercourses and Water Bodies overlay; again register. Look through the complex mylar sheet and redraw on this sheet the watercourses and water bodies that are obstacles to T-72 tanks.



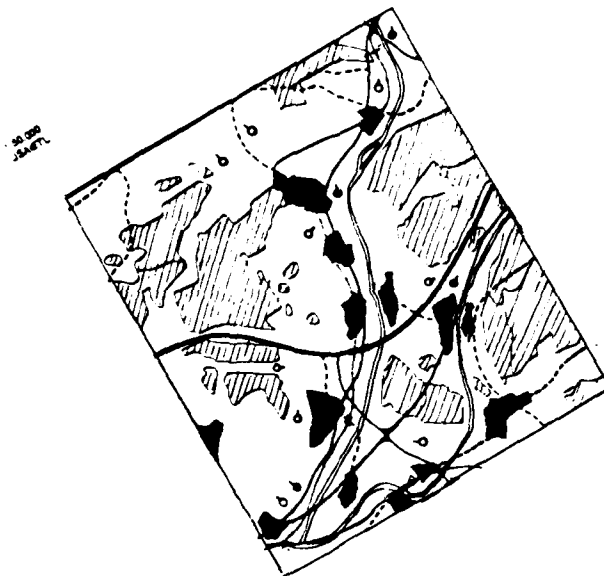
COMPLEX OVERLAY (MYLAR SHEET)  
COMPLEX OF BUILT-UP AREAS, VEGETATION  
AND WATERCOURSE AND WATER BODIES.

4. The complex overlay now contains all the built-up areas, vegetation, and watercourses and water bodies that present obstacles to tank movement.



\*Reference Terrain Analysis Procedural Guides.

5. The process of complexing pertinent factor overlays is continued. Slope, surface roughness and roads and related structures\* that are obstacles to tank mobility are added to the complex factor overlay. Gaps in the terrain that are devoid of existing obstacles are revealed. Locations for the deployment of a variety of reinforcing obstacles are symbolized on the completed Obstacle-Siting Map.

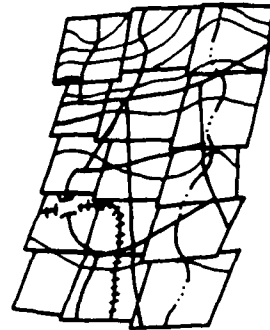


COMPLETED OBSTACLE-SITING MAP

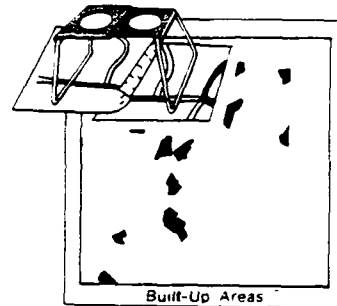
\*Reference Terrain Analysis Procedural Guide.

C. Photo Analysis

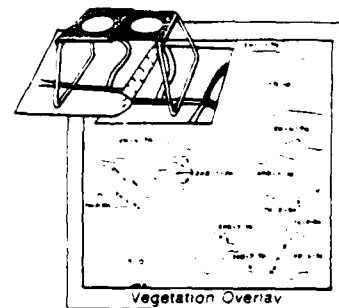
1. Prepare an informal (uncontrolled) lay-up from alternate photos.



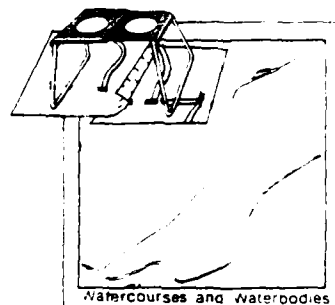
2. Examine stereoscopically the aerial lay-up for any changes or errors in the data base information. Revise and record any changes on draft overlay. These changes are positioned on the draft overlay by fitting to local detail on the subject factor map and the topographic base map. Clean up the overlay.



3. Examine stereoscopically the aerial lay-up for any changes or errors in the vegetation data base. Revise and record any changes on draft overlay. Clean up the overlay.

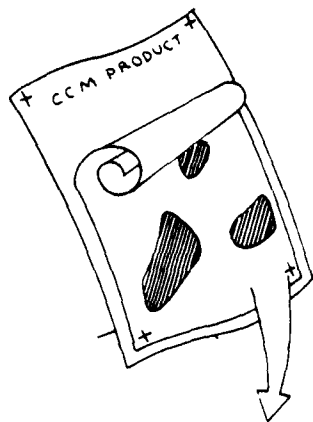


4. Do the same as in C3 for watercourses/water bodies, slope, surface roughness, and soil factor overlays. Clean up the overlays.



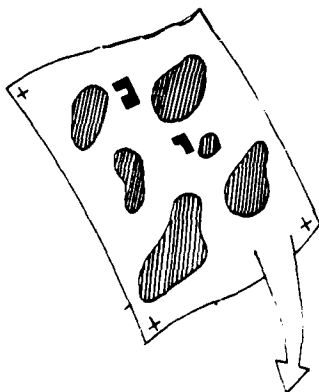
D. Preparatory Steps for Obstacle Siting Using Cross-Country Movement Map.

A.



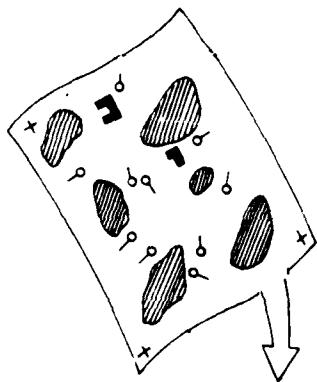
Trace from a CCM map product the areas that are existing obstacles to armor and/or infantry, i.e., T-76 or M-60. If wet and dry CCM's are available, consider two overlays. The 1:50,000 scale topographic base map, of the area should be available for reference.

B.



The overlay now shows only the areas of the CCM map that are existing obstacles to armor or infantry. The overlay will contain all natural, cultural, and urban obstacles that form an obstacle to movement.

C.



The same overlay is now studied to locate the best sites for reinforcing obstacles. These obstacles are used in the absence of existing obstacles or to complement the existing obstacles. Complementing means to fill gaps in terrain features or to extend existing obstacles. The reinforcing obstacles can be used purposely to narrow passages or to create choke points.

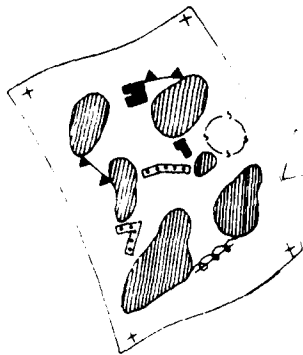


TABLE	
REINFORCING TERRAIN/ RE REQ'D	
OBSTACLES	
MINE -	3 HRS
FIELD	

D.

Selection of the specified reinforcing obstacles is the decision of the area commander. The terrain analyst may suggest several obstacle that are more amenable to the terrain and time required (table).

#### IV. THE MATHEMATICAL MODEL FOR EXISTING BARRIERS

The mathematical model used in this guide is taken in part from the Synthesis Guide for Cross-Country Movement<sup>1</sup> and enables the analyst to determine the maximum vehicle speed in a specific terrain. The model is a sequence of equations that takes the maximum vehicle speed for an unobstructed flat surface and reduces that speed by calculated factors representing terrain elements that would prevent a vehicle from achieving a speed not much greater than zero. These calculated factors reflect the stopping effect of built-up areas, vegetation, watercourses and water bodies, slope, soil, and surface roughness. This stopping effect can be the result of individual factors or of several factors in combination.

Built-up areas are treated as an obstacle to armor because they reduce the speed of the vehicles to approximately zero. If a built-up area lies within an otherwise high speed mobility corridor, it blocks this path to high speed armor.

The vegetation speed reduction factors can be calculated using the equations below:

$$F_1 = \frac{\text{STEM SPACING} - \text{MEAN STEM DIAMETER} - \text{VEHICLE WIDTH}}{2 \times \text{VEHICLE WIDTH}}$$

$$F_2 = \frac{(\text{STEM DIAMETER})^2 \times \text{VEHICLE WIDTH}}{(\text{VEHICLE OVERRIDE DIAMETER})^2 \times (\text{STEM SPACING})}$$

Where  $F_1$  and  $F_2$  are the speed reduction factors owing to the effects of vegetation elements and vehicle width, if either  $F_1$  or  $F_2$  is equal to or less than zero, the passage is blocked.

Watercourses and water bodies are treated the same as built-up areas. They are obstacles if by their size they prevent the crossing of the vehicle. As in built-up areas, there is no equation for watercourses and water bodies, simply a GO (no obstacle) or NO GO (obstacle).

The slope-elements stopping effect, expressed as a speed ( $S_1$ ), can be calculated using the equation below:

$$S_1 = M - \frac{(S)(M)}{G}$$

WHERE:  $S_1$  = SPEED AFTER SLOPE EFFECT (KPM)

<sup>1</sup>Alexander R. Pearson and Janet S. Wright, Synthesis Guide for Cross-Country Movement, ETL-0220, February 1980, U.S. Army Corps of Engineers, Engineer Topographic Laboratories, Fort Belvoir, VA 22060, AD-A084 007.

M = VEHICLE MAXIMUM SPEED (KPM)

S = SLOPE (%)

G = VEHICLE GRADABILITY (%)

If the speed ( $S_1$ )  $\leq 0.5$  KPH, the area is considered an obstacle. The speed of 0.5 KPH is arbitrarily picked as the speed below which the terrain behaves as an obstacle. In military situations, the definition of what constitutes a slow speed will depend on weapons, deployment, and time available to the friend and the enemy. It is a definition that is ultimately left to the military commander.

