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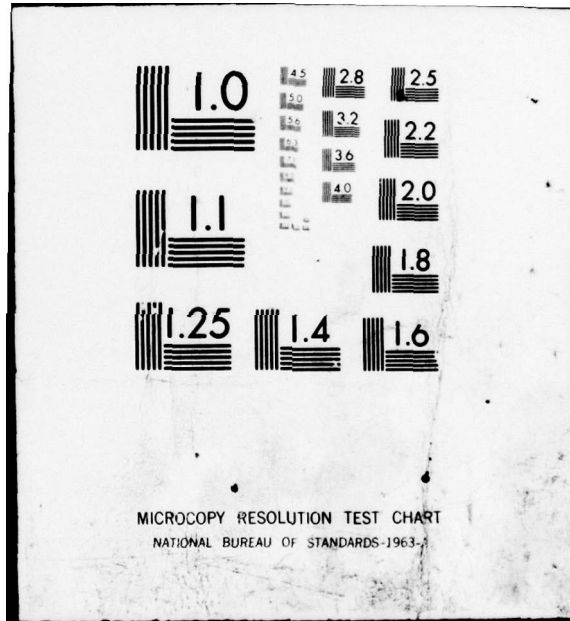
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Terrain analysis procedural
guide for roads and related
structures (Report No. 2 in the ETL series
on guides for Army terrain analysts)

Theodore C. Vogel

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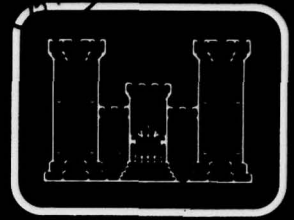
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PREFACE

This Terrain Analysis Procedural Guide for Roads and Related Structures, produced under authority contained in Project 4A762707A855, Task T3, Military Geographic Analysis Technology, is the second in a series of Terrain Analyst Guides that will be produced during the next 2 years. It is anticipated that after some modification to both format and content, these Guides will be republished as Department of Army Technical Manuals. In this regard, critical comments and suggestions for improvement are requested by the author. This work was conducted under the supervision of Mr. Alexander R. Pearson, Chief, Topographic Products Design and Development Group, MGI Data Processing and Products Division, Geographic Sciences Laboratory.

The author wishes to express his appreciation to Ms. Pauline Riordan and Mr. Orville Childers, Geographic Sciences Laboratory, for their interest, efforts, and support in preparing this guide.

COL Daniel L. Lycan, CE, was Commander and Director of ETL during the report preparation.

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TABLE OF CONTENTS

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
PREFACE		1
FIGURES		4
TABLES		5
I INTRODUCTION		6
A. Purpose		6
B. Background		6
C. Maps		11
D. Aerial and Ground Photography		12
E. Literature		12
II PROCEDURAL OUTLINE		13
A. Topographic Map Analysis		17
B. Aerial Photo Analysis		29
III ANALYSIS PROCEDURES		38
A. Map Analysis		38
A-1	Road Category and Identification	38
A-2	Road Classification (Type) and Surface Material	39
A-3	Width of Traveled Way	39
A-4	Culverts	40
A-5	Road Gradient	41
A-6	Height of Road Cuts and Fills	41
A-7	Emergency Drive-Offs	42
A-8	Level Crossings	42
A-9	Turn-out, Rest, and Park Areas	43
A-10	UTM Coordinates	43
A-11	Structure Length Determination	45
A-12	Structure Width Determination	46
A-13	Determination of Bypass Conditions	46
A-14	Ford Length Determination	47
A-15	Cross Section or Profile Determination	49
A-16	Determination of Ferry Travel Distance	50
A-17	Dimensional Plan of Ferry Terminals	50
A-18	Depth of Tunnel Overburden	50

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
B.	Photo Analysis	50
	B-19 Airphoto Scale Determination	50
	B-20 Preparation of Photos for Stereo Viewing	53
	B-21 Vertical Aerial Photography Measurements	55
	B-22 Surface Materials and Conditions	67
	B-23 Road Gradient	67
	B-24 Height of Road Cuts and Fills	69
	B-25 Bridge Analysis	69
	B-26 Type Construction	71
	B-27 Bypass Conditions	71
	B-28 Ford Width	73
	B-29 Ford Bottom Characteristics	73
	B-30 Length of Ferry Crossing	74
	B-31 Ferry Terminal Layout	75
	B-32 Vessel Information	75
	B-33 Approach Conditions (Fords and Ferries)	76
	B-34 Gallery, Snowshed Function	76
	B-35 Depth of Tunnel Overburden	77
BIBLIOGRAPHY		78
APPENDIXES		
A.	Specifications for the Preparation of Roads and Related Structures Factor Overlays	79
B.	Imagery Sources	100
	B-1 Sources of Aerial Imagery	100
	B-2 Sources of Ground Imagery	105
C.	Foreign Maps	106
GLOSSARY OF HIGHWAY TERMS		112

LIST OF FIGURES

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
1	Production and Use of Factor Overlays and Related Tables	8
2	Sample Factor Overlay	9
3	Sample Data Tables	10
4	Map Analysis - Road Net	14
5	Map Analysis - Related Structures	15
6	Photo Analysis - Roads and Related Structures	16
7	Grid Reference Box	44
8	The 100,000-Meter-Square Identification	44
9	Location of the 10,000-Meter Square	44
10	Structure Length Determination	45
11	Ford Length Determination	48
12	Cross Section or Profile Determination	49
13	Locating Principal Point of an Aerial Photo	54
14	Locating Conjugate Principal Point	54
15	Orienting Photos for Stereo Viewing	55
16	Parallax Wedge	57
17	Height Finder	57
18	Wedge Measurement of Vertical Clearance	58
19	Fusion of Parallax Wedge Under Stereo Viewing Conditions	59
20	Typical Bridge Construction	70
21	Bridge Mensuration Requirements	70
22	Depth of Overburden for Tunnels	77

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
A1	Sample Factor Overlay	80
A2	Format for Factor Overlay with Long Axis N-S	81
A3	Format for Factor Overlay with Long Axis E-W	82
A4	Data Tables I, II, III, IV, and V	83
A5	Bridge Types	96

LIST OF TABLES

<u>TABLE</u>		
1	Data Elements for Roads and Related Structures	7
2	Factor Overlay Road Symbols	19
3	U.S. Military Map Symbols for Road Related Structures	24
4	Aerial Photo Analysis for Related Structures	32
5	Airphoto Characteristics of Road Surface Materials	68
6	Structure Construction Type Identification from Vertical Aerial Photography	72
A1	Symbol Specifications for Roads and Related Structures	84
C1	Federal Republic of Germany Map Symbols for Roads and and Related Structures with English Translations (1:50,000 Scale)	107
C2	Union of Soviet Socialist Republic Map Symbols for Roads and Related Structures with English Translations	108

TERRAIN ANALYSIS PROCEDURAL GUIDE FOR ROADS AND RELATED STRUCTURES

I. INTRODUCTION

The capability to relocate manpower and materials from one point to another in an operational area is an essential ingredient of combat power and is often decisive to the outcome of a battle. Transportation is dependent on adequate lines of communication within a combat zone and transportation plans are dependent upon accurate intelligence concerning lines of communication (LOC). In addition to the road and highway network available in a combat zone, a commander must have accurate intelligence on the structures associated with the highways, i.e., bridges, tunnels, culverts, and fords, for example. This intelligence is important because the condition, weight, and size limitations of these structures must be known to select routes, to select targets, to provide maintenance and repair, and to assess an enemy's capabilities and options.

A. Purpose. The purpose of this Guide is to provide terrain analysts with step-by-step procedures for collecting, analyzing, and recording information on roads and related structures (table 1). Three principal sources are considered: maps, aerial photography, and literature. Detailed procedures are provided for maps and aerial photography; general guidance is provided for the analysis of literature.

B. Background. The first step in the generation of terrain intelligence and preparation of special purpose products is to extract data from a variety of source materials and to reduce the data to a uniform format. This first step of extracting data from available sources, then reducing and recording it in the desired form, is the most laborious and time-consuming step in the production cycle. If the process is delayed until a production requirement is imposed, the response time would be increased. However, if the extracting, reducing, and recording is performed in advance and if the preformatted results are maintained in a data base, then the time required to respond to a production requirement can be greatly reduced. One practical method of providing this information is the factor overlay concept, which preformats information for the data base.

Figure 1 illustrates the factor overlay concept for preformatting data in the form of factor overlays registered to standard topographic maps. Under this concept, data are extracted from various source materials and recorded on factor overlays (figure 2) and supporting data tables (figure 3). Separate overlays and tables are prepared for each 1:50,000 scale map sheet for each major terrain subject, e.g., surface materials, surface configuration, vegetation, drainage, and roads. Factor overlays and tables are intermediate products intended primarily as tools for the terrain analyst and are not customarily distributed outside of the topographic and intelligence community.

TABLE 1. DATA ELEMENTS FOR ROADS AND RELATED STRUCTURES

ROADS

Identification Number
 Category
 Segments
 Type
 Width
 Surface Material & Condition
 Shoulders
 Medians
 Obstacles
 Culverts
 Cuts and Fills
 Turn-outs, Emergency Drive-offs,
 & Parking Areas
 Level Crossings
 Obstructions & Constrictions

FORDS

Length
 Width
 Depth
 Bottom Conditions
 Approaches

FERRIES

Crossing Length
 Vessel Characteristics
 Approaches
 Load Class

BRIDGES AND OVERPASSES

Length
 Width
 Load Class
 Construction Type
 Clearances
 Bypass Conditions

TUNNELS, GALLERIES AND SNOWSHEDS

Length and Width
 Construction Details
 Overburden
 Clearances

NOTE: See Appendix A for a detailed description of data elements.

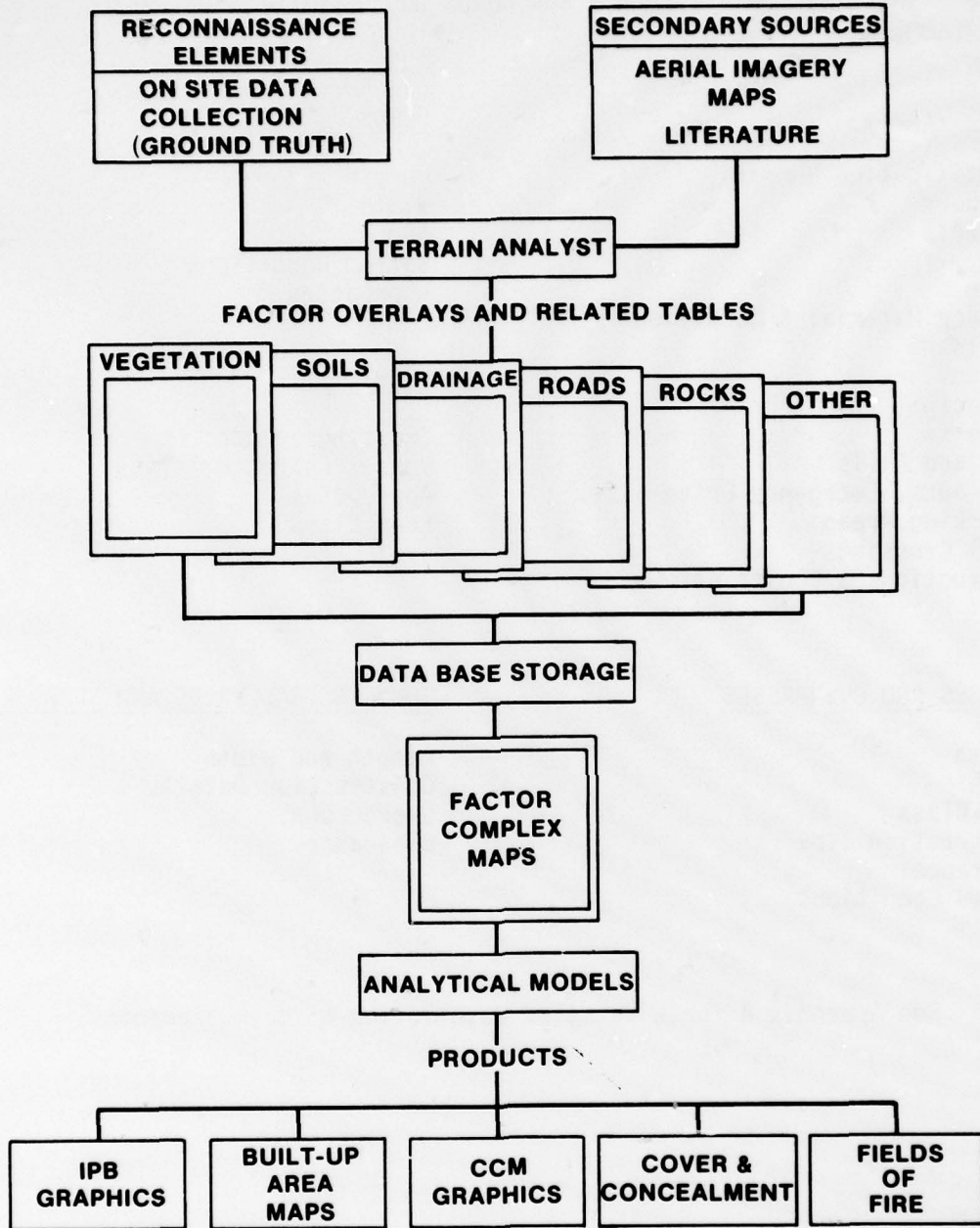
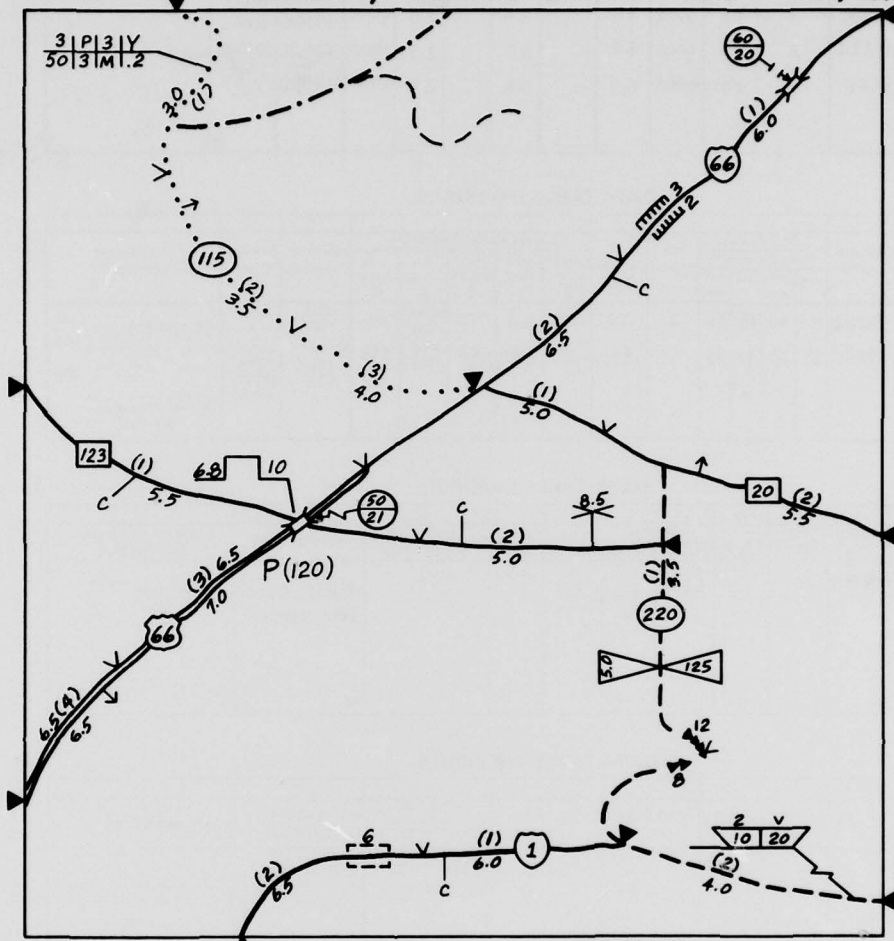


Figure 1. Production and Use of Factor Overlays and Related Tables

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- SOURCES**
- A. USAF Air Photos, 1976
 - B. Va. Dept. of Highways Route Map 1978.