If the speed ( $S_1$ ) is  $\geq 0.5$  KPH, we proceed to the next equation. These equations treat the combined effect of both vegetation and slope on the vehicles speed (KPH):

$$S_2 = S_1 \times F_1$$

OR

$$S_2 = S_1 \times F_2$$

WHERE:  $S_2$  = SPEED AFTER VEGETATION AND SLOPE EFFECT (KPH)

If the effect of slope and vegetation reduces the speed to 0.5 KPH or less, the area is considered an obstacle. However, as in the case of  $S_1$ , the speed  $S_2$  will be assumed to be greater than 0.5 KPH; thus we can proceed to the next step in the series of equations.

The effect of vegetation, slope, and surface roughness is reflected in the speed ( $S_3$ ) as calculated by the following formula:

$$S_3 = S_2 \times F_3$$

WHERE:  $S_3$  = SPEED AFTER SURFACE ROUGHNESS, VEGETATION, AND SLOPE EFFECT (KPH)

$F_3$  = A FACTOR  $\leq 1$  BY WHICH SURFACE ROUGHNESS REDUCES VEHICLE SPEED

AND WHERE:

$$f_3 = \frac{100 - \left[ \frac{2 (\text{Obstacle ht. (cm)}) + \text{Veh. approach angle (}^\circ\text{)}}{\text{Obstacle spacing (m)}} \right]}{100 (\text{constant for all vehicles})}$$

The surface roughness factor ( $F_3$ ) can be obtained from a table such as the following:

MAP UNIT	TRACKED VEHICLE (F <sub>3T</sub> )	WHEELED VEHICLE (F <sub>3W</sub> )
1	1	1
2	1	9
3	9	5
4	5	3
5	3	1
6	2	NO-GO
7	1	NO-GO
8	NO-GO	NO-GO

Note: F<sub>3</sub> Values are the same for all types of Tracked Vehicles (F<sub>3T</sub>) and for all types of Wheeled vehicles (F<sub>3W</sub>).

Again, if the speed (S<sub>3</sub>) is sufficiently reduced by the surface roughness (F<sub>3</sub>) as to fall below 0.5 KPH, the area is defined as an obstacle. If, however, the speed S<sub>3</sub> ≥ 0.5 KPH, the next equation in the series dealing with soil is employed:

$$S_4 = S_3 \times F_4$$

WHERE: S<sub>4</sub> = SPEED AFTER SOIL, SURFACE ROUGHNESS, VEGETATION, AND SLOPE CONSIDERED (KPH)

$$f_4 = \frac{\text{RATED CONE INDEX} - \text{VEHICLE CONE INDEX, L PASS}}{\text{VEHICLE CONE INDEX, 50 PASSES} - \text{VEHICLE CONE INDEX, 1 PASS}}$$

THE RATED CONE INDEX OF A SOIL (RCI) AND THE VEHICLE CONE INDEX (VCI) CAN BE FOUND IN TABLE C6, C7.

If the speed S<sub>4</sub> ≥ 0.5 KPH, it signifies that an area is trafficable to the vehicle specifications inputted at the beginning of this series of equation.

## V. PROCEDURES FOR CONSTRUCTING THE COMPLEX OVERLAY

### A. Constructing the Obstacle-Siting Overlay (Model Approach)

Step 1. Depending on the type of obstacle map to be produced, decide whether the dry or wet season Complex Overlay is to be prepared. If only a dry season obstacle map is to be produced, base the Complex Overlay on the various factor overlays that are for the dry season conditions only. The synthesis processes presented on the next several pages are based on data for the dry season.

#### Step 2.

a. Take the film positive or the lithographic map and aerial photos out of the data base. Place them on a table. Take a clean sheet of frosted mylar, the same size as the film or lithographic map, and place it, frosted side up, on the top of the film or litho map. Pin-register them or tape them together. Trace the corner tick marks on the mylar with a black fine-line pencil. Trace the neat line on the mylar lightly with a blue fine-line pencil.

b. Look through the mylar to find the built-up areas. They will appear as clusters of building symbols or sometimes as tinted areas. Using a black fine-line pencil, draw an angular outline that will tightly enclose clusters of building symbols or tinted areas that cover an area of 10 mm x 10 mm (.39 in x .39 in) \*or larger. Equivalent areas are acceptable providing the narrowest dimension is not less than 6 mm (.24 in). Color in these outlined areas with a red fine-line pencil as in figure 11 (aerial photos may be used to update the extent of the built-up areas).

#### Step 3.

a. Remove the mylar sheet (which will now be called the Complex Overlay). Pull the Vegetation Factor Overlay (figure 12) out of the data base. Put the Complex Overlay on top of the Vegetation Overlay. Pin-register, match corner ticks and tape the sheets together.

b. Trace all the lines of the Factor Overlay on the Complex Overlay with a black fine-line pencil. Do not draw any lines through colored areas already on the Complex Overlay, and where the space between them is smaller than 2.0 (.08 in)\*\*, do not draw the new line.

\*Represents an area of .25 km<sup>2</sup> at 1:50,000 scale.

\*\*100 meter spacing at 1:50,000 scale.

1:50,000  
USAETL

HOFFMAN  
Built-Up Area Overlay

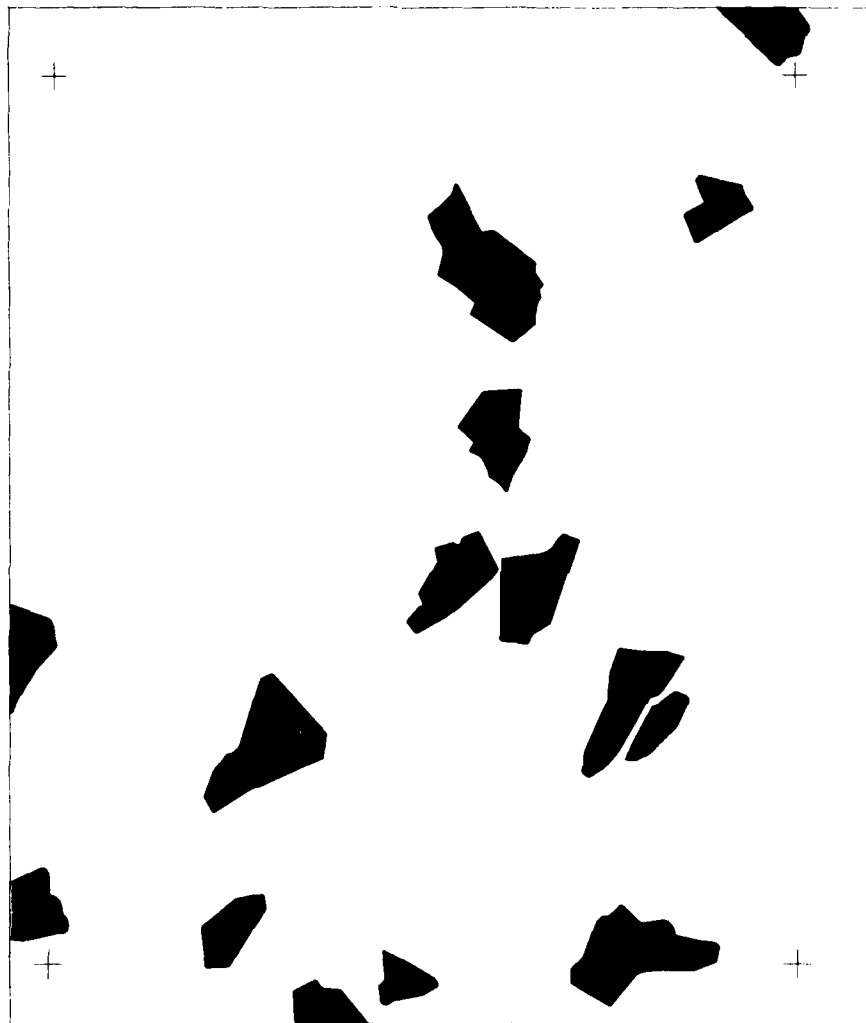
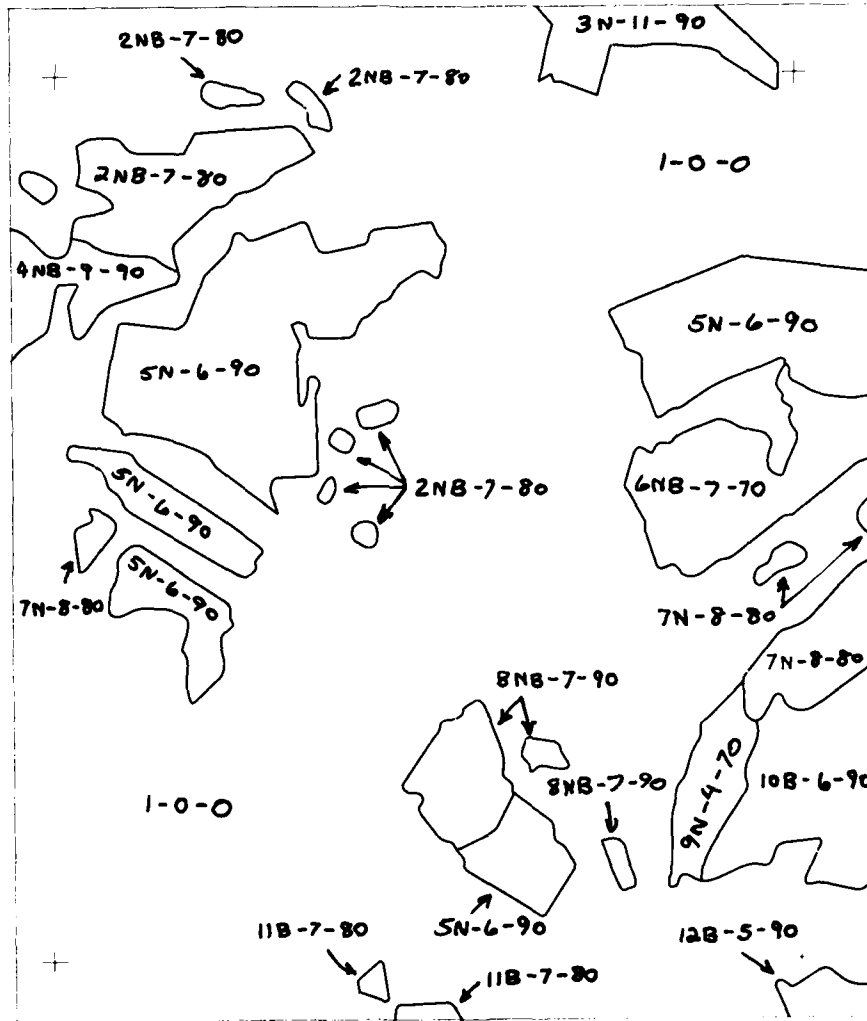


Figure 11. Sample Built-up Area Factor Overlay.

1:50,000  
USAETL

HOFFMAN  
Vegetation Overlay



**LEGEND**

MEAN HT. TO TOP  
OF CANOPY IN M.  
3B-7-80

MAP UNIT IDENT. 3B-7-80

% CANOPY CLOSURE  
DURING SEASON OF  
MAX. CLOSURE

N - NEEDLELEAF  
B - BROADLEAF  
NB - MIXED

Figure 12. Sample Vegetation Factor Overlay.

c. Refer to information in Data Tables accompanying the Vegetation Overlay (tables not shown). Insert this information in the CCM vegetation equations (see appendix A). When that part was done for this exercise, all the vegetation map units shown in figure 12 were found to be obstacles to the T-72 tank. All map units except map unit 1 were therefore colored in with a yellow fine-line pencil as in figure 13. Figure 13 is the Sample Complex Overlay with built-up areas and vegetation added.

#### Step 4.

a. Remove the Complex Overlay (figure 13) from the Vegetation Factor Overlay. Put the Vegetation Factor Overlay aside for later use. Pull the Watercourses and Water Bodies Factor Overlay (figure 14) out of the data base. Place the Complex Overlay (which now may have red areas, yellow areas, and black lines on it) on top of the Watercourse and Water Bodies Factor Overlay (figure 14). Pin-register, or match corner ticks and tape.

b. Refer to table C4 to determine the maximum fording depth of the T-72 tank. Compare this value with the low water depth of each watercourse segment. Trace and color in all drainage features indicated as a natural obstacle (NO GO) during the dry season with a blue fine-line pencil as shown in figure 14. When compiling a wet season overlay, trace in red all drainage features shown as an obstacle (NO GO) during the wet season. A Complex Overlay with built-up areas, vegetation, and watercourse/water bodies appears in figure 15.

#### Step 5.

a. Remove the Complex Overlay from the Watercourses and Water Bodies Factor Overlay. Put the Watercourse and Water Bodies Factor Overlay aside for later use. Pull the Slope Factor Overlay (figure 16) out of the data base. Pin-register, or match tick marks and tape. If a slope factor overlay does not exist, then refer to ETL's Terrain Analysis Guide for Surface Configuration<sup>2</sup> for procedures for obtaining slope.

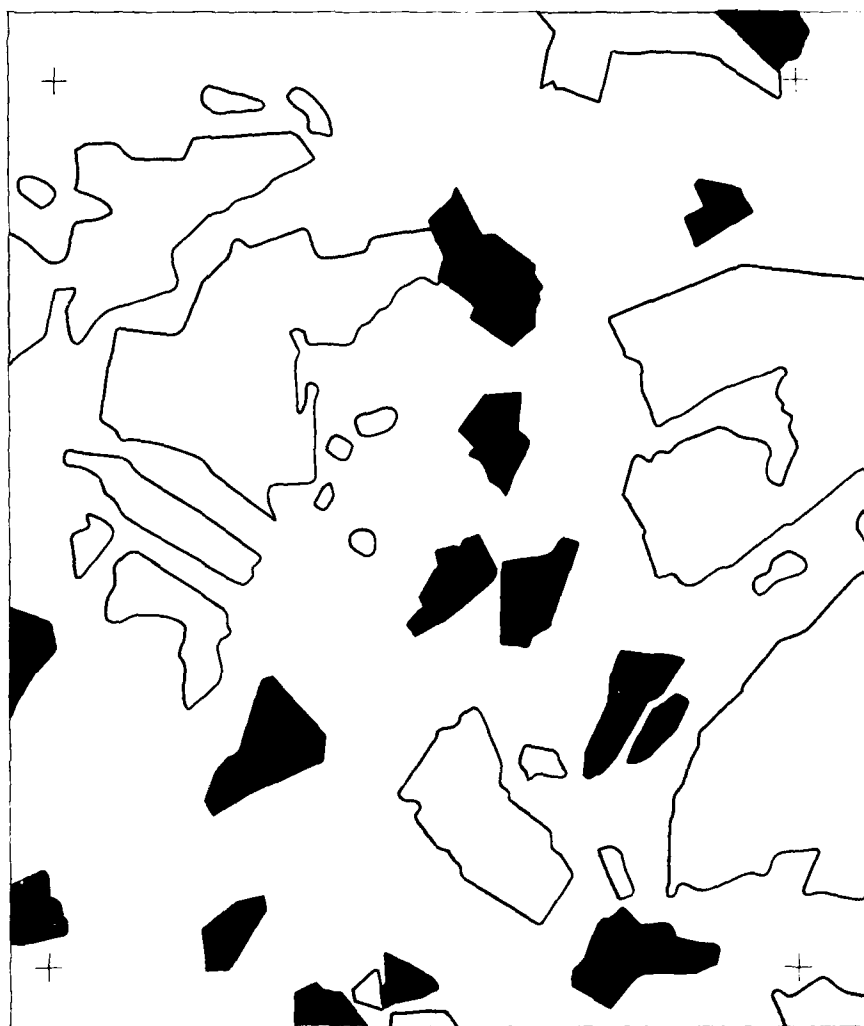
b. With a black fine-line pencil, trace only those steeply inclined areas from the Slope Factor Overlay that are natural obstacles to vehicular movement. Do not draw any lines through colored areas already on the Complex Overlay. If a new line nearly coincides with a line already drawn on the Complex Overlay and the space between them is smaller than 2.0 mm (.08 in), do not draw the new line.

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<sup>2</sup>Oliver Mintzer, Terrain Analysis Guide for Surface Configuration, U.S. Army Corps of Engineers, Engineer Topographic Laboratories, Fort Belvoir, VA 22060, Report in progress.

1:50,000  
USAETL

HOFFMAN  
'Obstacle Complex Overlay



LEGEND


 TREE SPACING AND  
STEM DIAMETER  
IMPEDES ARMOR

Figure 13. Sample Complex Overlay with Built-up Areas and  
Vegetation Added.

1:50,000  
USAETL

HOFFMAN  
Watercourses and Waterbodies Overlay

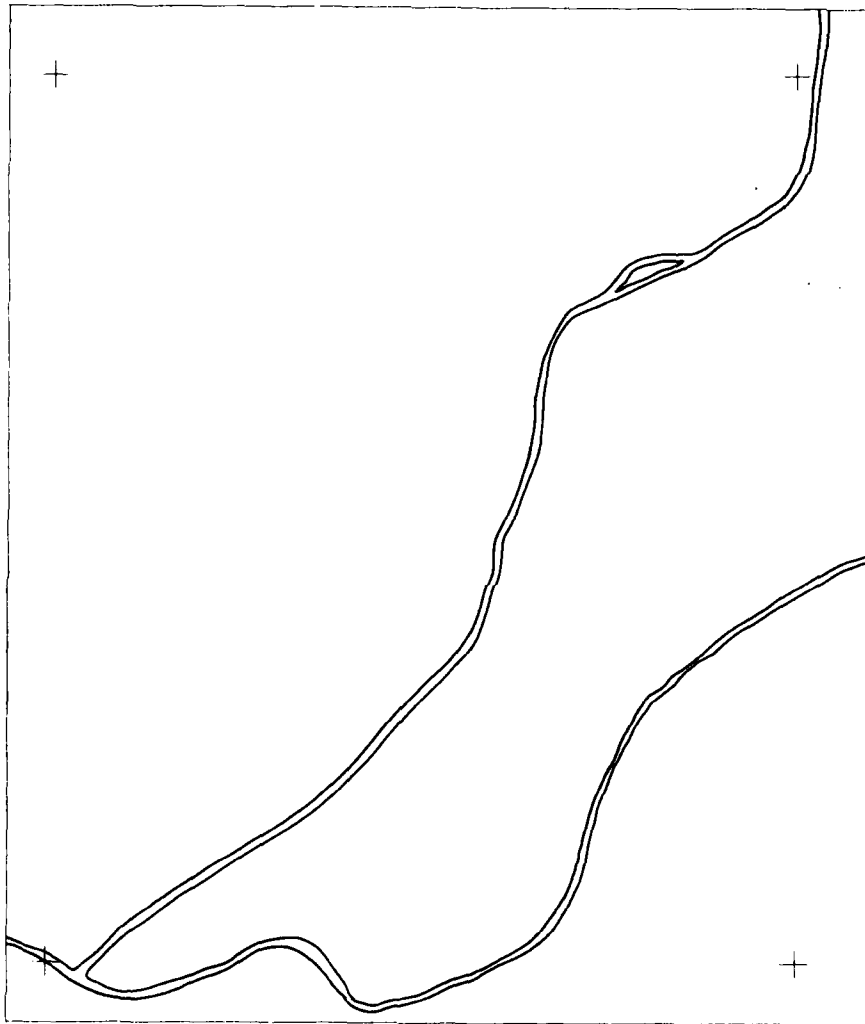


Figure 14. Sample Watercourses and Water Bodies Factor Overlay.