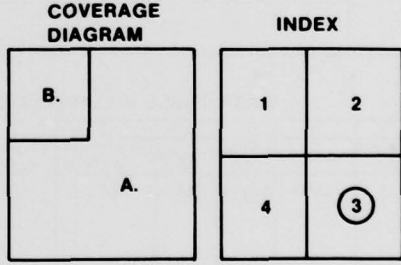


Figure 2. Sample Factor Overlay

DATA TABLE I-ROADS

1 ROAD NO	2 SEG NO	3 SEGMENT UTM	4 NO CUL	5 SURF MATL	6 COND	7 WIDTH (m) TRAVELED WAY		8 MEDIAN		9 SHOULDERS		10 OBSTACLES		11 CROSS SECTION OR COMMENT
						a.	b.	WIDTH (m)	MATL	WIDTH (m)	MATL	UTM	TYPE	
Md State 223	1	146780	3	pb	good	7.0		N.A.		2.0	gravel	124692	Stone Wall	
	2	351234	6	pb	good	6.0		N.A.		2.5	gravel	162321	Bridge	
	3	523611	2	rb	good	6.0		N.A.		2.0	gravel	267982	Rock Cut	

DATA TABLE II-BRIDGES

1 ROAD NO	2 SEG NO	3 BRIDGE NO.	4 BRIDGE UTM	5 LOAD CLASS				6 NO SPANS	7 TOTAL LENGTH (m)	8 SPAN CHARACTERISTICS					9 FEATURE CROSSED	10 BYPASS COND.	11 SKETCH OR COMMENT
				WHEEL		TRACK				CONST MATL	CONST TYPE	ROAD WIDTH C	OH CLEAR A	U B CLEAR E			
				→	←	→	←										
Va State 123	5	1	592114	105	40	65	25	2	124	MC	Slab	7.0m	unlimited	10m	Wind PIVER	?	
	6	2	131695	85	30	40	20	1	83	CS	Beam	6.5m	unlimited	9.5m	railroad; route 223	difficult (steep embankment)	

DATA TABLE III-FORDS

1 ROAD NO	2 SEG NO	3 FORD NO	4 FORD UTM	5 CROSSING LENGTH (m)	6 WIDTH (m)	7 DEPTH (m)		8 VELOCITY (km/hr)		9 BOTTOM CONDITIONS	10 APPROACHES	11 CROSS SECTION AND PROFILE
						PERIOD	DEPTH	PERIOD	VEL			
Macon Co. 7	8	1	421944	10	17	AUG MAY	1.0 1.8	AUG MAY	0.9 2.1	CS	difficult (Swampy ground, both banks)	

DATA TABLE IV-FERRIES

1 ROAD NO	2 FERRY NO	3 FERRY UTM	4 TYPE	5 NO VESSELS	6 LENGTH (each) (m)	7 LOAD CLASS (each)	8 CROSSING LENGTH (m)	9 APPROACH CONDITIONS		10 FEATURE CROSSED	11 TERMINAL LAYOUT
								Left	Right		
N.C State 34	1	31235	V	1	32	95	3400	Easy	Easy	Herring Bay	

DATA TABLE V-TUNNELS, GALLERIES, SNOWSHEDS

1 ROAD NO	2 SEG NO	3 STRUCT NO	4 FUNCTION	5 PORTAL UTM	6 LENGTH (m)	7 OVERBURDEN DEPTH (m)	8 ROADWAY WIDTH (m)	9 VERT CLEAR	10 HORIZ CLEAR	11 LINING MATL	12 BYPASS COND	13 CROSS SECTION AND PROFILE
W Va 304	6	3	tunnel	194642	600	49	7.0	10.0m	8.0m	Concrete	Impossible (steep rocky slopes)	

Figure 3. Sample Data Tables

Factor overlays are used in various combinations to generate factor-complex overlays that become, in effect, the manuscripts for special purpose products such as cross-country movement (CCM), fields of fire, intelligence preparation of the battlefield (IPB) graphics, etc. The data elements appearing on factor-complex maps become inputs for analytical performance-prediction models. For example, preparation of a cross-country movement map would begin by combining the overlays for surface configuration, surface materials, and vegetation into a complex overlay. Those data elements affecting CCM, i.e., slope, stem spacing, stem diameter, soil strength, etc., are then recorded for each complex area on the overlay. When processed by analytical models, these elements are transformed into CCM (vehicle-speed) predictions for each complex area.

The Road and Related Structures factor overlay with supporting data tables becomes a part of the data base described above. The source materials used in preparation of this factor overlay will include those given in figure 1. The amount and type of data collected will depend on the analyst's training, amount of reference literature available, geographic region, the type and scale of the aerial imagery that can be obtained, and the time available.

The source material used in preparation of the factor overlays will vary from area to area. Often, incomplete source material must be used. In addition, material from foreign sources must be used, which sometimes presents problems in translation, definition, etc. As better sources become available, first generation overlays will be revised to incorporate the additional information. In many cases, there will be areas for which no sources are readily available. When such areas are found, a collection effort must be initiated to obtain suitable source material.

In general, three major sources of information are available that will be helpful in the production of factor overlays for roads and related structures. These sources include tourist and government road maps; aerial and ground photography; and historical, technical and tourist literature. The technical literature includes all specifications and "as built" drawings that are produced after the construction of every road or related structure, regardless of country of origin. Even though some of these source materials are available through U.S. Government agencies, the best information can usually be obtained through direct contact with local governments and tourist bureaus. For Europe, the North Atlantic Treaty Organization (NATO) maintains a catalog of bridges that are greater than 15 meters in length.

C. Maps. With few exceptions, current military topographic maps are the best source to use when starting the production of factor overlays for roads and related structures. However, when possible, these

maps should be compared with the most recent aerial photography available to ascertain that they are current. Although maps produced by oil companies and automobile clubs are an excellent source of information, they usually do not follow a standard format. Produced at a variety of scales, they can be relied upon to indicate major routes and usually contain detailed insets that provide routes through major cities and towns. Since the scale, format, and symbology will vary with each publisher, the map legends should be studied before they are used as a source of information.

D. Aerial and Ground Photography. Reconnaissance photography, including vertical and oblique aerial photographs, are excellent sources of information, particularly when ground access is denied or map sources are known to be out of date. Both vertical and oblique aerial photography acquired in a manner that permits stereo or three-dimensional viewing will enable the analyst to obtain fairly accurate measurements of roads and related structures. (See appendix B for sources of photography.)

E. Literature. Literature sources include all reconnaissance reports, engineering reports, "as built" drawings, engineering drawings of roads and related structures, and any other written material that can be obtained and will provide useful information on these subjects. Normally, these materials are maintained by state, county, and city governments and are stored locally. The analyst is encouraged to seek these materials from local sources whenever possible.

Before proceeding further, it is suggested that the analyst obtain and maintain for reference, the following training manuals, field manuals, and texts:

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

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

TM 5-312, "Military Fixed Bridges," Headquarters, Department of Army, Corps of Engineers, Army Map Service, Vol. I and Vol. II, 1973.

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

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

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

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

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

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

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

II. PROCEDURAL OUTLINE

This section discusses the step-by-step sequence normally followed in making the factor overlays and data tables. In this section, the emphasis is on what analysis is to be done; the next section explains how the analysis is to be performed.

Production of a factor overlay for roads and related structures (bridges, underpasses, etc.) requires that the Terrain Analyst, with the aid of available source materials, locate, identify, measure, and graphically represent the location of the major data elements (table 1). In providing the Terrain Analyst with the procedures to obtain these elements, two assumptions have been made: (1) that 1:50,000 scale, topographic map coverage is available for all areas of interest; and (2) that the Terrain Analyst can locate additional source materials, including aerial photography. Because of the difficulty in determining the amount, type, and availability of source materials other than topographic maps and aerial photography, this Guide provides step-by-step instructions for obtaining the required data from only these two types of sources.

Figures 4, 5, and 6 outline the various steps to be followed in the production of the factor overlay and data tables for roads and related structures. The numbered steps of the figures refer to the corresponding step numbers in sections A and B, topographic map analysis and aerial photo analysis, respectively. The procedures necessary to accomplish each step are described in the analysis procedures section. The Terrain Analyst is encouraged to obtain as much data as possible from the map before proceeding through the series of steps required to obtain the data element information from aerial photography. The benefits to the Terrain Analyst that result from following this suggestion are threefold: (1) It provides a needed familiarity with the map sheet; (2) It will later aid in locating those areas of the map that require updating; and (3) The map information will assist interpretation of the aerial photos. Although procedures for obtaining data element information from both map and aerial photo source materials are contained in this guide, it is understood that not all of the information required (data elements) can be obtained from these sources. Data elements, such as Bridge Load

- 1A Review Sources & Select Base Map.
- 1B Register overlay to map and outline built-up areas.
- 1C Determine Route Category & ID number & record on overlay.
- 1D Determine road type & symbolize on overlay.
- 1E Determine road width & record alongside type symbol.
- 1F Locate and symbolize all culverts.
- 1G Locate & symbolize grades over 7%.
- 1H Locate & determine heights of cuts & fills. Symbolize on overlay.
- 1I Locate level crossings, turn-outs & pack areas; symbolize on overlay.
- 1J Locate segment end points and assign ID numbers.
- 1K Determine and record following data elements in Data Table 1:
Segment UTM
Number of Culverts
Surface Material
Width of Travelled Way
Medians.

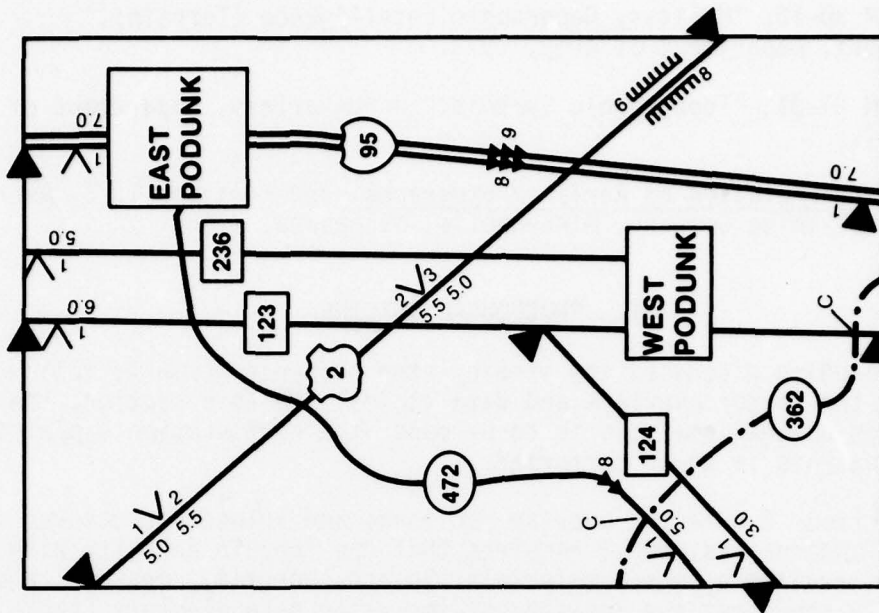


Figure 4. Map Analysis — Road Net

Note: For more detailed information on each step, refer to the identically numbered step in the topographic map analysis section.

- 3A Assemble Photos.
- 3B Add roads not shown on map to overlay.
- 3C Measure width of travelled way, shoulders & median. Determine material of surface & shoulders; verify segment end points.
- 3D Verify gradients over 7%.
- 3E Verify culverts.
- 3F Verify cuts & fills.
- 3G Locate & record obstacles & constructions.
- 3H Verify level crossings, drive-offs & park areas.
- 3I Prepare representative cross section.
- 3J Select vertical & oblique photos of bridges.
- 3K Determine Structural Characteristics of Bridges.
- 3L Select photos & compare with map evaluations of fords.
- 3M Assemble photos of tunnels, galleries & snowsheds.
- 3N Measure length and estimate width of fords. Estimate bottom conditions and verify approaches.
- 3O Assemble photos of ferries.
- 3P Evaluate length, vessels & approaches. Prepare terminal layout.
- 3Q Determine structure function.
- 3R Determine roadway width and clearances. Estimate lining of tunnels.
- 3S Prepare cross section of structure.
- 3T Evaluate structure bypass conditions.
- 3U Determine depth of overburden.
- 3V Determine structure function.
- 3W Evaluate structure bypass conditions.

Note: For more detailed information on each step, refer to the identically numbered step in the aerial photo analysis section.

Figure 6. Photo Analysis — Roads & Related Structures

Classification, cannot be obtained directly from either U.S. military maps or aerial photography; therefore, other sources, including on-site inspection, may have to be employed in many instances. Although the Terrain Analyst is encouraged to seek out and use all sources of information, it is important to use the information at hand to produce the factor overlay, realizing that it will have to be updated as more information becomes available.

A. Topographic Map Analysis

1. Roads - Data Table I.

Step #1A. Review the indexes to the data files and withdraw the source materials dealing with your area and topic of interest. These materials should include the current 1:50,000 scale map, large scale photography, existing road and bridge maps, studies, image interpretation reports, and reconnaissance reports.

Review the sources and determine whether they are adequate for the generation of the overlay. If they do not provide sufficient detail or coverage of the area, initiate action to collect additional material, and start your analysis with the material on hand.

Step #1B. Fasten a clean, translucent sheet of Mylar, or other transparent material, to a printed copy of the 1:50,000 scale map. Place registration ticks at each of the four map sheet corners. Although it is not essential, it may be helpful at later stages if the map sheet neatlines and the 10,000-meter grid lines are traced lightly in pencil. Add the map sheet name, number, and other required marginal information as listed in figures A2 and A3, appendix A.

Locate all major cities, towns, and built-up areas on the map sheet. Trace their outline onto the overlay with a soft pencil and label with the proper name. Small towns or villages located at road intersections or along roads should also be outlined and labeled with the proper name. Obtain the village name and symbol from the map.

Step #1C. Examine the map and determine the road category and identification number. Select appropriate symbols from table A1 and draw on the overlay astride the road (Procedure #1).

Step #1D. Refer to table 2, column 2. Compare these factor overlay symbols with the equivalent U.S. standard road symbols (column 4), and determine the type of classification of the road. Because of the color used in the standard road symbols, they have to be translated into symbols that can be duplicated on black and white reproduction equipment.

Beginning in the northwest corner of the map, select a road, track, or trail and trace its alignment onto the overlay with a soft lead pencil. During this process, be sure that you are using the proper overlay road symbol from table 2. Break the road symbol at the category ID symbol. Continue this process until all routes have been traced onto the overlay. When routes intersect with a built-up area, continue the road through the area only if it is considered a major route, i.e., federal or state. When the map symbol for a bridge, ford, or other LOC-related structure is encountered, place a check mark by the symbol and continue to trace the route (Procedure #2).

Step #1E. Indicate the width of each road segment in meters.

The width of Traveled Way Symbol (symbols 10-15, table A1, appendix A) indicates the total width of the road surface available for use by traffic. This distance does not include the width of the road shoulders, which may or may not exist. An estimate of road width can be obtained from the compilation specifications of each route symbol as listed below:

1. More than two lanes. A constructed roadway at least 27 feet (8.2 meters) wide.

2. Two lanes. A constructed roadway at least 18 feet (5.5 meters) and less than 27 feet (8.2 meters) wide.

3. One lane. A constructed roadway at least 8 feet (2.5 meters) and less than 18 feet (5.5 meters) wide.

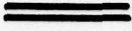










4. A natural traveled way that can accommodate four-wheeled or tracked vehicles and is at least 5 feet (1.5 meters) but less than 8 feet (2.5 meters) wide is classified as a track.

5. A natural traveled way less than 5 feet (1.5 meters) wide is classified as a trail.

Place symbol 9 at each point where there is a change in the width. Record the width of each road segment adjacent to the Traveled Way Symbol. See symbol 7, table A1, appendix A. For example, if the map symbol indicates a two-lane road for a certain segment, place 5.5 to 8.2 meters next to the Width of Traveled Way Symbol for that particular road segment (Procedure #3).

Step #1F. Follow along each route locating all culverts or areas where the map indicates that a stream or creek passes beneath a roadway. Place symbol 25, table A1, appendix A, next to each culvert that you have located.

TABLE 2. FACTOR OVERLAY ROAD SYMBOLS

1	2	3	4
FACTOR OVERLAY ROAD TYPES	FACTOR OVERLAY SYMBOLS	EQUIVALENT US STANDARD ROAD TYPES	EQUIVALENT US STANDARD ROAD SYMBOLS
Dual Highway		Divided Highway, with Median Strip K, Kb, p*	
All Weather, Hard Surface		Two or More Lanes Wide One Lane K, Kb, p*	 
All Weather, Loose Surface		Two or More lanes Wide One Lane pb, rb, r*	 
Fair Weather, Loose Surface		Fair or Dry Weather 2 Lanes l, nb, n*	
Track		Track (natural surface)	
Trail/Foot Path		Trail Foot Path (natural surface)	

*Symbols represent probable road surface material; see Appendix A, section III-B-5 for symbol descriptions.

There are no U.S. map symbols for culverts; therefore, look for areas where a single line stream or creek passes beneath a roadway (Procedure #4).

Step #1G. Locate all road gradients greater than 7 percent. Grades greater than 7 percent are symbolized by placing arrowheads at the bottom and top of each gradient. The arrowheads will be positioned so that the flat end of the first arrowhead marks the bottom of the grade and the point of the second arrowhead marks the top of the grade. (Arrowheads point uphill.) The actual grade in percent will be recorded adjacent to the first arrowhead (symbol 16, table A1, appendix A). (Procedure #5)

Step #1H. Locate all road cuts and fills. The conventional symbols for cuts and fills will be supplemented by a number indicating the height (cut) or depth (fill) in meters of each of these features.

The height and depth of road cuts and fills are estimated from the contour lines, Procedure #6. The analyst should record the maximum vertical distance in each case. Use symbol 26, table A1, appendix A, to mark the height (cut) or depth (fill) of each of these features that has been located.

Step #1I. Locate all level crossings, emergency drive-offs, turn-out, rest, and park areas that are adjacent to roads and that can be used by vehicles as stopping points. The best method for locating these areas is to search along each route for those map symbols that indicate one of the features. As areas are located, label each with the appropriate symbol from table A1 (Procedures #7, #8, and #9).

Step #1J. Assign segment identification numbers.

(1) Locate the points at which each route starts or ends within the map sheet. (A route is defined as a road with the same category and identification number throughout its length.) Place symbol 8 (table A1) at each start or end point. Route-ending points usually occur at the following points:

- (a) Junctions with other roads.
- (b) Built-up areas.
- (c) Map sheet neatlines.
- (d) International boundaries.
- (e) State boundaries (state and county roads only).
- (f) County boundaries (county roads only).

(2) Check each route between end points and verify that a category symbol and identification number exists for each route.

(3) Check each route between end points and verify that a segment limit symbol exists at each of the following points:

(a) Road width changes.

(b) Road type changes.

(c) Surface material changes.

(4) Beginning at the western edge of the factor overlay, number each road segment sequentially within each route from west to east, or north to south. Between each road segment end point symbol, place a road segment identification number (Symbol 9, table A1, appendix A).

Step #1K. Construct data table I and complete columns 1, 2, 3, 4, 5, 7, and 8.

(1) Column 1, Road No. Enter the road category and identification number for the route. Some examples are Interstate 95, Maryland State 223, and Fairfax County 422.

(2) Column 2, Segment No. List the segment numbers in sequence for each route.

(3) Column 3, Segment UTM. Enter the UTM coordinates (+ 10m) for the initial point of each segment. The coordinates for the first segment are taken at the route start symbol (Procedure #10).

(4) Column 4, No. of Culverts. Count the number of culverts symbolized within each segment and enter in the column in line with the segment number.

(5) Column 5, Surface Material. Estimate the surface material for each segment based on the map symbol (see table 2). Enter the surface material symbol in column 5 in light pencil. Since the map does not give the exact surface material, this entry will be revised as other sources are analyzed.

(6) Column 7, Width of Traveled Way. Enter the road widths as recorded on the overlay in column 7. If the road is dual, enter the north or west routes in column 7a, and the south or east routes in 7b. Enter widths for all others in 7a, leaving 7b blank.

(7) Column 8, Median. Examine each segment containing divided highways or dual routes and attempt to determine the width and material of the median. In some cases, for example, where the median is wide, it will be possible to measure the width and determine the material from the vegetation symbol. If an estimate cannot be made, place question marks in the two columns.

2. Bridges - Data Table II

Step #2A.

(1) Review the map sheet and locate all bridge and overpass symbols.

(2) Draw the bridge symbol (Symbol 20) on the overlay directly over the map symbol. Place the circle for the bridge symbol adjacent to the bridge symbol, but do not draw the bypass portion of the symbol at this time.

(3) Assign each bridge an identification number and record the number in the lower half of the bridge symbol circle. Identification numbers will start with the number 1 and run in sequence throughout the sheet. Identification numbers should be assigned so they run consecutively within a route and in the same sequence as the segment numbers. In general, bridge numbers should increase from west to east and north to south.

Step #2B.

(1) Construct Data Table II in accordance with Appendix A.

(2) Working with each bridge in sequence, determine the following information and record it in Data Table II.

(a) Column 1, Road Number. Enter the road category and identification number in the same manner and sequence as for Data Table I.

(b) Column 2, Segment Number. Enter the segment numbers in sequence.

(c) Column 3, Bridge Number. Enter the bridge numbers in sequence.

(d) Column 4, Bridge UTM. Determine the UTM Coordinates (± 10m) for the center of the bridge using Procedure #10.

(e) Column 7, Total Length. Record the total length of the structure in meters, abutment to abutment. Use Procedure #11 to determine the length. If the length cannot be determined, leave the column blank.

(f) Column 8c, Road Width. Estimate the width of the roadway using Procedure #12, and record temporarily.

(g) Column 8a and 8b, Construction Material and Construction Type. U.S. Maps seldom indicate the construction material for bridges, but foreign maps sometimes provide this information. Although sketchy, any information on these two data elements should be recorded to assist in later photo analysis. Study the map legend carefully and compare it with tables 3, C1 and C2 to determine what kind of estimate is possible. If no estimate can be made, leave the column blank at this time.

(h) Column 9, Feature(s) Crossed. Based on the map information, record the name of the feature(s) crossed.

Step #2C. Examine the area in the vicinity of each bridge, and estimate the bypass conditions using Procedure #13. Add the correct bypass symbol to the bridge symbols on the factor overlay. Enter in Column 10 the bypass condition with a brief note as to why the bypass is difficult or impossible (deep water, dense vegetation, wet ground, etc.).

3. Fords - Data Table III.

Step #2D.

(1) Search the map sheet for all symbols indicating the presence of a ford. Use table 3 or C1 to help identify the symbols. Draw the ford symbol (Symbol 21, table A1) on the overlay adjacent to each ford location, but do not make any entries in the symbol at this time.

(2) Check all points at which roads cross double line streams. If there is no symbol to indicate a bridge, tunnel, or ferry, assume a ford and draw the ford symbol adjacent to the site.

(3) Assign each ford an identification number in the same way bridge numbers were assigned (step 2A). Record the identification number onto the overlay ford symbol.

Step #2E. If feasible, measure the length of the ford crossings using Procedure #14. Record the length of the crossings in meters onto the overlay symbols.

TABLE 3. US MILITARY MAP SYMBOLS FOR ROAD RELATED STRUCTURES


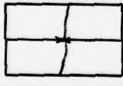
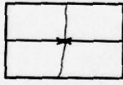



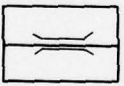

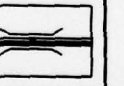
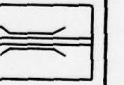


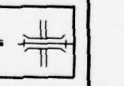
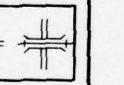





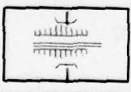
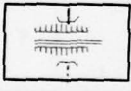

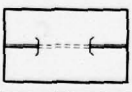
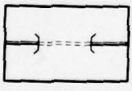
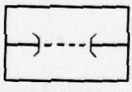

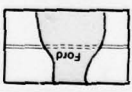
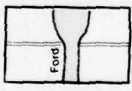
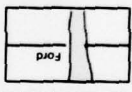

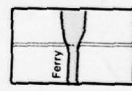
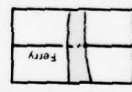

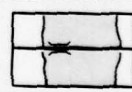
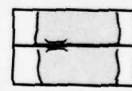

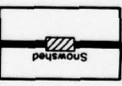
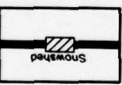
STRUCTURE	MAP SYMBOL (TM 21-31)			DMA MAP SPECIFICATIONS	DATA ELEMENTS OBTAINABLE FROM MAP	EXTRACTION PROCEDURES
	1:50,000 LARGE	1:250,000 MEDIUM	1:1,000,000 SMALL			
FOOTBRIDGE 			No Symbol	(1) Bridge symbols are usually representative in that their length must be exaggerated in order to portray these features legibly. The minimum plotted length for any bridge is 0.66 inch (1.50 mm) at publication scale. (2) Bridges are shown wherever they relate to the road network portrayed on the map. (3) Bridges that plot longer than 0.06 inch (1.50 mm) at publication scale are shown to scale.	LOCATION LENGTH WIDTH BYPASS CONDITIONS OBSTACLE NAME	PROCEDURE 10 PROCEDURE 11 PROCEDURE 13
VIADUCT OR HIGHWAY BRIDGE 				(4) A bridge that carries both a road and a railroad is shown by the road bridge symbol only. The railroad symbol is dropped at the bridge abutments.	LOCATION LENGTH WIDTH BYPASS CONDITIONS OBSTACLE NAME	PROCEDURE 10 PROCEDURE 11 PROCEDURE 12 PROCEDURE 13
HIGHWAY DRAW BRIDGE 					LOCATION LENGTH WIDTH BYPASS CONDITIONS OBSTACLE NAME	PROCEDURE 10 PROCEDURE 11 PROCEDURE 12 PROCEDURE 13
OVERPASS OR UNDERPASS 				(1) Road overpasses are symbolized as illustrated by the symbol. (2) The same treatment is used to portray a grade separation of more than two levels.	LOCATION LENGTH WIDTH BYPASS CONDITIONS	PROCEDURE 10 PROCEDURE 11 PROCEDURE 12 PROCEDURE 13
DAM CARRYING ROAD 			No Symbol	Standard road symbols are employed along with symbol for dam.	LOCATION LENGTH WIDTH BYPASS CONDITIONS OBSTACLE NAME	PROCEDURE 10 PROCEDURE 11 PROCEDURE 12 PROCEDURE 13

TABLE 3. US MILITARY MAP SYMBOLS FOR ROAD RELATED STRUCTURES (CONT.)

STRUCTURE	MAP SYMBOL (TM 21-31)			DMA MAP SPECIFICATIONS	DATA ELEMENTS OBTAINABLE FROM MAP	EXTRACTION PROCEDURES
	1:50,000 LARGE	1:250,000 MEDIUM	1:1,000,000 SMALL			
 CULVERTS			No Symbol	1. A culvert is a masonry conduit which serves as a channel-crossing for water beneath a railroad embankment or a road. 2. Large culverts at the base of fills are shown if they have landmark significance. Small culverts are not symbolized.	LOCATION	PROCEDURE 4 & 10
 ROAD TUNNEL				1. Outside of populated places all tunnels are shown. To insure legibility, the minimum plotted size for any tunnel is 0.06 inch (1.50 mm) at publication scale. Tunnels that plot longer than the above size are plotted to scale. 2. Short tunnels which enable a road to underpass other linear manmade features are portrayed as underpasses.	LOCATION LENGTH WIDTH BYPASS CONDITIONS DEPTH OF OVERBURDEN	PROCEDURE 10 PROCEDURE 11 PROCEDURE 12 PROCEDURE 13 PROCEDURE 18
 FORD				Fords are shown where they relate to roads shown on the map	LOCATION LENGTH WIDTH BYPASS CONDITIONS	PROCEDURE 10 PROCEDURE 11 & 14 PROCEDURE 12 PROCEDURE 13
 FERRY				1. Vehicular and railroad ferries are portrayed only when they are in regular operation for the purpose of transporting traffic between two points separated by water. 2. Pedestrian ferries are not shown unless they are the only means of crossing in the area.	LOCATION OF TERMINALS TRAVEL DISTANCE DIMENSIONED PLAN OF TERMINALS BYPASS CONDITIONS OBSTACLE NAME	PROCEDURE 10 PROCEDURE 11 & 16 PROCEDURE 17 PROCEDURE 13
 CAUSEWAY			Same as Highway Bridge	1. A causeway is a constructed passage-way from roads or railroads across open water. They may contain bridges to permit passage of boats. 2. The feature is not specially symbolized. The label "CAUSEWAY" is added parallel to the road or railroad alignment. Bridges are appropriately symbolized.	LOCATION* LENGTH WIDTH BYPASS CONDITIONS OBSTACLE NAME	PROCEDURE 10 PROCEDURE 11 PROCEDURE 12 PROCEDURE 13

*Associated Bridges Only.

TABLE 3. US MILITARY MAP SYMBOLS FOR ROAD RELATED STRUCTURES (CONT.)

STRUCTURE	MAP SYMBOL (TM 21-31)			DMA MAP SPECIFICATIONS	DATA ELEMENTS OBTAINABLE FROM MAP	EXTRACTION PROCEDURES
	1:50,000 LARGE	1:250,000 MEDIUM	1:1,000,000 SMALL			
SNOWSHED 			No Symbol	Minimum plotted length is 0.06 inch (1.50 mm) on 1:50,000 map	LOCATION LENGTH WIDTH BYPASS CONDITIONS	PROCEDURE 10 PROCEDURE 11 PROCEDURE 12 PROCEDURE 13

Step #2F.

Appendix A. (1) Construct Data Table III in accordance with

(2) Enter the road numbers, segment numbers, and ford numbers in Columns 1, 2, and 3, respectively, of Data Table III in the same manner as bridges were handled on Data Table II.

Step #2G. Determine the UTM coordinates (+ 10m) for the center of each ford using Procedure #10, and record in Column 4 of Data Table III.

Step #2H. Enter the length of crossing in meters in Column 5 of Data Table III.

Step #2I. Use Procedure #15 and the map to construct a cross section of the ford and approaches. Place a dimensioned sketch of the cross section in Column 11 of Data Table III.

Step #2J.

(1) Examine the map and the cross section, and evaluate the approach conditions for each side of the ford. Add the correct approach condition symbol to the overlay ford symbol.

(2) Record the approach conditions in Column 10. If either approach is considered difficult, add a brief statement why it is considered difficult.

4. Ferries - Data Table IV.

Step #2K.

(1) Search the map sheet and locate all ferry symbols.

(2) Draw the ferry symbol (Symbol 22) adjacent to the site, but make no entries in the symbol at this time.

(3) Assign ferry identification numbers in the same manner as for bridges and fords. Record the identification numbers in the ferry symbols.

Step #2L. Estimate the type of ferry based on the map information. If both ends of the ferry connect to roads, assume a vehicular ferry. If one or both sides connect with a trail, assume a foot ferry. Record the type ferry on the overlay symbol.

Step #2M. Complete Columns 1, 2, 3, 4, 8, 9, 10, and 11 of Data Table IV.