1:50,000  
USAETL

HOFFMAN  
'Obstacle Complex Overlay

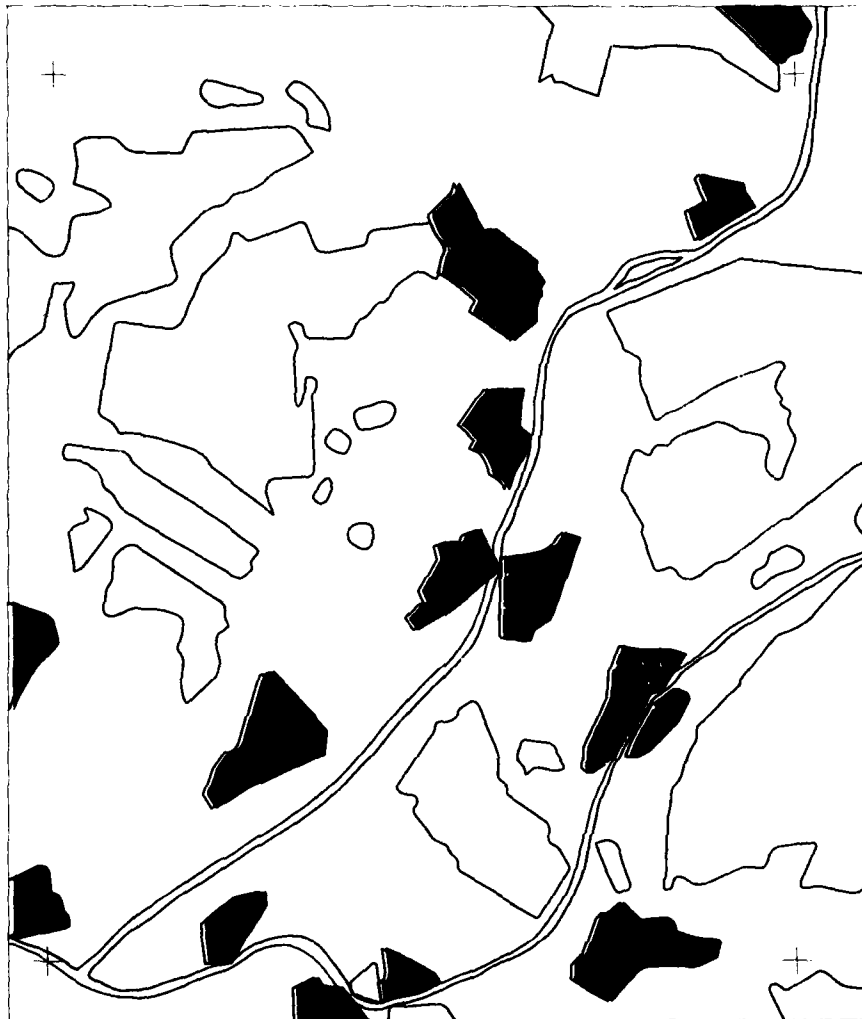


Figure 15. Sample Complex Overlay with Built-up Areas, Vegetation, and Watercourses and Water Bodies Added.

c. In compiling the sample Complex Overlay, look in table C4 to find the maximum slope (") for the T-72 tank. Find areas with slopes that exceed this maximum slope value and that will contribute as being natural obstacles (NO GO) for T-72's (figure 16). Color them in with a yellow fine-line pencil. In the Sample Slope Overlay shown, no areas exceed 30°, so it is doubtful that the slopes contribute much to the obstacle system, especially during the dry season.

#### Step 6.

a. Remove the Complex Overlay from the Slope Factor Overlay. The sample Complex Overlay now consists of built-up areas, vegetation, watercourses/water bodies, and slope (figure 17). Pull the Surface Roughness Factor Overlay (figure 18) out of the data base. Pin-register, or match corner tick marks and tape.

b. Trace the boundaries of surface roughness - units 6, 7, and 8 for wheeled vehicles; units 7 and 8 for tracked vehicles - onto the Complex Overlay with a black fine-line pencil. Do not draw any lines through colored areas already on the Complex Overlay. If a new line nearly coincides with a line already drawn on the Complex Overlay and the space between them is smaller than 2 mm (0.8 in), do not draw the new line. Color in the newly bounded areas with a yellow fine-line pencil as shown in figure 19.

#### Step 7.

a. Remove the Complex Overlay from the Surface Roughness Overlay. The Sample Complex Overlay now consists of built-up areas, vegetation, watercourses/water bodies, slope, and surface roughness (figure 19). Pull the Soil Factor Overlay (figure 20) out of the data base. Pin-register, or match corner tick marks and tape.

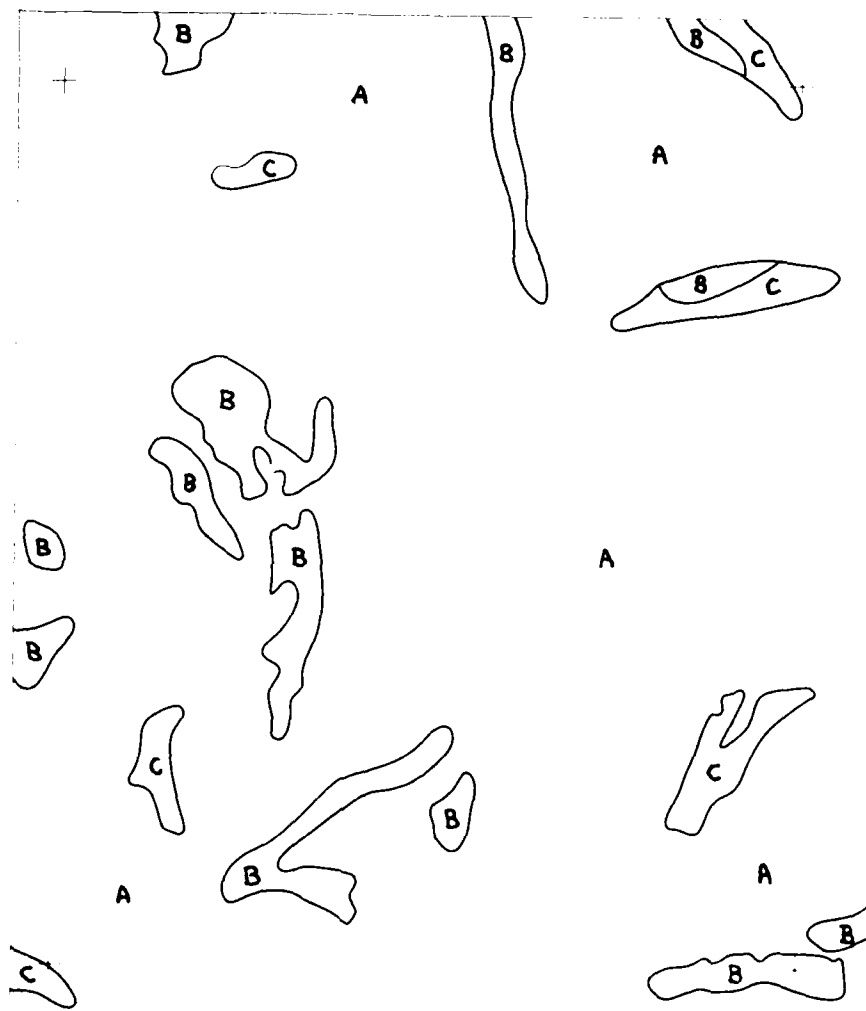
b. Since in this example it is the dry season, the soil overlay will not significantly add to the total obstacle areas. The general light (sandy) nature and low rainfall of the Hoffman area does not affect the surface strength of the soil (table C6).

c. Look in tables C7 & C8 to find all the NO GO soils that offer an obstacle to the T-72 for the dry season. Find these soil obstacles areas on the overlay. Color them in with a yellow fine-line pencil. Figure 21 is a Sample Complex Overlay with built-up areas, vegetation, watercourses/water bodies, slope, and soil. There is no difference between figures 19 and 21, because during the dry season, the soils are not weak enough to contribute to the overall obstacle area.

d. Trace all the lines on the Sample Soil Factor Overlay onto the Complex Overlay with a black fine-line pencil. Do not draw any lines through colored areas already on the Complex Overlay. If a new line

1:50,000  
USAETL

HOFFMAN  
Slope Overlay



LEGEND  
A=0-3%  
B=3-10%  
C=10-30%  
D=30-45%  
E=45-60%  
F=>60%

Figure 16. Sample Slope Factor Overlay.