- (1) Enter the Road Numbers and Ferry Numbers in Columns 1 and 2.
- (2) Use Procedure #10 to determine the locations of both ferry terminals and record in Column 3.
- (3) Record the ferry type, as previously recorded on the symbol, in Column 4.
- (4) Measure the straight line distance between the two terminals in meters and record in Column 8 (Procedure #16).
- (5) Evaluate the approaches to each ferry terminal in the same manner as for fords and record in Column 9.
- (6) Determine the name of the river or stream crossed from the map and enter in Column 10.
- (7) Study the map to determine if any information is provided on the facilities and layout of the terminal. Look for piers, docks, pilings, parking areas, etc. Use Procedure #17 to sketch a layout of each terminal in Column 11.

5. Tunnels, Galleries, and Snowsheds - Data Table V

Step #2N.

- (1) Search the map sheet for symbols indicating the presence of a tunnel, gallery, or snowshed.
- (2) Study the map legend and determine the structure function.
- (3) Draw the proper symbol (23 or 24) on the overlay over the map symbol.
- (4) Assign each structure an identification number in the same manner as for bridges and fords, and record the identification number alongside the structure symbol.

Step #20. Construct Data Table V in accordance with figure A4, Appendix A.

Step #2P. Complete Columns 1, 2, 3, 4, 5, 6, 7, 8, and 12 of Data Table V.

(1) Enter the road number, segment number, and structure number in Columns 1, 2, and 3, respectively, in the same manner as for Data Table II - BRIDGES.

(2) Enter the structure function (tunnel, gallery, or snowshed) in Column 4.

(3) Use Procedure #10 to determine the UTM coordinates ($\pm 10m$) for both portals of each structure and record in Column 5.

(4) Use Procedure #11 to determine the length of the structures and record the lengths in meters in Column 6.

(5) Use Procedure #18 to estimate the maximum overburden depth in meters and record in Column 7 (tunnels only).

(6) Use Procedure #12 to estimate the width of the road within the structure in meters and record in Column 8.

(7) Use Procedure #13 to evaluate bypass conditions and record in Column 12.

B. Aerial Photo Analysis.

1. Roads - Data Table I.

Step #3A. Locate and assemble large scale photography of the area. Organize the photos in sequence within each flight line. Make sure there is complete coverage of the map sheet. If oblique photos are available, include them in the collection.

(1) Familiarize yourself with tables 4, 5, and 6.

(2) Compare the date of the photograph and the date of the last map revision or update. If the photograph is more recent than the map, the photograph should be used. If the map is more recent, greater weight should be given to the map information. However, even if the map is more recent, it should not always take precedence over the photograph. One reason for this is that map information is often generalized; as a result tracks and trails are often omitted.

(3) Determine the scale of the aerial photography (Procedure #19).

Step #3B. Orient each aerial photo in sequence and compare with the map sheet (Procedure #20). Look for any roads, tracks, or trails that do not appear on the map. Compare the outline of all built-up areas on the photos with the map symbolization of the same area. With the overlay registered to the map, carefully sketch any new road alignments or built-up area outlines on the overlay with a soft lead pencil. In all instances, use the proper overlay symbols (Table A1).

Step #3C.

(1) Study each segment of each route and determine the following information:

(a) Width of Traveled Way. Procedure #21-1. Compare with results obtained from the map analysis and record the final decision on the overlay and in Column 7, Data Table I.

(b) Shoulder Width. Procedure #21-1. Record in Column 9, Data Table I.

(c) Width of Median. Procedure #21-1. Record in Column 8, Data Table I.

(d) Road Surface Material, Condition, Median and Shoulder Surface Material. Procedure #22. Record in Columns 5, 6, 8, and 9, respectively.

(2) Compare the width of the traveled way and the surface materials information obtained from the photography with that obtained from the map analysis and make final decisions. Verify the location of segments and points. If the end points determined from the photos differ from those obtained from the map, use those points obtained from the photos. Relocate the end point symbols on the overlay, renumber the segments if necessary, and determine the UTM coordinates of the relocated points. Change entries in Data Table I as appropriate.

Step #3D. Use Procedure #23 to verify the gradient of each hill that has a grade of 7 percent or more. Change the number indicating the gradient for each hill, as required on the overlay and in Column 10, Data Table I.

Step #3E. Examine those areas on the aerial photography where the map indicates the presence of either a culvert or a stream passing beneath a roadway. Using Procedure #20 to orient the aerial photos for stereoviewing. Check these areas to verify the location of a culvert. Also check all areas on the photography where a stream or drainageway intersects a roadway. If there are indications of culverts in these areas, place symbol 25, table A1, appendix A, at each of these locations. Change the entry in Column 4, No. of Culverts, as necessary.

Step #3F. Locate on the aerial photography each road cut and fill that is indicated on the map sheet. Be sure to locate the cuts and fills along any new road alignments you may have added to the overlay from the aerial photography. Use Procedure #24 to verify the height (cuts) and depth (fills) of each of these features located. Transcribe these measurements to the overlay.

Step #3G. Locate the aerial photos of the built-up areas that are indicated on your map sheet and orient for stereo viewing (Procedure #20). Carefully follow the through-routes through each built-up area on the aerial photography. Locate any zones where buildings, stone walls, etc. constrict the width of the route to less than 4 meters. If there are any of these zones present, determine the width and length of these constrictions with your tube magnifier. If they are 4 meters or less in width, mark these locations with symbol 17, table A1, appendix A. Place the width and length measurements next to each symbol. Use Procedure #10 to determine the UTM coordinates, and record the coordinates and type obstacle or constriction in Column 10, Data Table I.

Step #3H. Stereoscopically examine all areas previously selected as level crossings, emergency drive-offs, turn-outs, and rest and park areas. Verify the identifications and make additions, deletions, or changes on the factor overlay as required.

Step #3I. Study the information obtained thus far on each segment and prepare a simple, dimensioned cross section sketch of a representative portion of the section in Column 11, Data Table I. Include the shoulders and ditches where practical. Add any comments that may help the user understand the character of the segment.

Step #3J. Recheck all steps from 3A through 3I. Clean up the factor overlay and data table.

2. Bridges - Data Table II.

Step #4A. Select large scale vertical photos that provide stereo coverage for each bridge recorded on the factor overlay. If oblique photos are available, place them with the vertical photos.

Step #4B.

(1) Determine the scale of the photos using Procedure #19.

(2) Study the photographs carefully to become familiar with the general characteristics of the bridge. Refer to table 4, as necessary, for quick reference to data element extraction procedures. Use Procedure #21-1 to measure the total length of the bridge. Record the results in Column 7, Data Table II.

TABLE 4. AERIAL PHOTO ANALYSIS FOR RELATED STRUCTURES

STRUCTURE	DATA ELEMENTS REQUIRED	OBTAINABLE FROM VERTICAL PHOTOGRAPHY	OBTAINABLE FROM OBLIQUE PHOTOGRAPHY	DATA ELEMENT EXTRACTION PROCEDURE
Bridges	ID Number	No	No	Use Map
	UTM Coordinates	No	No	Procedure #10
	Load Classification	No	No	Procedure #25
	Cross-Section View (Dimensioned)	Yes	Yes	Procedures #15, 25, & 26
	Elevation View (Dimensioned)	Yes	Yes	Procedures #25 & 26
	Type Construction	Yes	Yes	Procedure #26
	Obstacle Crossed	Yes	Yes	Check Map for Name
	Bypass Conditions	Yes	Yes	Procedure #27
Fords	Road Number, Category, & Segment	No	No	Use Map
	ID Number	No	No	Use Map
	UTM Coordinates	No	No	Procedure #10
	Bottom Characteristics	Yes	Yes	Procedure #29
	Cross-Section View (Dimensioned)	Yes	Yes	Procedure #15
	Obstacle Crossed	Yes	Yes	Check Map for Name
	Condition of Approaches	Yes	Yes	

TABLE 4. AERIAL PHOTO ANALYSIS FOR RELATED STRUCTURES (CONT.)

STRUCTURE	DATA ELEMENTS REQUIRED	OBTAINABLE FROM VERTICAL PHOTOGRAPHY	OBTAINABLE FROM OBLIQUE PHOTOGRAPHY	DATA ELEMENT EXTRACTION PROCEDURE
Ferries	ID Number	No	No	Use Map
	UTM Coordinates	No	No	Procedure #10
	Length of Crossing	Yes	Yes	Procedure #30
	Vessel Information Propulsion Type Length, Beam, Capacity	Partial	Partial	Procedure #32
	Obstacle Crossed	Yes	Yes	Check Map for Name
	Terminal Layout	Yes	Yes	Procedure #31
	Condition of Approaches	Yes	Yes	Procedure #33
Tunnels Galleries Snowsheds	Road Number, Category, & Segment	No No No	No No No	Use Map Use Map Use Map
	ID Number	No	No	Use Map
	Function	Yes	Yes	Procedure #34
	Bypass Conditions	Yes	Yes	Procedure #27
	Depth of Tunnel Overburden	Yes	Yes	Procedure #35
	Construction Materials	Yes	Yes	Procedure #26
	Cross-Section	No	Yes	Procedure #15

(3) Use Procedures #25 and #26 to determine the number of spans, material, and construction type for each span. Record the results in Columns 6, 8a and 8b respectively.

(4) Use Procedures #21-1 and #21-2 to measure the road width, overhead clearance, and underbridge clearance. Record the results in Columns 8c, 8d, and 8e, respectively, Data Table II.

(5) Evaluate the bypass conditions using Procedure #27 and compare with the evaluation made during the map analysis. Resolve any conflicts between the two evaluations and enter in Column 10, Data Table II. Add the proper bypass symbol to the bridge symbol on the factor overlay.

(6) Use Procedure #25 to estimate the military load class. Record this information in Column 5, Data Table II, and in the upper half of the bridge symbol on the factor overlay.

(7) Review the bridge information developed to this point and prepare a dimensioned sketch in Column 11, Data Table II.

3. Fords - Data Table III.

Step #5A.

(1) Collect stereo vertical photos and obliques for each site identified by the ford symbol on the factor overlay.

(2) Carefully study the photos of each ford site. Become familiar with the general character of the approaches and stream channel crossed (Procedure #33).

(3) Review the evaluations made during the map analysis and see if the initial analysis is confirmed.

Step #5B.

(1) Use Procedures #19 and #21-1 to measure the length of crossing. Compare with the length obtained during the map analysis and resolve any differences. Record in Column 5, Data Table III.

(2) Use Procedure #28 to estimate the width of the ford. Record the estimate in Column 6, Data Table III.

(3) An accurate estimate of ford depth and water velocity from aerial photos is usually difficult, and often impossible to obtain. Normally, a rough estimate is the best that can be done. Look for indicators in the form of sandbars, exposed rocks, ripples, and eddies that indicate shallow water. Use general terms to describe the velocity, such as swift, sluggish, etc. Record your estimates of depth and velocity in Columns 7 and 8 respectively, of Data Table III. Record the date of the photography in the Period column. Attempt to refine the photo-derived depth and velocity estimates with available scientific literature.

(4) Use Procedure #29 to estimate bottom conditions and record in Column 9, Data Table III.

(5) Examine each ford site stereoscopically (Procedure #20). Attempt to verify the profile prepared during the map analysis. If necessary, use Procedure #21 to modify or correct the profile.

(6) Study the revised profile and re-evaluate the approach conditions. Revise the entries in Column 10, Data Table III, as necessary.

4. Ferries - Data Table IV.

Step #6A. Assemble the photos, both vertical and oblique, of each ferry site. Include the two terminals and the water gap between them for each site.

Step #6B.

(1) Orient the photos for viewing (Procedure #20). Scan the terminals and the probable route between them.

(2) Use either Procedure #21-1 or #30 to determine the crossing length between terminals, and compare with the legend obtained during the map analysis. Resolve any discrepancies and record the results in Column 8, Data Table IV.

(3) Use Procedure #31 to determine the layout of the terminals and draw dimensioned sketches in Column 11, Data Table IV.

(4) Count the number of ferry vessels. Use Procedure #32 to determine the type, length, and estimated load class of each vessel. Record the results in Columns 4, 6, and 7 respectively, of Data Table IV.

(5) Evaluate the condition of the right and left bank approaches using Procedure #33. Record the results in Column 9, Data Table IV. Right bank is that bank on your right while facing downstream.

5. Tunnels, Galleries, and Snowsheds - Data Table V.

Step #7A. Assemble the photos that provide coverage of each structure, and orient according to Procedure #20.

Step #7B. Examine each structure and verify or change the function (tunnel, gallery, or snowshed) previously recorded in Column 4, Data Table V. Tunnels should pose no particular problem, but distinguishing between galleries and snowsheds may be difficult. Both are found in hilly or mountainous areas, or at the base of large cuts. If the structure was not identified on the map, consider the following factors:

(1) Galleries will have the sturdier, thicker roofing to resist the impact of falling rock.

(2) There will be exposed rock outcrops or boulders uphill from a gallery.

(3) Rock debris or boulders may appear on the roof of the galleries. In addition, there will be evidence of previous slides or rock falls on the downhill side.

(4) The areas uphill from snowsheds may be vegetated and will lack the factors that indicate a gallery (See Procedure #34).

Step #7C. Use Procedure #21-1 to verify the length of the structure. Record the results in Column 6, Data Table V.

Step #7D. Determine the depth of overburden for tunnels using Procedure #35. Compare with the estimate made during the map analysis, resolve any differences, and record the results in Column 7, Data Table V. Make no entry in Column 7 for galleries or snowsheds.

Step #7E.

(1) Select those photos that provide the best views of tunnel portals or the ends of galleries and snowsheds. Obliques are preferred, but verticals with images of the structures near the edges can often be used.

(2) Determine the scale of the photo at the image of the portal using Procedure #19. Use Procedure #21 to measure the roadway width. Also measure the vertical and horizontal portal clearances. Record the results in Columns 8, 9, and 10 respectively of Data Table V.

(3) Because the lining material of tunnels cannot be determined from photos, Column 11 should be left blank. However, the construction material of galleries and snowsheds can often be estimated from obliques; therefore the estimate (timber, concrete, masonry, steel, concrete piers, timber roof, etc.) should be recorded in Column 11.

Step #7F. Using information previously obtained, draw a cross section of the structure or a sketch of the portal face in Column 13. Dimension the drawing, indicate the shape of the opening and material of the face.

Step #7G. Evaluate the bypass conditions, considering the same factors as for bridges. Record the conditions in Column 12.

Review the completed factor overlay and data tables. Check to see that all numbered features on the overlay are included in the data tables. Also ensure that information that appears on both the overlay and the data tables agree. Give special attention to those cases where evaluations made during the map analysis were later changed during the photo analysis.

Review all available reports and other literature sources for information that may have been overlooked.

Intensify the symbols, lettering, and line work. Remove any work notes that are no longer needed.

Prepare a list of data elements that are still missing. Indicate the UTM coordinates and specific information needed so the list may be used as a collection guide.

III. ANALYSIS PROCEDURES

A. MAP ANALYSIS

Procedure Number	Map Analysis Procedure
1	<p data-bbox="493 415 976 447"><u>Road Category and Identification:</u></p> <p data-bbox="493 474 1321 625">The category and identification of roads on most topographic maps are indicated by symbols placed astride or adjacent to the road symbol. The identification numbers (or letters) appear inside the symbol, with the category explained in the legend.</p> <p data-bbox="493 653 1289 856">Tracks and trails are not categorized or assigned identification numbers. In some areas where the roads are not given identification numbers by the local government, it will be necessary to assign arbitrary numbers. In this case, the engineering organization responsible for maintenance will usually assign the numbers.</p> <p data-bbox="493 890 1289 947">Determine the correct category from the map legend and select the proper symbol from table A1.</p> <p data-bbox="493 980 1321 1123">Draw the symbol astride the road on the overlay, and enter the identification number inside the symbol. Locate the symbols so they do not cover bridges, intersections, or other features that may later require symbols of their own.</p> <p data-bbox="493 1157 1321 1331">Follow the road throughout its length on the map, and look for points at which either the category or the ID number change. Consider the following comments as you follow the road: (These comments are based on U.S. conditions, but comparable conditions exist in foreign areas.)</p> <ol data-bbox="493 1365 1321 1629" style="list-style-type: none"><li data-bbox="493 1365 1321 1421">(1) Interstate and federal routes are not changed when state or county boundaries are crossed.<li data-bbox="493 1455 1321 1541">(2) State roads change both category and ID numbers when state boundaries are crossed, i.e. Virginia 216 may become Maryland 33 when the state line is crossed.<li data-bbox="493 1575 1321 1629">(3) County roads either terminate or change category when county or state boundaries are crossed.

Procedure
Number

Map Analysis Procedure

1
(cont.) Place a route terminal symbol (8) at each point of change, and add new category symbols and ID numbers as necessary.

2 Road Classification (Type) and Surface Material:

Study the map legend carefully and compare with tables 2, 3, and A1. Determine which factor overlay symbol is to be used for each map symbol.

Trace the alignment of each road, track, and trail, using the symbol selected. Break the tracing at the category symbol, and change the symbol whenever the classification changes. Place a segment symbol at each point of change.

Check the points at which roads cross international, state, or county boundaries: the road types often change at these points.

Estimate the material of the road surface as best you can from the map legend, and record lightly alongside the road.

3 Width of Traveled Way:

The accuracy with which the width of the traveled way can be determined will vary with the topographic map available for use. The FRG, USSR, and some other European maps indicate the width in meters. The U.S. maps, however, indicate the width by the number of lanes or a range of widths. The following information indicates the lane widths as currently shown on U.S. military maps.

Procedure Number	Map Analysis Procedure	
	METERS	FEET
Trail	Less than 1.5	Less than 5
Track	At least 1.5 but less than 2.5	At least 5 but less than 8
One Lane	At least 2.5 but less than 5.5	At least 8 but less than 18
Two Lanes	At least 5.5 but less than 8.2	At least 18 but less than 27
More than Two Lanes	At least 8.2	At least 27

3
(cont.)

Follow each route and determine the number of lanes and widths. Convert the lane width to meters and lightly record this value on the overlay alongside the road.

Show the decimal followed by a number or zero even though the width is an even meter. This detail is required to avoid confusion with the segment numbers that do not show the decimal.

In the case of dual routes, indicate the width of each route. If the source map gives only the overall width, assume half the width on each side.

Note every point at which a change in width occurs and place a segment symbol at such points.

4

Culverts:

Culverts are infrequently symbolized on topographic maps. If the map being used does symbolize these structures, they may be taken directly from the map and symbolized in accordance with table A1.

If the culverts are not symbolized on the map, search the routes for points at which the road crosses single-line intermittent or perennial streams. If there is no symbol to indicate a bridge, ford, or ferry, it may be assumed that there is a culvert at that point. Go back along the route and look for points where the adjacent contours indicate the road crosses a draw or gully; these are points at which there are probably culverts.

5 Road Gradient:

a. Using the contour lines as indicators, locate all road gradients on hills that appear to be near or greater than 7 percent. A hill with a 7 percent gradient or slope will have a 7 meter vertical increase for every 100 meters of horizontal distance.

b. At the location of each gradient, determine the elevation of the top (E_1) and bottom (E_2) of the slope. Subtract the lower elevation from the higher elevation.

$$E_1 - E_2 = \Delta E$$

c. Determine the horizontal distance (HD) between the top and bottom of the slope, points E_1 and E_2 respectively, and divide this number into ΔE . The resulting number multiplied by 100 will equal the gradient expressed as a percent.

$$\frac{\Delta E}{HD} = G \times 100 = \text{percent gradient}$$

d. If your answer is 7 percent or greater, mark the hill on the overlay according to symbol 16, table A1, appendix A.

6 Height of Road Cuts and Fills:

a. Locate and determine the elevation of the contour line that is immediately adjacent to the top of either the cut or fill map symbol. If the top of the cut or fill symbol falls between two contour lines, estimate the elevation and add this number to the contour line that has the lower elevation.

b. Locate and determine the elevation of the contour line that is located immediately adjacent to the bottom of either the cut or fill symbol. This elevation should be estimated, as above, if the bottom of the symbol is located between two contour lines.

c. Subtract the number (elevation) you determined for the bottom of the map symbol from the number (elevation) you determined for the top of either the

Procedure Number	Map Analysis Procedures
---------------------	-------------------------

6
(cont.)

cut or fill symbol. This elevation is an estimate of the height of either the road cut or fill.

d. Record this number to the nearest meter on the overlay adjacent to symbol 26, table A1, appendix A.

7

Emergency Drive-Offs:

These emergency areas are usually characterized by flat areas adjacent to the road and easily accessible from the road. In flat, open country it is unnecessary to show all such areas. In broken or heavily forested areas with few flat areas, the emergency areas are important and must be shown.

Care must be taken not to show areas where there are obstacles between the road and the area. Areas with fences, cuts, fills, or deep ditches should be avoided.

Look for farm roads and tracks leading from the roads to adjacent fields, to flat areas, to athletic fields, etc.

8

Level Crossings:

Level crossings (grade crossings) may or may not be symbolized on the topographic map. If the map legend gives a symbol for such crossings, use symbol 19 from table A1 at each point.

Where such crossings are not specifically symbolized on the map, look for points where road and railroad symbols cross. If there is no map symbol indicating a bridge or overpass, it may be assumed that a grade crossing exists.

The clearance beneath the catenary is required only if the railroad is electrified and uses overhead wires. Electrified railroads are usually labeled, but the catenary clearance is seldom given. If the railroad is electrified, but no clearance is given on the topographic map, check the railroad factor overlay. If the clearance cannot be determined, place a question mark above the crossing symbol on the overlay to indicate that there are overhead wires but the clearance is unknown.

9 Turn-Out, Rest, and Park Areas:

These features can only be determined if they are symbolized on the map. Where they are symbolized, it is usually possible to measure the length of the area.

Select only areas within 100 meters of the road and with an access from the road.

Look for highway rest stops, shopping center parking lots, stadium and athletic field parking lots, parks, factory and business parking lots, and municipal airfields.

10 UTM Coordinates:

To determine the UTM map coordinates for any point or feature on a map, locate the grid reference box (figure 7) that appears in the marginal information of each map sheet. The box contains step-by-step instructions for using the grid, and the U. S. Army Military Grid Reference System. The grid reference box is divided into two parts. The left portion identifies the grid zone designation and the 100,000 meter square. If the sheet falls in more than one 100,000-meter square, the grid lines that separate the squares are shown in the diagram and the values for these grid lines are given. The right portion of the grid reference box explains how to use the grid and is keyed to a point on the map.

The following is an example of a military grid reference:

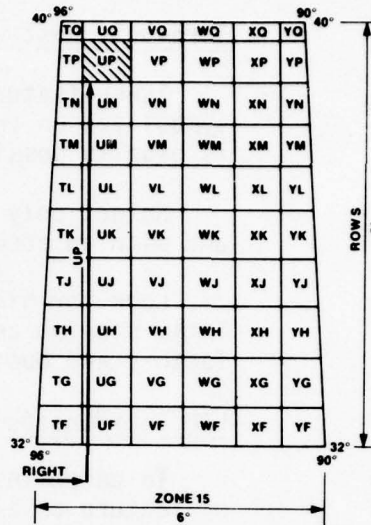
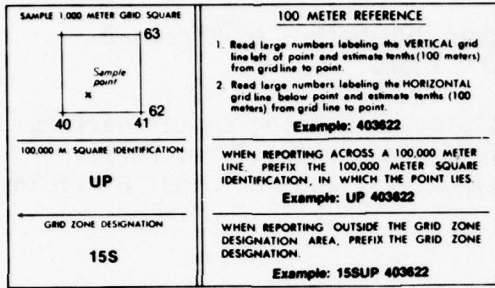
15S locates the 6° x 80 area (grid zone designation) (figure 7).

15SUP locates the 100,000-meter square (figure 8).

15SUP46 locates within the 10,000-meter square (figure 9).

To locate the 1,000- and 100-meter square, follow the same procedure; read right, and then up, measuring the distance in each case. Record the location information in the appropriate Data Table.

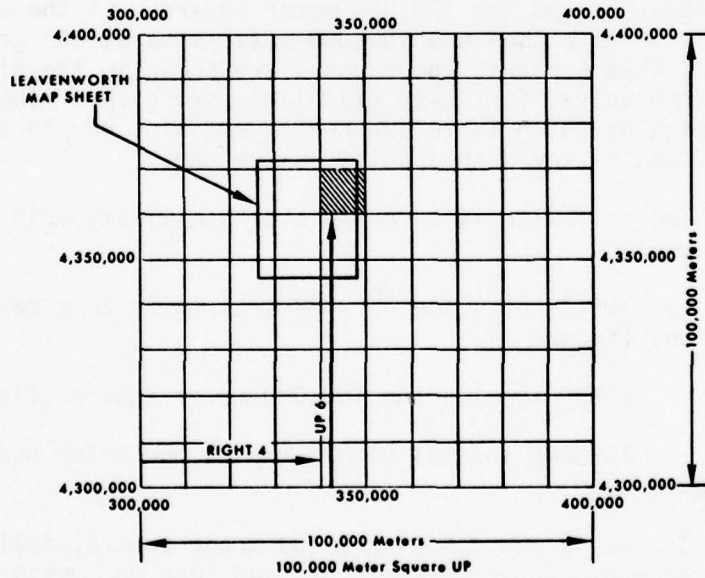
10.
(cont.)



(▨ Indicates area located)

Figure 7. Grid Reference Box

Figure 8. The 100,000-Meter Square Identification



(▨ Indicates area located)

Figure 9. Location of the 10,000-Meter Square

Procedure
Number

Map Analysis Procedure

10.
(cont.)

15SUP4062 locates within the 1,000-meter square.

15SUP403622 locates within the 100-meter square.

11

Structure Length Determination:

The symbols for bridges, tunnels and galleries are usually not drawn to their true scale on U. S. military maps. In order to legibly portray these features, they are plotted at a minimum length of 0.06 inches (1.50mm), regardless of map scale. The structure symbols that measure more than 0.06 inches (1.50mm) represent the true length of the structure.

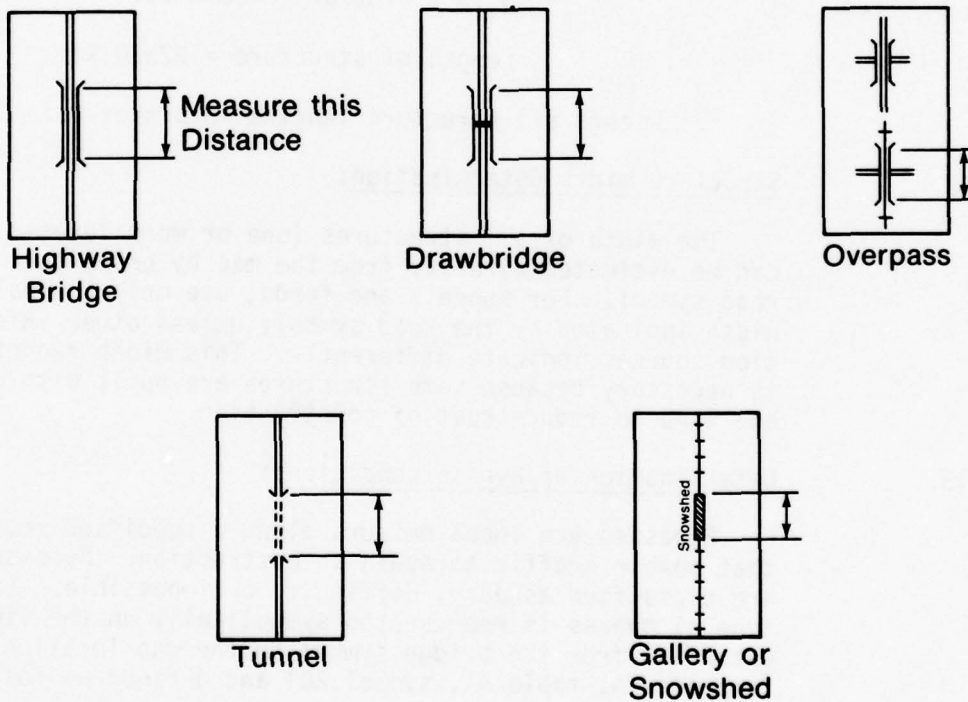


Figure 10. Structure Length Determination

11.
(cont.)

To determine the true length of a structure, the following steps should be employed:

a. Determine the length of each structure symbol with a tube magnifier that is calibrated in either inches or millimeters. These measurements are made as shown in figure 10.

b. For those structures longer than 0.06 inches, (1.50mm) multiply their length by the map scale factor:

Example: Map Scale = 1:50,000

Measured Symbol Length = 0.15 inches

1 inch on map = 4166.67 ft. on ground

$0.15 \times 4166.67 = 625.0$ ft.

Length of structure = 625.0 ft.

c. Record all structure lengths in proper Data Table.

12.

Structure Width Determination:

The width of all structures (one or more lanes) can be estimated directly from the map by using the road symbol. For tunnels and fords, use only one-half the width indicated by the road symbol, unless other information sources indicate differently. This width reduction is necessary because some structures are built with only one lane to reduce cost of construction.

13.

Determination of Bypass Conditions:

Bypasses are local detours along a specified route that enable traffic to avoid an obstruction. Bypasses are classified as easy, difficult, or impossible. Each type of bypass is represented symbolically on the line extending from the bridge symbol to the map location (appendix A, table A1, symbol 20) and defined as follows:

a. Bypass easy. The obstacle can be crossed within the immediate vicinity of the bridge by a U.S. 2½-ton, 6 x 6 truck (or NATO equivalent) without work to improve the bypass.

13
(cont.)

b. Bypass difficult. The obstacle can be crossed within the immediate vicinity of the bridge, but some work will be necessary to prepare the bypass.

c. Bypass impossible. The obstacle can only be crossed by one of the following methods:

1. Repair of existing bridge.
2. Construction of a new bridge.

Bypass conditions can be determined from detailed study of the area directly adjacent to the obstruction.

The following factors should be considered when evaluating bypass conditions:

Steepness of bank slopes

Depth of water

Denseness of vegetation

Roughness of surface

Presence of boulders

Presence of approaches

Wet, soft ground

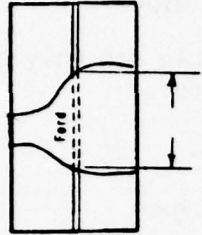
14

Ford Length Determination:

The crossing length of a ford can be estimated from the map symbol by measuring the distance between the stream margins (figure 11). Streams indicated by a single line symbol are always 25 meters or less in width and cannot be used for this purpose.

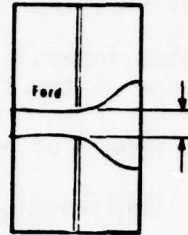
14
(cont.)