1:50,000  
USAETL

HOFFMAN  
Obstacle Complex Overlay

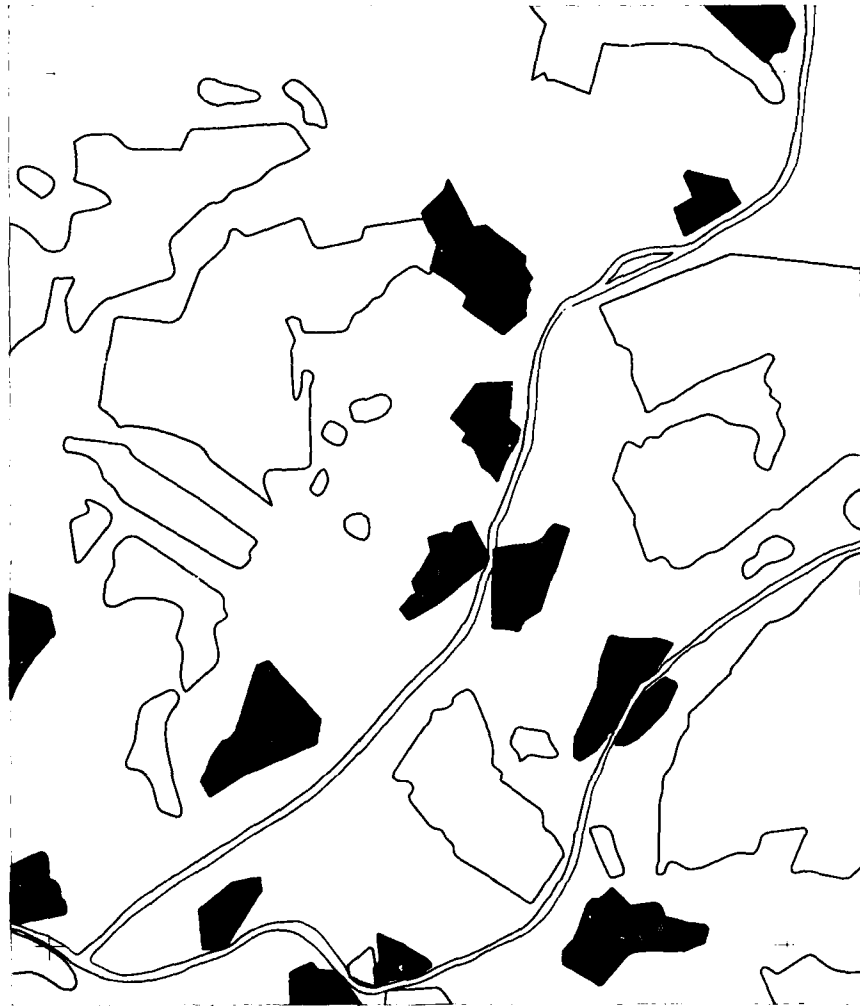
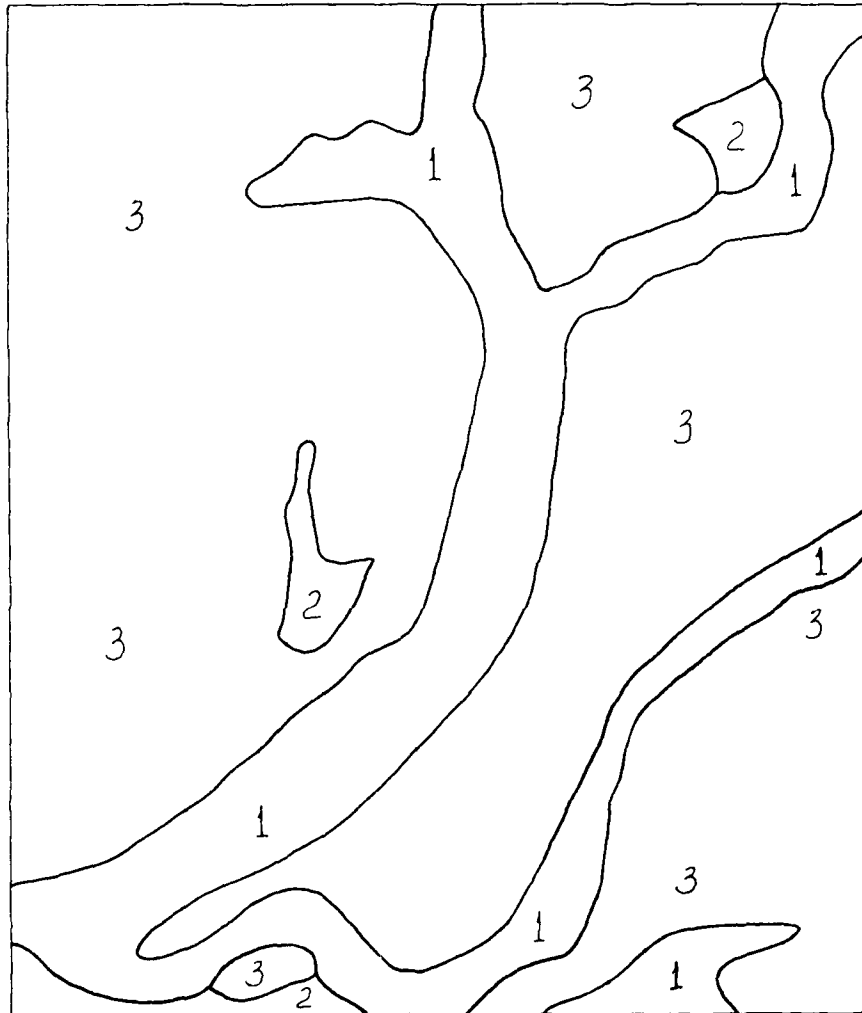


Figure 17. Sample Complex Overlay with Built-up Areas, Vegetation, Watercourses and Water Bodies, and Slope Added.

1:50,000  
USAETL

HOFFMAN  
Surface Roughness Overlay



LEGEND

- |                                   |                                   |
|-----------------------------------|-----------------------------------|
| 1. VERY SMOOTH, NO IRREGULARITIES | 6. MANY CLOSELY SPACED, LARGE     |
| 2. FEW SMALL IRREGULARITIES       | 7. MANY CLOSELY SPACED, LARGE     |
| 3. MANY SMALL IRREGULARITIES      | IRREGULARITIES W/SOME V. LARGE    |
| 4. MANY SMALL, SOME LARGE         | 8. MANY CLOSELY SPACED VERY LARGE |
| 5. MANY LARGE                     | IRREGULARITIES                    |

Figure 18. Sample Surface Roughness Overlay.

1:50,000  
USAETL

HOFFMAN  
Obstacle Complex Overlay

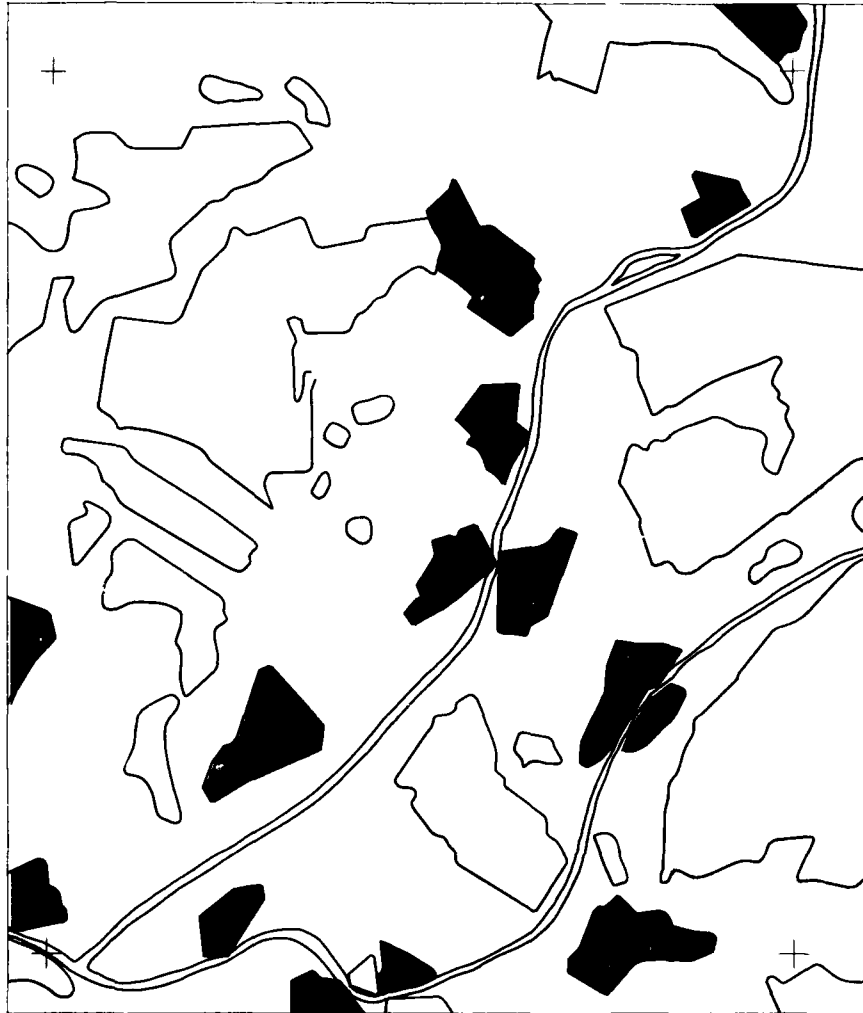
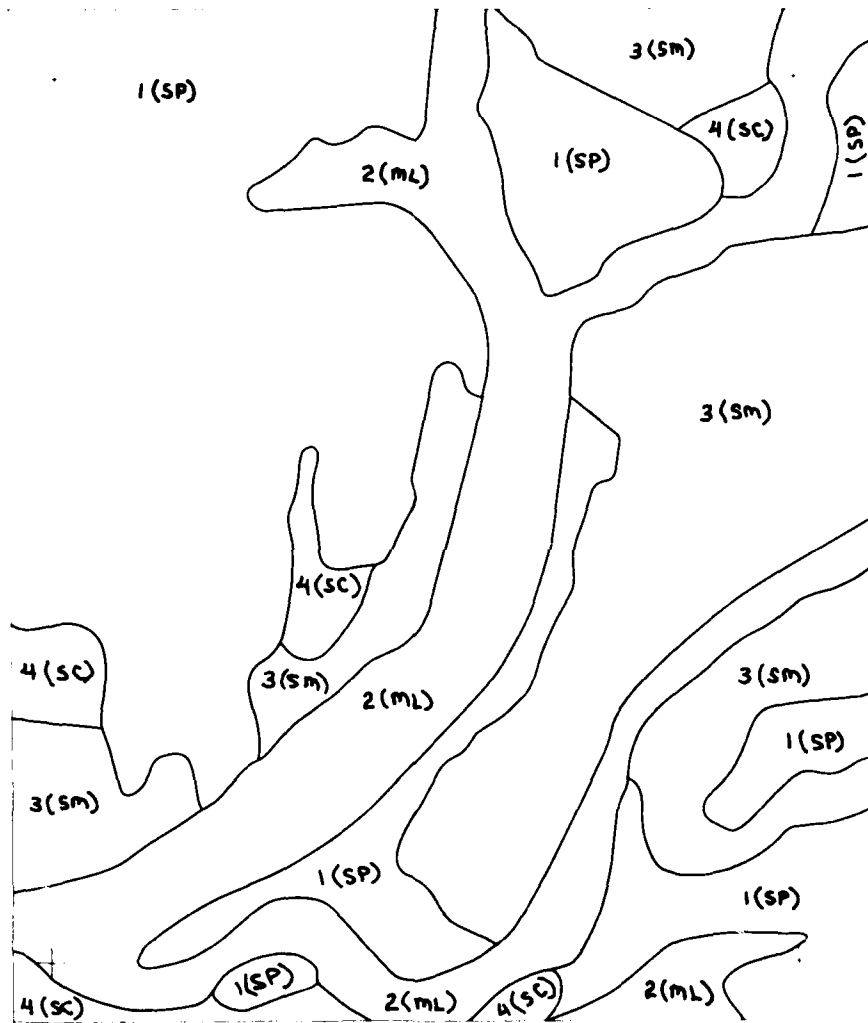


Figure 19. Sample Complex Overlay With Built-up Areas, Vegetation, Watercourses and Water Bodies, Slope, and Surface Roughness Added.

1:50,000  
USAETL

### HOFFMAN Soil Overlay



#### LEGEND

UNIT MAP NO. → 1 (SP)  
↓  
USES SYMBOL FOR SURFACE LAYER

SP - POORLY GRADED OR GRAVELLY SANDS  
SM - SILTY SANDS, SAND-SILT MIXTURE  
SC - CLAYEY SANDS, SAND-CLAY MIXTURE  
ML - INORGANIC SILTS

Figure 20. Sample Soil Factor Overlay.

1:50,000  
USAETL

HOFFMAN  
'Obstacle Complex Overlay

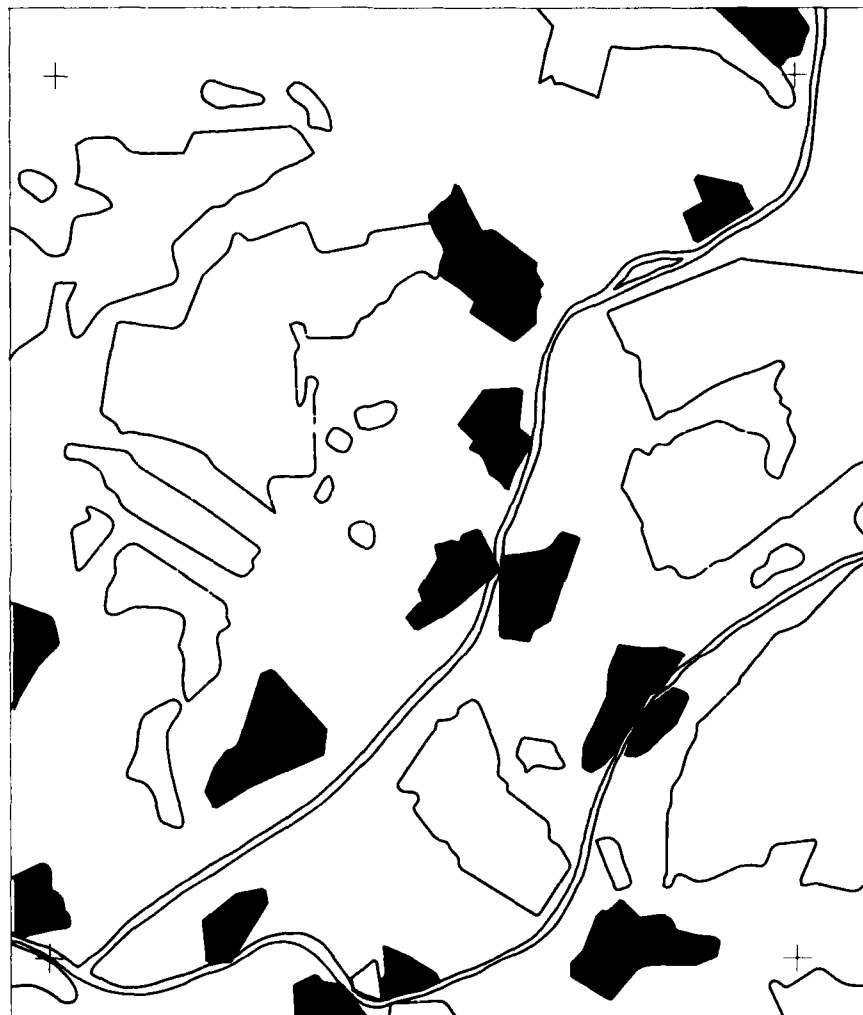


Figure 21. Sample Complex Overlay with Built-up Areas, Vegetation, Watercourses and Water Bodies, Slope, Surface Roughness, and Soil Added.

nearly coincides with a line already drawn on the Complex Overlay and the space between them is smaller than 2 mm (.08 in), do not draw the new line.

Step 8.

a. Remove the Complex Overlay from the Soil Factor Overlay. Pull the Roads and Related Structures Overlay (figure 22) out of the data base. Place the Complex Overlay on top of the Roads and Related Structures Overlay. Pin-register, or match corner ticks and tape.

b. Trace and color in black all the roads and structures features as shown in figure 22.



Step 9.

a. Figure 23 is a Sample Complex Overlay with built-up areas, vegetation, watercourses/water bodies, slope, soil, and roads/related structures.

b. Determine the most likely avenues of approach between the combined obstacles.

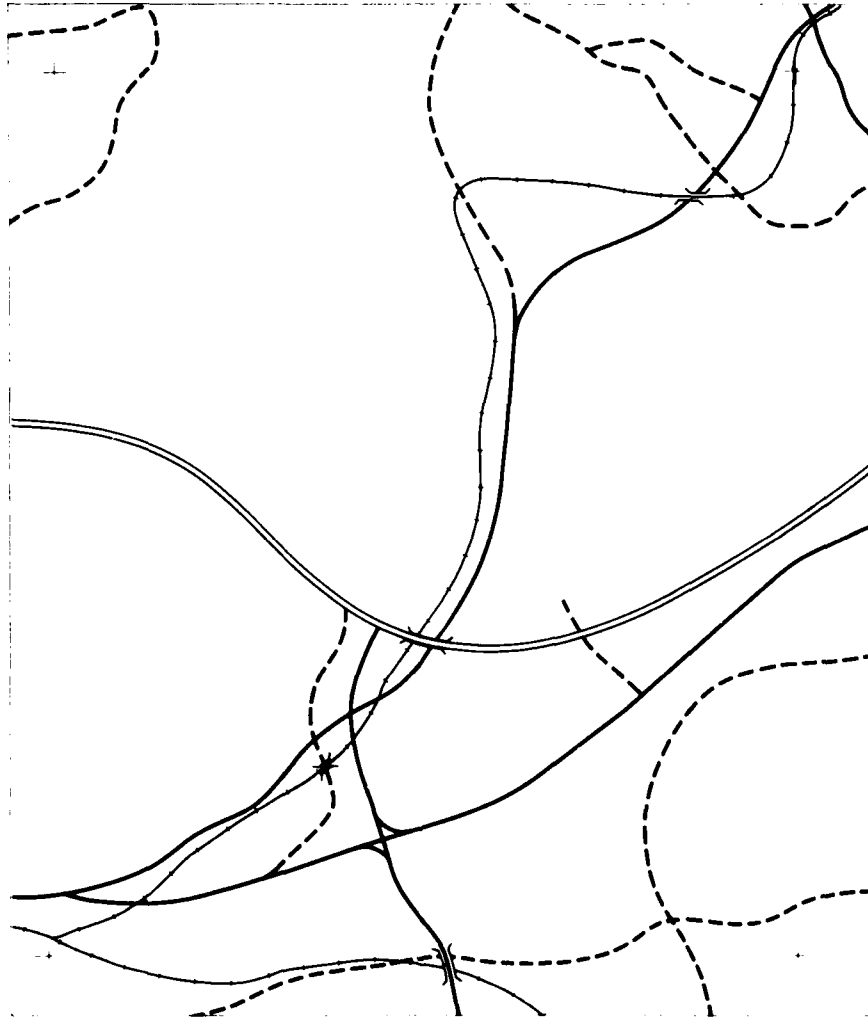
c. Indicate with green arrows the likely avenues of approach (figure 24).

Step 10.

With the help of the avenues of approach and roads/related structures, the optimum locations can be selected for placing reinforcing obstacles to enhance this part of the barrier system assigned to the Hoffman Quadrangle (figure 25). The reinforcing obstacle symbol is drawn as  for undefined obstacles and  for defined obstacles. An undefined obstacle is one that the tactical commander selects to best enhance the defense. A defined obstacle is one that is specified by higher headquarters to most likely fulfill a broader strategic plan.