Large Scale



Measure
this
Distance

Medium Scale



Small Scale

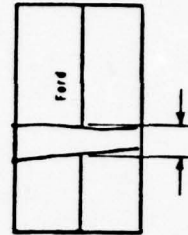


FIGURE 11. Ford Length Determination

Example: Map Scale = 1:50,000

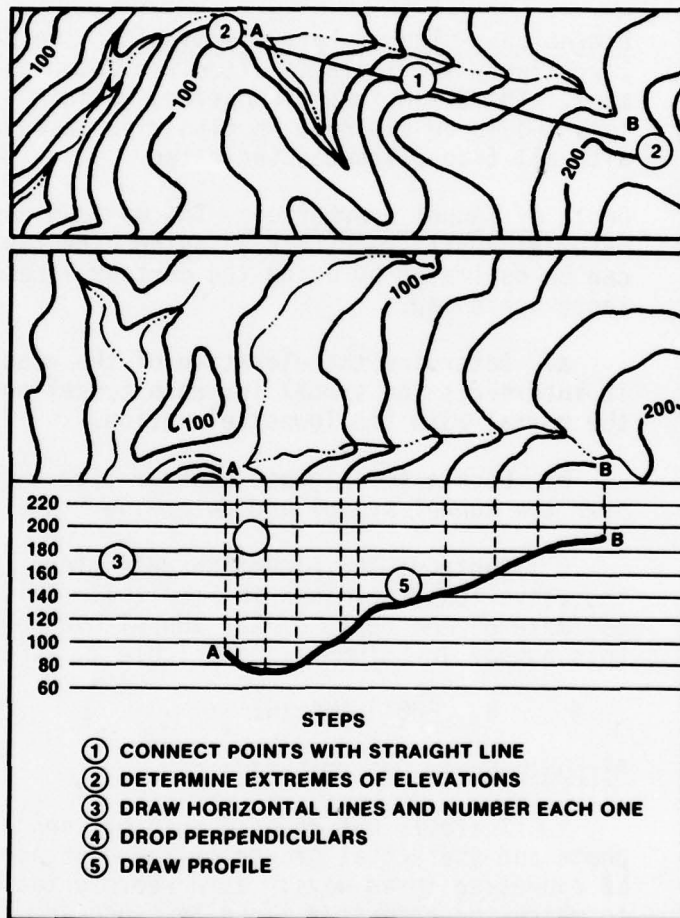
Ford Length (Map) = 12.5mm

Actual Ford Length = $\frac{50,000 \times 12.5}{1,000}$

= 625 meters.

15

Cross Section or Profile Determination: To prepare a cross section of the topography from point A to point B, follow steps 1 through 5 as shown in figure 12 below.



For additional details see FM 21-26.

Figure 12. Cross Section or Profile Determination

- 16 Determination of Ferry Travel Distance: Actual distance of ferry travel cannot be determined from map analysis because the route indicated on the map is usually an approximation. When ferry terminals are directly opposite each other, the width of the river can be used as an approximate travel distance. If the terminals are located on different maps, determine the straight line open water distance and record it in Data Table IV, Column 8. When distances are approximated, this fact should be noted in Column 8 adjacent to the distance.
- 17 Dimensional Plan of Ferry Terminals: The plan view of large ferry terminals is often indicated on U.S. military maps. The dimensions of wharves, buildings, and parking lots should be sketched in plan view on Data Table IV with all true distances indicated.
- 18 Depth of Tunnel Overburden: The maximum depth of the material (soil, rock, etc.) laying directly over a tunnel can be estimated by using the contour lines found on a topographic map.
- a. Determine the elevation of the road surface where it intersects the symbol for each tunnel portal. Select the portal with the lowest elevation.
 - b. Locate the highest contour line that passes directly over the tunnel symbol and determine its elevation.
 - c. Subtract the elevation determined in Step (a) from the elevation determined in Step (b). This number is an estimate of the depth of the tunnel overburden. Record this number in Column 7, Data Table V, as an estimate.
- B. PHOTO ANALYSIS
- 19 Airphoto Scale Determination:¹
- a. Scale is the relationship between distances on a photo and the actual ground or map distance. Scale may be expressed three ways: as a representative fraction (R.F.) in which the numerator is unity, such as $\frac{1}{10,000}$; as a ratio,

¹Department of the Army, "Imagery Interpretation Handbook," Vol. I, TM 30-245, 1967.

19
(cont.)

such as 1:10,000; or as a relationship between dissimilar units, such as 1 inch equals 1 mile. In the case of the representative fraction or ratio, the numerical relationship is valid regardless of the unit of measure used, that is, 1 inch on the map equals 10,000 inches on the ground or 1 meter on the map equals 10,000 meters on the ground. A scale expressed in dissimilar units, for example, 1 inch equals 1 mile, may be better understood by the user. The representative fraction for this scale is $\frac{1}{63,360}$, that is, 1 inch on the map equals 63,360 inches on the ground (the number of inches to a statute mile).

b. The three methods of obtaining the scale of a vertical photograph, in decreasing order of accuracy, are the determination of the relationships of photo to object of known dimensions, photo to map, and focal length of camera to absolute altitude of camera.

(1) Photo to Object of Known Dimensions. A scale determination can be made by relating the measurement of an object on the photo to the actual known dimensions of the object. Such objects might be aircraft, ships, port facilities, railroads, or buildings. For example, the wing span of a particular aircraft is 42 feet. The measurement on a photo is 0.007 foot.

$$\text{R.F.} = \frac{\text{measured image length}}{\text{actual length}} = \frac{d}{D}$$

$$\text{R.F.} = \frac{0.007}{42} = \frac{1}{6,000}$$

(2) Photo to Map. When the distance is measured between two points on the photo that can be located on the map, the horizontal measurements of these distances on the map and on the photo form a ratio, D:d.

This ratio is the same as that between the R.F.'s on the map and of the photo, that is, $D:d = \text{R.F. of the map} : \text{R.F. of the photo}$. For example:

Procedure Number	Photo Analysis Procedure
------------------	--------------------------

19
(cont.)

Map measurement = 0.108 foot.

Photo measurement = 0.432 foot.

$$\text{R.F. of the map} = \frac{1}{50,000}$$

$$\text{R.F. of the photo} = \frac{1}{X}$$

$$\frac{0.108}{0.432} = \frac{X}{50,000}$$

$$0.43X = 5,400$$

$$X = 12,500$$

$$\text{R.F. of the photo} = \frac{1}{12,500}$$

(3) Focal Length of Camera to Altitude of Camera. Properly titled aerial photography will indicate the focal length of the camera and the altitude from which the photo was taken. Inserting this information, expressed in the same unit, $\frac{f \text{ (focal length of camera)}}{H \text{ (absolute altitude)}}$ will give the R.F. of the photo. For example,

$$f = 20 \text{ inches}$$

$$H = 18,000 \text{ feet}$$

$$\text{R.F.} = \frac{20 \text{ inches}}{18,000 \text{ feet}} = \frac{1.67 \text{ feet}}{18,000 \text{ feet}}$$

$$\text{R.F.} = \frac{1}{10,800}$$

(4) In areas that have elevations other than sea level, the barometric altitude figure found in the photograph title requires conversion to obtain absolute altitude. The altimeter records barometric pressure translated into feet above sea level. It will indicate approximately the same pressure for 18,000 feet, whether the aircraft is flying over Death Valley or the Rockies.

19
(cont.)

But, obviously, the scales of pictures taken over these areas from an indicated 18,000 feet will not be the same. When the ground elevation is known, the $\frac{f}{H}$ formula is refined to $\frac{f}{H-h}$, where h is the elevation (in feet above sea level) of the area being photographed. The interpreter should refer to the radar altitude if this information is available.

In determining the scale, the three methods just mentioned have common errors that should be recognized by the image interpreter. Therefore, it is necessary to check and recheck all measurements used for scale determination to minimize errors.

c. Oblique Aerial Photography. The scale of oblique aerial photography is difficult to determine because it constantly varies from the foreground to the background of the photo. In the event that vertical aerial photography is not available and oblique photography has to be employed to obtain the necessary data, the analyst should consult the "Image Interpretation Handbook,"² pages 3-16 to 3-35.

20

Preparation of Photos for Stereo Viewing: Before proceeding further, it is strongly suggested that the analyst review the "Image Interpretation Handbook,"³ pages 3-1 to 3-15.

Orient aerial photographs in the following manner for stereo viewing:

a. Locate the principal point of each aerial photo by constructing lines from one fiducial mark to the opposite fiducial mark (figure 13).

²Department of the Army, "Image Interpretation Handbook," TM 30-245, Vol I, pp. 3-16 to 3-35.

³Ibid, pp. 3-1 to 3-15.

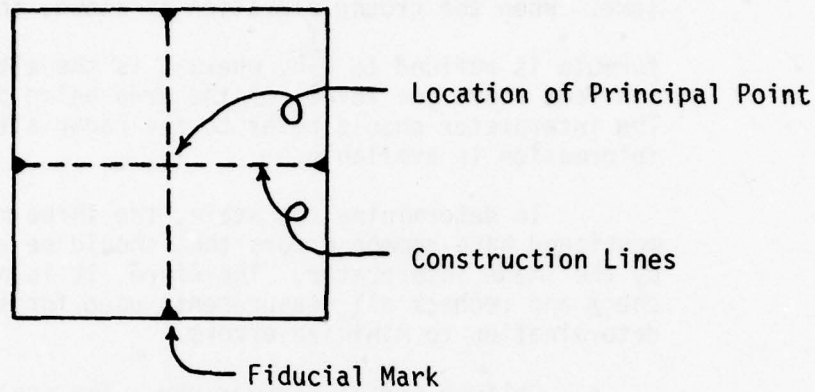


Figure 13. Locating Principal Point of an Aerial Photo

- b. Using a stereoscope, locate and mark with a pinprick the principal point (PP1) of Photo #1 on Photo #2.
- c. Repeat this process and locate the principal point (PP2) of Photo #2 on Photo #1.
- d. Place photos on flat surface and orient so that all principal points fall on a straight line (figure 14).

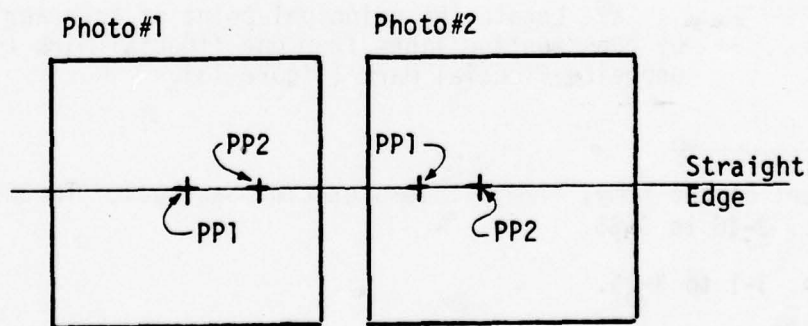


Figure 14. Locating Conjugate Principal Point

20
(cont.)

e. Move the photos along this line until the object of interest on each photograph is approximately 2.25 inches (52mm) apart (figure 15).

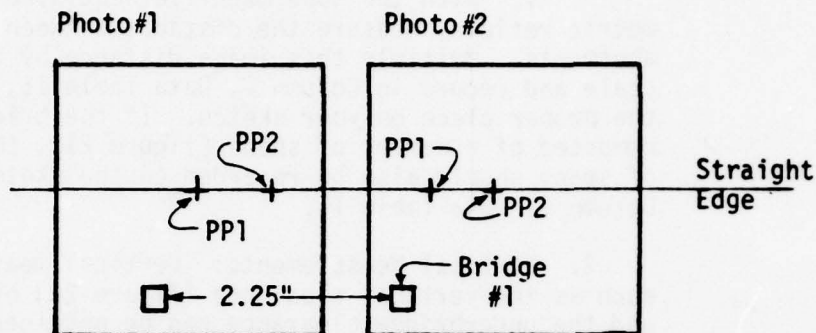


Figure 15. Orienting Photos for Stereo Viewing

f. When stereo viewing of aerial photography is required, all photos should be oriented in the above manner.

21

Vertical Aerial Photography Measurements:

1. Horizontal Measurements:

a. Orient two adjacent aerial photos (stereo pair) as in Procedure #20 in order that the object (Bridge #1) to be measured on Photo #1 is 2.25 inches (52mm) from the object (Bridge #1) on Photo #2 (figure 15).

b. Secure photos with drafting tape.

c. With the tube magnifier, closely study the bridge portals and determine the location of the traveled way (figure 20).

d. Determine the distance between the curbs of the traveled way with a tube magnifier equipped with a metric scale. Multiply the image measurement by the photo scale to determine the true measurement. Record this value on the bridge cross-sectional sketch in Column 11 and Column 8C, Data Table II.

21
(cont.)

e. Determine the length of Bridge #1 by first locating, under stereo viewing conditions, the abutments at each end of the bridge.

f. With the tube magnifier equipped with a metric reticle, measure the distance between the abutments. Multiply this image distance by the photo scale and record in Column 7, Data Table II, and at the proper place on your sketch. If the bridge is composed of a number of spans (figure 21), the number of spans should also be recorded on the sketch and in Column 6, Data Table II.

2. Vertical Measurements: Vertical measurements such as the vertical clearance (figure 20) of the bridge and the underbridge clearance can be obtained from stereo aerial photography by using either a Parallax Wedge (figure 16) or a Height Finder (figure 17). Although measurements made with these instruments are more accurate than those obtained from a map, they are not as accurate as those obtained from on site measurements or measurements obtained from "as-built" drawings.

a. Parallax Wedge:

(1) Position wedge over top of object (lower edge of bridge superstructure) as shown in Figure 18A.

(2) View the photos in stereo as shown in figure 19A (assume reading of 0.023 feet).

(3) Position wedge over base of object (road surface directly adjacent to bridge portal) as shown in figure 18B.

(4) View the photos in stereo as shown in figure 19B. (Assume reading of 0.024.)

(5) Subtract smaller displacement reading from larger (0.024 ft. - 0.023 ft. = 0.001 ft. = amount of displacement).

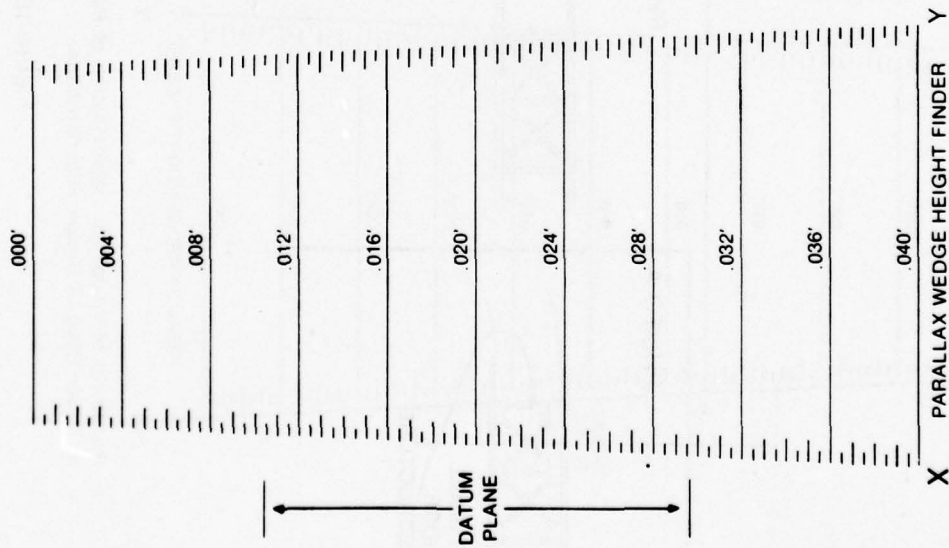
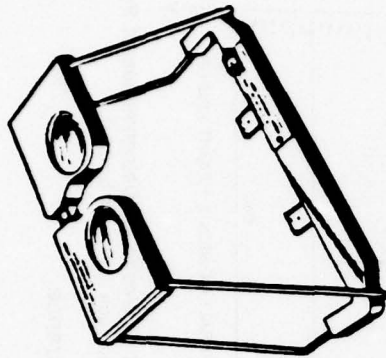
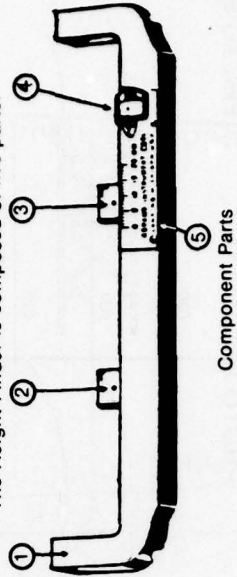


Figure 16. Parallax Wedge



The Height Finder is composed of five parts:

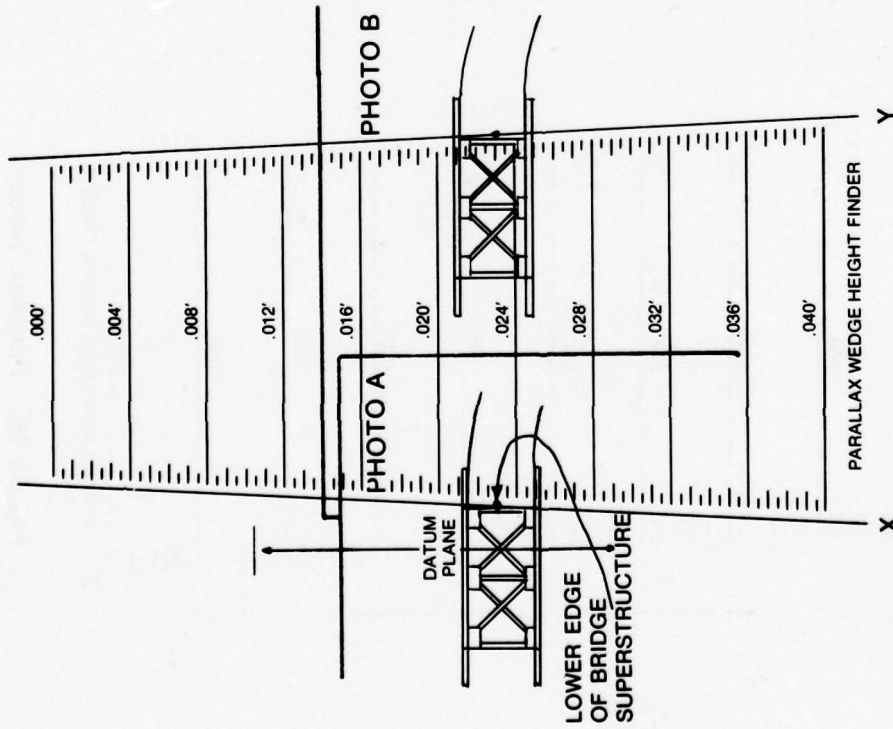
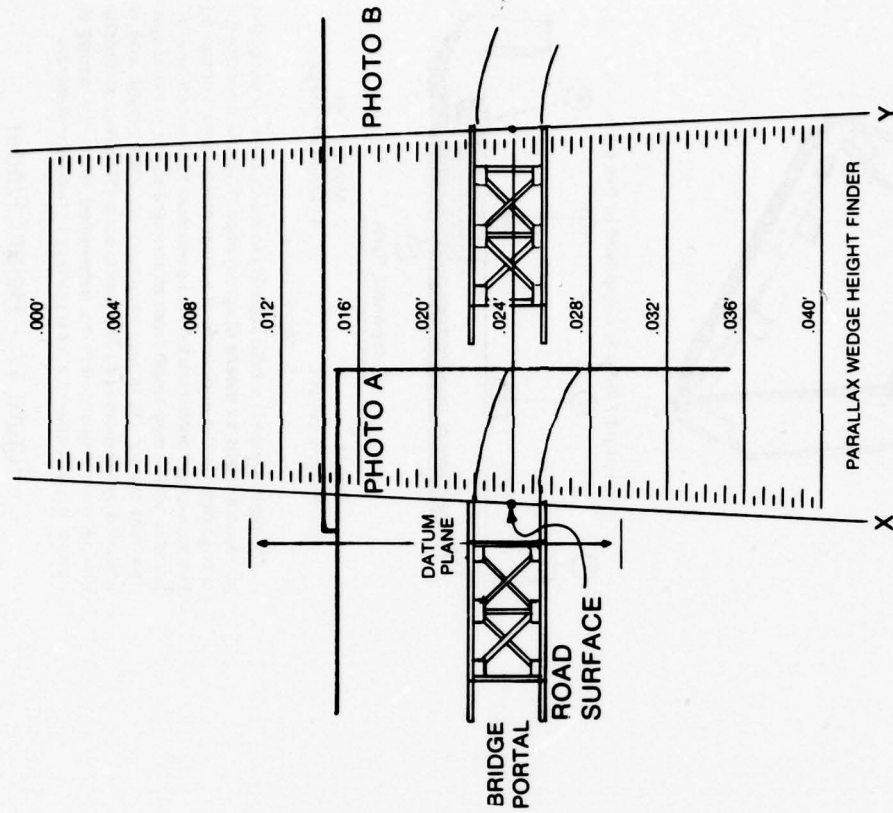


Component Parts

- 1. Frame
- 2. Reference Dot
- 3. Moving Dot
- 4. Cylinder gauge
- 5. Metric Scale

The rigid frame (1) is held securely to the cross-member of the stereoscope legs by means of spring clips. The reference dot (2) is engraved on the underside of a clear plastic lens. Loosening two screws will permit the lens to be adjusted to eliminate any "Y" parallax which may result from attachment to the stereoscope. The moving dot (3) is also engraved on clear plastic and is actuated by the gauge (4). The metric scale (5) measures directly the parallax displacement as determined when the gauge is turned. It is capable of a total reading of twenty millimeters.

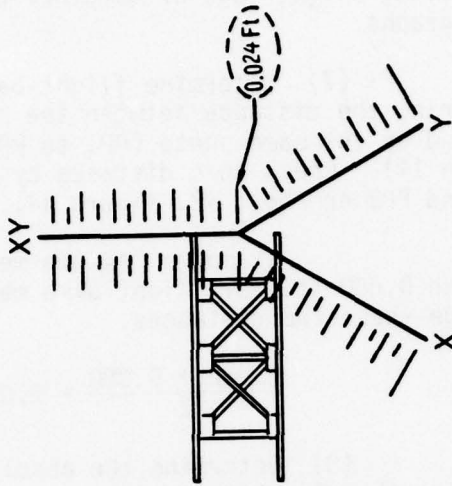
Figure 17. Height Finder



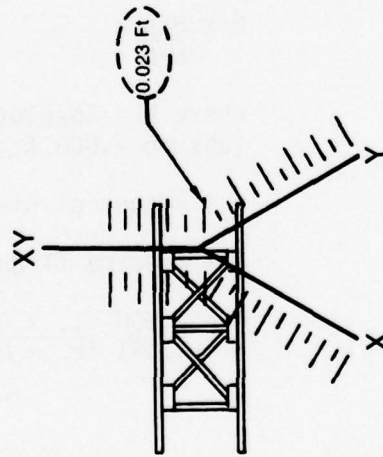
A. Placement of Wedge for Determination of Parallax at Lower Edge of Bridge Superstructure.

B. Placement of Wedge for Determination of Parallax at Road Surface (base of bridge).

Figure 18. Wedge Measurement of Vertical Clearance



A. Lines Fused at Top of Image



B. Lines Fused at Base of Image

Figure 19. Fusion of Parallax Wedge Under Stereo Viewing Conditions

Procedure
Number

Photo Analysis Procedure

21
(cont.)

(6) Determine altitude of aircraft by consulting flight logs or marginal data on aerial photographs.

(7) Determine flight-base distance by measuring the distance between the principal points plotted on the same photo (PP1 to PP2 on Photo #1, figure 14). Check this distance by measuring between PP1 and PP2 on Photo #2, figure 14.

Example: Assume measurements of 0.082 ft. and 0.080 ft. for flight base measurement. Then average these two distances.

$$\frac{0.082 + 0.080}{2} = 0.081 \text{ ft.}$$

(8) Determine the absolute altitude by locating the elevation of the road surface from map contour lines near the bridge. Subtract this distance from the aircraft altitude to obtain absolute altitude.

(9) Solve the formula

$$h = \frac{H \times p}{b+p}$$

where H = Absolute altitude of aircraft
(assume 2,000 ft.*)

p = Amount of displacement (0.001 ft.)

b = Average flight base distance (0.081 ft.)

$$h = \frac{2,000 \text{ ft.} \times 0.001 \text{ ft.}}{0.081 \text{ ft.} + 0.001 \text{ ft.}} = 24.4 \text{ ft.} = \text{vertical clearance of bridge}$$

Multiply by 0.305 to record the data in meters.

*Height of aircraft above the terrain surface rather than altimeter altitude, which is height above sea level.

21
(cont.)

(10) Record this distance on the cross-section sketch in Column 11, Data Table II.

(11) Determine the underbridge clearance (using the same method as above) by measuring the difference in elevation between the bridge deck and the surface of the feature passing beneath the bridge. Since the bridge substructure will not be visible to the analyst, the height of the substructure will have to be estimated and subtracted from the computed underbridge clearance distance.

(12) Record the underbridge clearance distance on the sketch in Column 11, Data Table II.

b. Height Finder

(1) Orient photos according to Procedure #10 and secure with masking or drafting tape.

(2) Attach the Height Finder to the stereoscope by placing the instrument on the cross member of the stereoscope legs with the gauge to the right. Push down ends of the Height Finder to engage the spring clips. Slide the Height Finder as far toward you as the construction of the stereoscope legs will permit (see figure 17). This will place the dots directly below the stereoscope lens.

(3) The stereometer is a stereoscope with special measuring attachments. Under each lens is a glass plate that rests on its respective photograph of a stereoscopic pair. On the bottom of each glass plate is a small dot. The dot under the left lens remains in a fixed position. The dot under the right lens may be moved by an adjusting knob along the eye base of the stereometer. The movement of the right dot is measured by a micrometer dial. The range of distance between the dots is significant. For example, on a particular stereometer, when the adjusting knob is turned so that the dots are at minimum separation, the dots may be 60 millimeters apart. When the adjusting knob is turned so that the dots are at a maximum separation, the dots may be 70 millimeters apart.

Procedure Number	Photo Analysis Procedure
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21
(cont.)

To take parallax measurements from a stereo pair of photographs with this instrument, corresponding points on the two photographs must be between 60 and 70 millimeters apart when the photographs are properly oriented for stereoscopic vision. Relative to the graduation of the instrument, the numbers may increase or decrease in magnitude when the dots converge. For example, if there is a range of 10 millimeters between minimum and maximum separation of the dots, the readings may be 0 at minimum and 10 at maximum separation or 0 at maximum and 10 at minimum separation, depending on the type of stereometer.*

(4) Datum Plane. Since all elevations are relative, some reference plane must be established. This reference plane is the datum plane, an imaginary horizontal plane above which the photographic aircraft is flying at a known altitude. The datum plane is readily determined when either a shoreline or a control point of known elevation above sea level appears in the photographs and the altitude of the aircraft above sea level is known.

(5) Datum Plane Reading. A stereo pair of photos showing at least one point on the datum plane is oriented under the stereometer so that the flight line (line connecting principal point and transferred principal point) is parallel to the eye base of the stereometer. The left dot is placed on the datum plane point. The right dot is moved by the adjusting knob to the same point on the second photograph and fused with the left dot. The fused dot appears to be floating in contact with the ground at this datum point. The micrometer reading, to the nearest hundredth of a millimeter, is recorded. This is the datum plane reading.

*Department of the Army, "Image Interpretation Handbook," TM 30-245, 1967.

21
(cont.)

(6) Differential Parallax. After measurement of the datum plane point, the left dot is placed on the point of undetermined elevation so that the photographic flight line and stereometer eye base are parallel. The micrometer knob is rotated until, when viewed stereoscopically, the right dot is fused with the left dot and appears to be floating in contact with the point of undetermined elevation. The new micrometer reading is taken and the difference between this reading and the datum plane reading is calculated. If the second reading represents a convergence of the dots, the difference is labeled with a plus sign; if it represents a separation of the dots, the difference is labeled with a minus sign. This value is the differential parallax; it has both magnitude and a sign. The higher the elevation, the closer together corresponding points will appear in the stereoscopic pair of photographs so that a convergence of the dots is labeled with a plus sign. For example, if the stereometer is graduated such that numbers increase when the dots converge, a reading at the point of undetermined elevation greater than the reading at the datum plane represents a convergence of the dots and the difference in the readings is labeled with a plus sign. A reading at the datum plane represents a separation of the dots and the difference is labeled with a minus sign. If the stereometer is graduated such that numbers decrease when the dots converge, the reverse is true.

(7) Elevation Computation. When the magnitude and the sign of the differential parallax have been determined, the elevation or depression of the point above or below the datum is computed by the formula

$$h = \frac{H \times p}{b + p}$$

where,

h = Difference in elevation between datum plane and point in feet.

H = Absolute altitude in feet.

p = Differential parallax in millimeters (to nearest 0.01mm).

b = Distance between principal points of photographs in millimeters.

21
(cont.)

(This parameter is determined by plotting the principal point of each photo on the other photo and measuring the distance between the centers. When there are differences in elevation of the principal points of the two photos, the measurements of b will give different results on each photo. This can be corrected by using the formula, $\frac{(b_1 + b_2)}{2}$).

2

(8) The parameters p and b may be measured in any desired unit, provided they are expressed in the same unit. In all cases, the unit in which h is given in the equation will be the same as that in which H is expressed. When p is a negative quantity, h will also be a negative quantity representing the distance of the point below the datum plane.

(9) Relative Elevation of Other Points. Once the relative elevation of the first point has been determined, another formula may be used to determine the relative elevation of other points in the same set of photographs. This formula is not as accurate as the first formula, but for practical purposes it is adequate for measuring small differences in elevation:

$$\frac{h}{p} = \frac{h^1}{p^1} \quad \text{or} \quad h^1 = \frac{h p^1}{p}$$

where,

h = Difference in elevation between datum plane and first point, already determined in feet.

p = Differential parallax used for first determination in millimeters.

h^1 = Difference in elevation between datum plane and second point to be determined in feet.

p^1 = Differential parallax as measured for second point in millimeters.

(p and p^1 may be measured in feet; both terms must be expressed in the same unit.)

21
(cont.)

(10) To illustrate the use of the formula given in paragraph (7), suppose that the height of a sea cliff in a stereoscopic pair of aerial photographs is to be determined. The photographs showing both the datum plane point (on the shoreline) and a point at the top of the cliff are first oriented under the stereometer with the lines of flight (principal point to transferred principal, PP1 and PP2, point) of the photographs parallel to the eye base of the stereometer. The points to be measured are checked for distance limitations of the stereometer (between 60mm and 70mm), and found to be within the limits. The stereometer readings increase as the dots converge. The left dot is placed at the datum plane point and the right dot is fused with it stereoscopically by adjustment of the micrometer dial. The fused dot must appear to be in contact with the datum plane point when viewed stereoscopically. Upon fusion of the dots a micrometer dial reading of 3.38 millimeters is recorded. This is the datum reading. The left dot is then moved to the point at the top of the sea cliff and the right dot is fused by adjustment of the micrometer dial. When fused stereoscopically, the dot appears to be in contact with the top of the sea cliff. The micrometer reads 3.98 millimeters. The difference between this reading and the datum plane reading is 0.60 millimeters. Since the reading is greater than the datum plane reading, it represents a convergence of the dots and the difference is labeled with a plus sign (+0.60). The principal point of one photograph of the stereo pair is plotted on the other photograph and the distance between centers measures 76.2 millimeters. The height of the photographic aircraft above the datum plane (sea level) has been determined at 5,000 feet. The elevation of the sea cliff with respect to the datum plane is computed as follows:

$$h = \frac{Hxp}{b+p}$$

where, H = 5,000 feet.

p = +0.06 millimeters.

b = 76.2 millimeters.

Procedure Number	Photo Analysis Procedure
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21
(cont.)

$$h = \frac{5,000 \times 0.60}{76.2 + 0.60} = \frac{3,000}{76.80} = 39 \text{ feet} \times .305$$

$$= 11.9 \text{ meters}$$

(11) To determine the height of a building on the same stereoscopic pair using the formula given in paragraph (9), suppose that when the dots are fused on the base of the building, the micrometer dial reads 4.28 millimeters. When the dots are fused at the top of the building, the micrometer reads 4.58 millimeters.