1:50,000  
USAETL

HOFFMAN  
Roads and Related Structures Overlay



- LEGEND
- ==== DUAL HIGHWAY
  - ALL WEATHER, HARD SURFACE
  - - - - ALL WEATHER, LIGHT SURFACE
  - + + + + RAILROAD
  - ⌒ BRIDGE

Figure 22. Sample Roads and Related Structures Factor Overlay.

1:50,000  
USAETL

HOFFMAN  
Obstacle Complex Overlay



Figure 23. Sample Complex Overlay With Built-up Areas, Vegetation, Watercourses and Water Bodies, Slope, Surface Roughness, Soil, and Roads Added.

1:50,000  
USAETL

HOFFMAN  
Obstacle Complex Overlay



LEGEND



AVENUES OF APPROACH



COMBINED OBSTACLES

Figure 24. Sample Complex Overlay Showing Avenues of Approach.

1:50,000  
USAETL

HOFFMAN  
Obstacle Complex Overlay



LEGEND  
○ REINFORCING OBSTACLES  
(UNSPECIFIED)

◐ COMBINED EXISTING OBSTACLES

Note: Roads left out for simplicity

Figure 25. Sample Complex Overlay Showing Reinforcing Obstacles in Locations Devoid of Existing Obstacles.

B. Constructing the Obstacle-Siting Overlay Derived from a Cross-Country Movement Map.

A first glance at a CCM map should reveal how much effort will be required to develop an effective obstacle system (figure 26). The amount of additional effort will generally be in direct proportion to the amount of armor-trafficable terrain present. An example of a high percentage of armor-trafficable terrain requiring numerous reinforcing obstacles is presented on the CCM map of Fort Riley, Kansas (figure 26). Virtually all of the area is favorable to armor traffic.

The Fort Riley CCM map, however, has areas not negotiable by armor that can be extended into an obstacle system by using reinforcing obstacles placed at strategic locations (figure 27). The type of obstacle is at the discretion of the commander, and listings describing various obstacles with the required effort, time, and terrain appear in table 1, 2, and 3.

Although most CCM maps show road and rail networks, the vivid coloring of the basic CCM map makes them difficult to locate. It is suggested that in the construction of potential minefield sites from available CCM maps, some means should be employed to enhance the lines of communication (LOC). An LOC transparency would be helpful in a more intelligent selection of optimum location of reinforcing obstacles.

As in step 1, lines of communication do not stand out, and some means to represent the LOC should be considered.

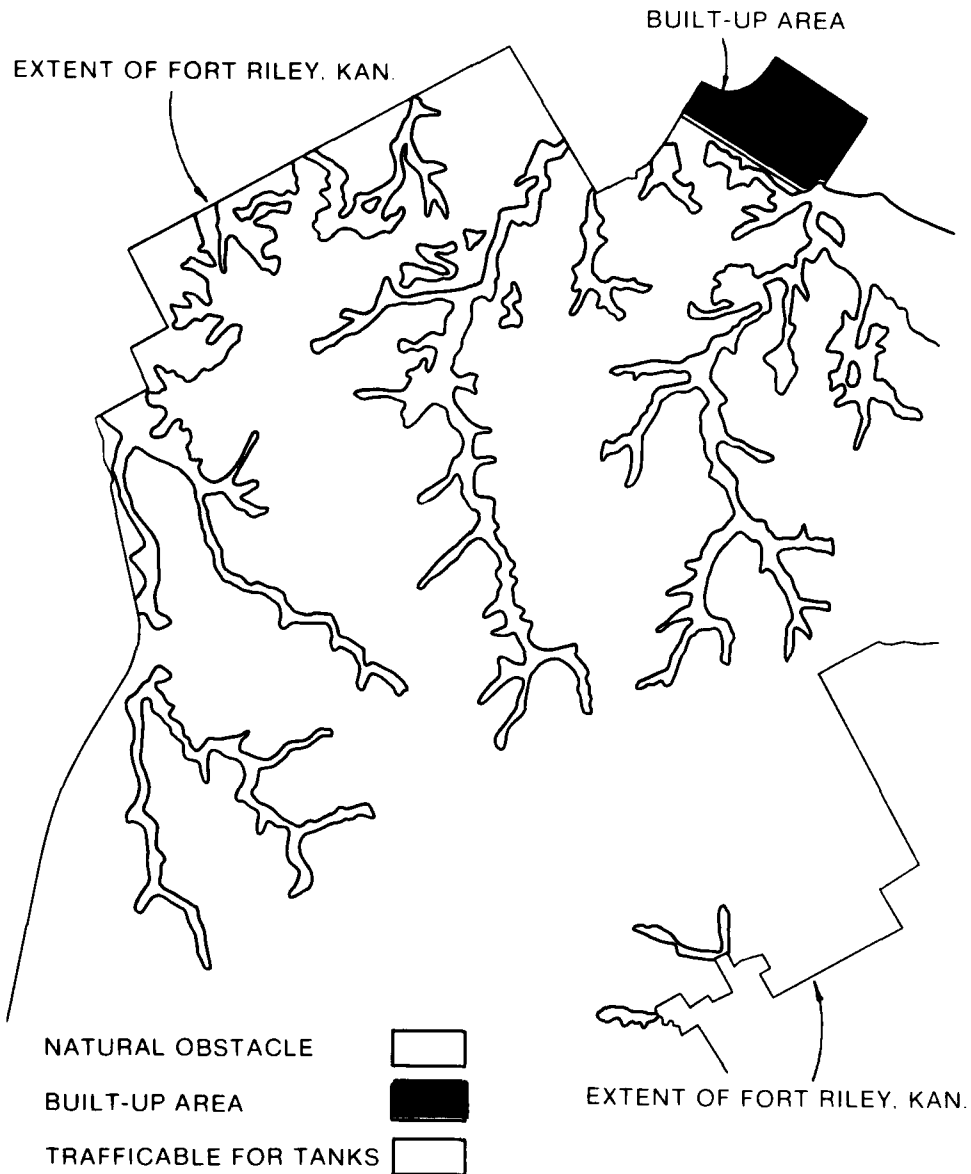
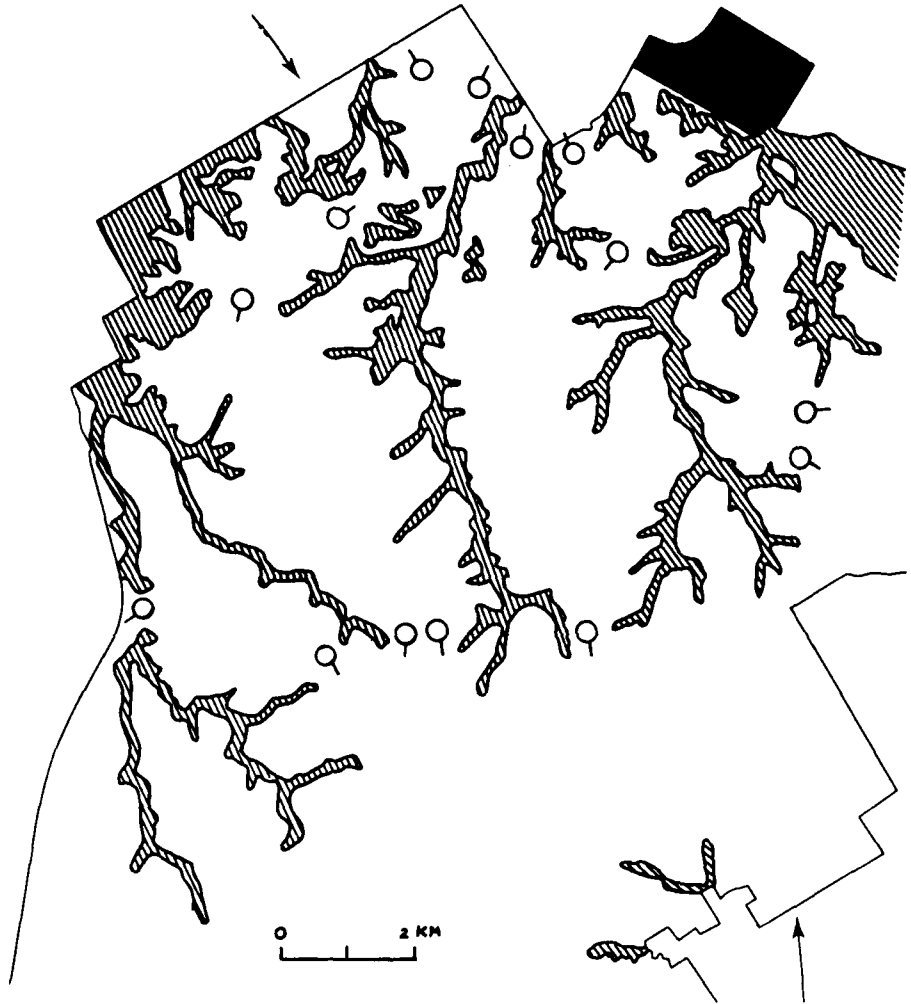




Figure 26. The Result of Tracing on an Overlay the NO GO (Existing Obstacles) Areas from an Actual CCM Map of Fort Riley, Kansas.

EXTENT OF FORT RILEY, KAN.



NATURAL OBSTACLE   
UNSPECIFIED REINFORCING OBSTACLE 

EXTENT OF FORT RILEY, KAN.

Figure 27. The Siting of Unspecified Reinforcing Obstacles to Extend or Complement the Existing Obstacles (Natural Obstacles). Version Very Close to the Final Product.

Table 2. Reinforcing Obstacles vs Time and Effort.

<u>OBSTACLES</u>	<u>EFFORT/TIME</u>
Road Craters Type A	2 Sqd Hrs (434 lbs explosives)
Road Craters Type B (Hasty)	2 Sqd Hrs (400 lbs explosives)
Road Craters Type C (Mines)	1 Sqd Hr (730 lbs explosives)
Bridge Type A (4 lanes)	3 Sqd Hrs (900 lbs explosives)
Bridge Type B (2 lanes)	? Sqd Hrs (500 lbs explosives)
Bridge Type C (Secondary 2 lane)	1 Sqd Hr (370 lbs explosives)
Antitank Ditches Sand (scraper/pusher) Clay	100 meters/hr 125 meters/hr
Sand (dozer/loader) Clay	100 meters/hr 80 meters/hr
Abatis (with mines)	2 Sqd Hrs (300 lbs explosives)
Wire (general purpose barbed)	1 man-hr for 300 meters
Concertina (Triple)	1 platoon-hr/300 meters
Trenches 2 ft x 4 ft	15 meters/hr w/backhoe
Mineplanter Minefield (300 meters)	2 Sqd Hrs
Tow/Position :	1 Sqd Hr (Handtools)
Tank/APC Defilade	0.5 Dozer-hr

Table 3. Reinforcing Obstacles vs Terrain Requirements.

<u>Obstacle</u>	<u>Requirements</u>
Ditches Cuts Embankments	Sufficient soil depth. Absence of trees preferred.
Tanktraps	Sufficient soil depth. Absence of trees preferred.
Hedgehogs	Not on high slopes. Excellent in tall grass, wheat.
Abandoned Equipment	Almost anywhere
Dragons Teeth	Not on high slopes, swamps
Minefield (Buried) - AT	Sufficient soil depth (30 cm). Absence of trees. Not on mountain sides, marshes.
Minefield (Surface) - AT	Not generally on mountain sides. Absence of trees preferred.
Antipersonnel Mines - AP	Sufficient soil depth (15 cm)
Craters	Soil
Lapland Fence	Used in deep snow
Log Obstacle	Source of trees
Abatis	Tree diameter of at least 55 cm
Wire (all types)	None
Caltrops	Not on steep slopes. excellent in high grass
Snow Obstacles	None
Ice Tanktraps	None

## APPENDIX A

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## APPENDIX B

### GLOSSARY

Barrier Trace - General line joining the major nature obstacles astride avenues of approach.

Barrier System - A coordinated series of related barriers located in depth and designed to canalize or stop enemy movement.

Forward Barrier - A barrier located generally along the initial and successive defense areas of the forward divisions. Consists of defense areas, strong points, coordinated fire of all weapons, and natural and artificial obstacles.

Barrier - Consists of defense areas, strong points, coordinated fields of fire of all weapons, and natural and artificial obstacles. They are not necessarily continuous, but may consist of a series of coordinated obstacles located in depth.

Choke Point - A location where a minimum of effort will result in an obstacle with the greatest effect.

Strong Point - A battle position which is fortified as strongly as possible within the time constraints to withstand direct assaults from armor and dismounted infantry. It is located on key terrain that is critical to the defense, and it controls an avenue of approach likely to be used by enemy mechanized forces.

Obstacle - Any obstruction that stops, delays, or restricts movement.

Existing Obstacles - Obstacles, both natural and cultural, that are already part of the terrain.

Natural Obstacles - Obstacles that are the result of nature.

Cultural Obstacles - Obstacles that are the works of man, such as stone walls, dikes, canals, and built-up areas.

Factor Overlay - A method of preformatting data to a uniform format, generally on semitransparent overlay.

Synthesis - The combination of terrain factors and their effects.

Reinforcing Obstacles - Obstacles specifically constructed, emplaced or detonated to serve the purpose of an anticipated military action (conventional) or one that already is in progress (dynamic).

Fields of Fire - An area that a weapon or group of weapons can cover effectively with fire from a given position. The type of weapon

determines which factors of the terrain will be significant to fields of fire. The natural terrain must be evaluated according to its suitability for flat-trajectory weapons, high-trajectory weapons, rockets, and guided missiles, including those with nuclear capabilities.

Concealment - The hiding or disguising of military installations or activities from enemy observation.

Cover - Protection from enemy fire.

Avenues of Approach - An area of terrain which provides a suitable, relatively easy route of movement for a force of a particular size and type. It should provide concealment and cover from defenders' observation and fields of fire for the attackers.

Gap - A portion of a barrier in which no obstacles have been constructed. It is wide enough to enable a friendly force to pass through in tactical formation; it is in excess of 16 meters and seldom less than 100 meters.

Barrier Study - A study of the terrain in a specific area, based on the broad operational concept for the area and designed to develop recommendations for the optimum use and maximum effect of natural and artificial obstacles as well as for construction effort within the area. The term is used almost exclusively at echelons above corps level.

Echelons Above Corps (EAC) - A fairly recent description of all military organizations above corps, i.e. Field Army, Army Group, and Theater of Operations.

APPENDIX C  
SAMPLES TABLES



TABLE C2. SLOPE FACTOR TABLE ( $S_1$ )

MAP UNIT	SLOPE (%)	$S_1$ (kph)	NO GO



TABLE C4. COMPARISON OF TANK CHARACTERISTICS

	Vehicle					
	XM-1	M-60	M-113	M-35	T-62	T-72
Gradability (%)	68.7	60	60	64	62.5	(62.5)
Max. Road Speed (kph)	71	48	48	56	50	(60)
Width (m)	3.65	3.63	2.69	2.43	3.37	3.38
Override Diameter (m) (at Breast Height)	0.25	0.15	0.1	06		(0.18)
Vehicle Cone Index, 1 Pass (VCI)	24	25	20	30	23	45
Vehicle Cone Index, 50 Passes (VCI <sub>50</sub> )	56	70	47	69	68	(60)
Max Fording Depth, w/o Snorkel (m)	1.22	1.22	Swims	76	1.40	(1.40)
Max. Fording Depth, w/Snorkel (m)	2.34	2.44	Swims		5.00	(5.50)
Max. Stream Velocity Vehicle Can Cross (m/s)	(3.5)	3.4	1.8	(1.0)	(3.4)	(3.4)
Vehicle Approach Angle (°)	22.5	43	70	48		(32.5)
Max. Height. Vert Obstacle (m)	1.24	.91	.61	.35	.80	(1.00)
Ditch Crossing Capability (m)	2.77	2.59	1.68	.55	2.85	(2.80)

( ) = Estimated

TABLE C5. SAMPLE SURFACE ROUGHNESS  
 FACTOR TABLE ( $F_{3T}/F_{3W}$ ) FOR  
 TRACKED & WHEELED VEHICLES

MAP UNIT	TRACKED VEHICLE ( $F_{3T}$ )	WHEELED VEHICLE ( $F_{3W}$ )
1	1	1
2	1	9
3	9	5
4	5	3
5	3	1
6	2	NO-GO
7	1	NO-GO
8	NO-GO	NO-GO















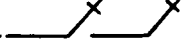


TABLE C6. RATED CONE INDEX FOR SOILS

USCS Symbol	RCI Dry Season	RCI Wet Season
GW	N/A	N/A
GP	N/A	N/A
GM	100 <sup>+</sup>	72
GC	100 <sup>+</sup>	90
GM-GC	100 <sup>+</sup>	81
SW	N/A	N/A
SP	N/A	N/A
SM	100 <sup>+</sup>	82
SC	100 <sup>+</sup>	82
SM-SC	100 <sup>+</sup>	82
ML	100 <sup>+</sup>	55
CL	100 <sup>+</sup>	46
ML-CL	100 <sup>+</sup>	51
OL	46	46
MH	100 <sup>+</sup>	83
CH	100 <sup>+</sup>	90
OH	40	40
Pt	35	35



APPENDIX D  
OBSTACLE SYMBOLOGY

OBSTACLE	SYMBOL	REMARKS
Road Blocks, Craters and Blown Bridges:		
a. Proposed .....		
b. Prepared but Passable .....		
c. Completed .....		
Wire		
a. Type Unspecified .....		
b. Concertina, Single .....		
c. Concertina, Multiple .....		
d. Single Fence .....		
e. Double Fence .....		
f. Double Apron Fence .....		
g. Low Wire Fence .....		
h. High Wire Fence .....		
Tripwire .....		
Mines, Type Unknown .....		
Mines, Antipersonnel .....		
Mines, Antitank .....		
Mines, Antitank, Bobbytrapped .....		
Double Antitank Mines .....		
Bobbytrapped Double Antitank Mines .....		
Antipersonnel Mines Connected to Tripwire .....		
Row of Antipersonnel Mines .....		
Row of Antitank Mines .....		
Cluster of Mines .....		

OBSTACLE	SYMBOL	REMARKS
<b>Minefield</b>		
a. Minefield of 1000 Mixed AT and AP Mines.....		
b. Minefield of 1500 AT Mines .....		
c. Belt of 500 AT Mines Some of Which are Boobytrapped. A Lane Traverses Belt. ....		
<b>Boundaries</b>		
a. Unfenced AT Minefield.....		
b. Unfenced AT Minefield (Unknown) .....		
c. Scatterable Minefield with AT and AP Mines. Date Time Group Designates Time of Self-Destruction. ....		
d. Dummy Minefield (Fenced) .....		
<b>Gaps of Lanes</b>		
a. A Belt of 600 Mixed AP Mines and Double AT Mines. Some of Which are Bobbytrapped. A Gap Traverses Belt .....		
Trench System (Under Construction).....		
Unoccupied Strong Point .....		
Demolished Area .....		
Tank Obstacle (Unspecified).....		
Tank Wall or Bank .....		
Tank Ditch.....		
Stakes, or Rails or Similar Obstacles .....		
Directed Obstacle (General) or Obstacle Area.....		
Directed Obstacle (Specific) .....		
Aircraft of Anti-airborne Obstacles.....	