Base of building:

$$h^1 = \frac{h p^1}{p}$$

$$h = 39 \text{ feet}$$

$$p = 0.60\text{mm}$$

$$p^1 = 0.90\text{mm}$$

$$h^1 = \frac{39 \times 0.90}{0.60} = 58 \text{ feet above datum.}$$

Top of building:

$$h = 39 \text{ feet}$$

$$p = 0.60\text{mm}$$

$$p^1 = 1.20\text{mm}$$

$$h^1 = \frac{39 \times 1.20}{0.60} = 78 \text{ feet above datum.}$$

Height of building:

$$78 - 58 = 20 \text{ feet} \times .305 = 6.1 \text{ meters.}$$

22

Surface Materials and Conditions:

a. In table 5, the generalized air photo characteristics of road surface materials are listed. The photo appearance should be compared with the table, and the surface material estimate should be made during the map analysis. The route category should also be considered when the type material is not readily apparent; national routes are usually concrete or bitumen and county roads are often gravel.

b. Surface condition is difficult to estimate except from very large scale photography. Look for evidence of frequent patching, checks, broken edges, potholes, ruts, and frost or heat heaving.

c. Surface material of medians and shoulders can be bare ground, grass, trees, shrubs, gravel, bitumen, or concrete. In some instances, the median may be only a wall or barrier and will be difficult to detect. Use the largest scale photos available and the highest practical magnification.

23

Road Gradient:

a. Follow Procedure #20 to orient aerial photos for stereo viewing. Study the entire map area and locate all road gradients (hills) that appear to be near or greater than 7 percent.

b. Use Procedure #21-2 to determine the elevation of the top and bottom of each hill, points E_1 and E_2 respectively.

c. Determine the horizontal distance (HD) between points E_1 and E_2 using Procedure #21-1.

d. Subtract E_2 from E_1 and divide by HD; multiply the answer by 100.²

$$\frac{E_1 - E_2}{HD} \times 100 = \text{gradient (percent)}$$

e. If your answer is 7 percent or greater, mark the hill on the overlay according to symbol 16, table A1, appendix A.

TABLE 5. AIR PHOTO CHARACTERISTICS OF ROAD SURFACE MATERIALS

FILM TYPE	AIR PHOTO CHARACTERISTICS			
	CONCRETE	PAVING STONE	BITUMEN	GRAVEL
Panchromatic	Ctr Line Pres; Def Margins; Light-Toned	Ctr Line Pres; Light to Dark-Toned Depending on Materials; Pattern of Blocks May Be Detectable	Ctr Line Pres; Indef Margins; Dark-Toned	No Ctr Line; Indef Margins; Light to Dark Gray Tone
				No Ctr Line; Indef Margins; Tone Dependent on Soil Color
Black and White Infrared	Ctr Line Pres; Def Margins; Light-Toned	Ctr Line Pres; Light to Dark-Toned Depending on Material; Pattern of Blocks May Be Detectable	Ctr Line Pres; Indef Margins; Dark-Toned	No Ctr Line; Indef Margins; Light to Dark Gray Tone
				No Ctr Line; Indef Margins; Tone Dependent on Soil Color
Color	Ctr Line Pres; Def Margins; Light-Toned	Ctr Line Pres; Light to Dark-Toned Depending on Material; Pattern of Blocks May Be Detectable	Ctr Line Pres; Indef Margins; Dark-Toned	No Ctr Line; Indef Margins; Light to Dark Gray Tone
				No Ctr Line; Indef Margins; Tone Dependent on Soil Color
Color Infrared	Ctr Line Pres; Def Margins; Light-Toned	Ctr Line Pres; Light to Dark-Toned Depending on Material; Pattern of Blocks May Be Detectable	Ctr Line Pres; Indef Margins; Dark-Toned	No Ctr Line; Indef Margins; Light to Dark Gray Tone
				No Ctr Line; Indef Margins; Tone Dependent on Soil Color

24

Height of Road Cuts and Fills:

- a. Orient adjacent aerial photos of each cut or fill for stereo viewing according to Procedure #20.
- b. With stereo viewing, locate the point on either the cut or fill that has the highest elevation.
- c. Using either the Parallax Wedge or the Height Finder, determine the elevation of this point (Procedure #21).
- d. Locate a point on either the cut or fill that appears under stereo viewing to have the lowest elevation.
- e. Determine the elevation of this point using the same method employed in Step c.
- f. Subtract the lower elevation from the higher elevation and record the height (cut) or depth (fill) next to the symbol on the overlay.

25

Bridge Analysis:

- a. By providing a side view of the structure, oblique photos are the best source to determine the type construction, material, length, overhead and underbridge clearances, number and type of spans, and length of individual spans (figure 21). Measurement is dependent on accurate determination of the scale, which must be done carefully. Where practical, duplicate measurements should be made on vertical photography and the results averaged.
- b. Although measurements on vertical photos are usually more accurate than similar measurements made on obliques, the vertical photos do not provide the side view so useful in determining the type of construction. Where there is a definite shadow of the bridge, it will often provide much of the same information available from oblique coverage. When there is no shadow of the bridge, examine the surrounding verticals and look for an image of the bridge that falls near the edge of the photograph. Images near the edge of vertical photos are often displaced or tilted so that the side of the object is visible.

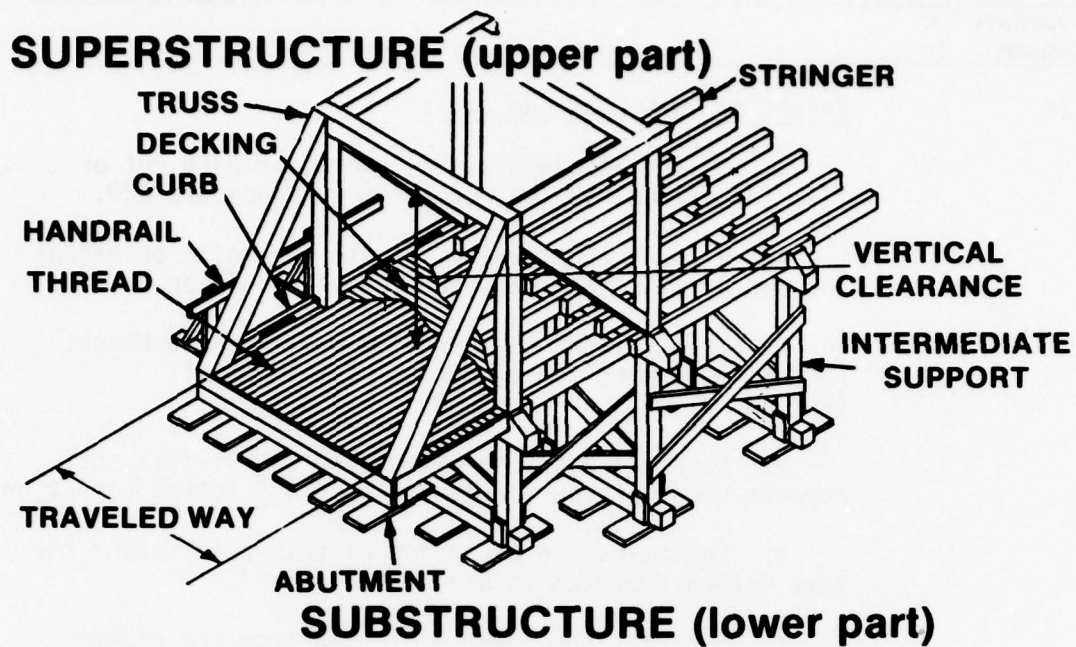
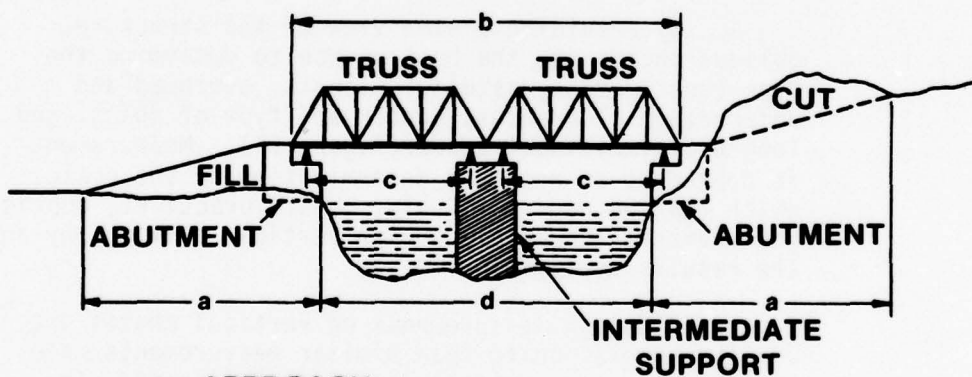


Figure 20. Typical Bridge Construction



- a = APPROACH
- b = OVERALL LENGTH
- c = SPAN LENGTH, BEARING TO BEARING
- d = LENGTH, ABUTMENT TO ABUTMENT

Figure 21. Bridge Mensuration Requirements

Procedure
Number

Photo Analysis Procedure

25
(cont.)

c. Determination of the military load class cannot be done directly from aerial photography, but can be roughly estimated from vehicles that were using the bridge at the time the photograph was taken. Examine the photos and identify any vehicles that may appear on the bridge. If the load class of the vehicle can be estimated, it can be assumed that the class of the bridge is at least the same. If no vehicles are actually on the bridge, examine the vehicles that have already crossed or are approaching the bridge.

26

Type Construction: On large scale (1:2000 to 1:15,000) aerial photography - panchromatic, color, etc. - structure construction type and materials such as masonry, wood, steel-reinforced concrete, and steel are easily identified by indicators that appear on the photograph. These indicators include photographic tone/color, texture, and careful study of the structure shadow. With detailed study of the photographs, especially under stereo conditions, the analyst should be able to determine not only the type of construction but also the major type of material composing the structure. Table 6 provides an aid for obtaining this data.





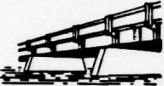


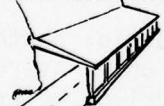
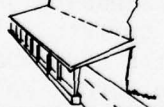
27

Bypass Conditions: Although the standard topographic map will supply all of the necessary information to determine bypass conditions for each bridge and LOC structure, aerial photography must be employed to continuously update the map, particularly under combat conditions.

To determine bypass conditions from aerial photography, study the area adjacent to the structure under stereo conditions and note any indications of shallow water, which can be identified, for example, by sandbars or rocks that are visible through the water surface. In addition, look for vehicle tracks along the river bank that indicate the location of an existing ford. When the structure is a dam used as a bridge, examine the downstream side of the dam. On the downstream side, the water is often shallow enough to be used as a bypass, and because dams are almost always sited where bedrock is close to the surface, the stream bottom conditions are usually firm enough to support most types of vehicles.

TABLE 6.

STRUCTURE CONSTRUCTION TYPE IDENTIFICATION
FROM VERTICAL AERIAL PHOTOGRAPHY

STRUCTURE TYPE	SPAN TYPE	PHOTO INDICATORS	PHOTO TONE/ COLOR/TEXTURE	PROBABLE MATERIAL TYPE
Bridge	 SUSPENSION BRIDGE	Towers Cable and Cable Anchors Shadow Outline of Towers and Suspension Cables. Texture of Tower Surfaces.	Color: Green, Red, Black Tone: Dark Gray	Steel Reinforced Concrete
	 TRUSS	Presence of Superstructure Cross Hatch Pattern of Span Members, Detail Visible from Shadow Detail.	Color: White, Gray, Red, Silver Tone: Light to Dark Gray Texture: Rivet Pattern	Steel
	 SLAB	Absence of Superstructure Type of Guard Rails: (1) Angular (2) Rounded, Smooth	Beam, Girder, and Slab Bridge Design Preclude Identification of Construction Material from Vertical Aerial Photography. When Possible, the Analyst Should Obtain Low Oblique Photography of These Types of Bridges.	
	 BEAM	Absence of Superstructure Type of Guard Rails: (1) Angular (2) Rounded, Smooth, Length		
	 GIRDER	Absence of Superstructure Type of Guard Rails: (1) Angular (2) Rounded, Smooth, Length, Shadow Detail		
	 ARCH (closed spandrel)	Shadow Detail: Massive Structure	Color: White, Red Tone: Gray, Light Gray Texture: Rough Joint Patterns	Masonry Structures are massive and usually old. Reinforced concrete spans are smaller.
	 ARCH (open spandrel)	Shadow Detail: Open Structure, Smooth, Rounded Span Members	Color: White to Light Gray Tone: Gray to Light Gray Texture: Smooth	Smooth Rounded Span Members: Reinforced Concrete Angular Span Members: Steel
Snowshed		Location: Mountainous Areas Length	Color: Light Gray to White Tone: Light Gray Texture: Smooth	Difficult to determine from Vertical Photo. Long Structures (100 m) are probably reinforced concrete.
Gallery		Location: Limited to Mountain Sides and Valleys. Rock and Landslide Indications in Area.	Roof Material not Indicative of Material.	Recent Construction: Reinforced Concrete. Old Structure: Wood

28

Ford Width:

a. Look for indications that the roadway continues across the channel. The indications would appear as two faint lines that mark the sides of the traveled way.

b. Some fords have the sides of the roadway marked by boulders that appear on the imagery.

c. Where the ford has been raised by adding material to the bottom of the stream, the sides may appear as lines of ripples or eddies of a lighter tone than the surrounding water.

d. Use Procedure #21-1 to measure the width.

29

Ford Bottom Characteristics: The ability to determine ford bottom characteristics - paved, rocky, sandy, etc. - from aerial photography depends on a number of factors. These factors include water depth, water clarity, film type, and photo scale. The analyst should attempt to determine this data element by the following method:

a. Orient aerial photos of the ford for stereo viewing (Procedure #20).

b. Study the area around the ford and the river, or stream channel, both upstream and downstream of the ford.

c. Look for indications that the road surface is continued across the channel. Evidence of the sub-surface road would appear as two faint lines that mark the width of the road surface or traveled way.

d. Rapids, white water, and exposed rocks or boulders indicate a rocky bottom. Bars, braiding, and steep banks will often indicate coarse-grained material such as sand or gravel. Meanders and ox bows in the immediate vicinity indicate relatively slow moving streams with fine-grained material. Angular drainage patterns with frequent sharp changes in direction indicate rock control and probably a rocky bottom. In

Procedure Number	Photo Analysis Procedure
29 (cont.)	swift-flowing streams in mountainous areas the fine materials do not settle; therefore, the bottoms are usually rocky or firm.
30	<p><u>Length of Ferry Crossing:</u> Ferry crossing length can be easily determined from aerial photography if both terminals appear on a single photograph. If two or more photos are required, a mosaic of a number of photos will have to be constructed.</p>
	<p>a. Single Photo Method.</p>
	(1) Determine scale of photos (Procedure #19).
	(2) Locate terminals.
	(3) Measure open water distance between terminals with tube magnifier or scale.
	(4) Multiply the measured distance by the denominator of the representative fraction to determine true distance.
	<p>b. Mosaic Method.</p>
	(1) Determine number of photos required to cover the entire open water distance between ferry terminals.
	(2) Secure photo containing the most western terminal to a suitable flat surface.
	(3) Carefully place the adjacent photo over the edge of the first photo, aligning common terrain features of Photo #2 with Photo #1. Continue this process until the second ferry terminal appears on a photo.
	(4) Check your work making certain that all photos are properly aligned.
	(5) Scale the open water distance between ferry terminals. Multiply the photo distance by the denominator of the photo representative fraction (Procedure #21-1).

31

Ferry Terminal Layout:

a. Orient the photos for each terminal according to Procedure #20 and examine the terminal facilities and approaches.

b. Examine the land facilities. Look for large buildings, parking lots, winches, guyline towers, and any other features that may affect the use or capacity of the site. Where feasible, determine the dimensions of the site and major structures.

c. Examine the water approaches. Look for obstacles, evidence of the channel, fenders, piers, and pilings.

32

Vessel Information:

a. Ferry Length, Beam, and Capacity.

(1) Orient photos according to Procedure #20 for stereo viewing.

(2) Locate one or more of the vessels.

(3) Determine the photo scale (Procedure #19).

(4) With the tube magnifier equipped with a metric reticle, measure the length and width of each vessel. Multiply the photo distances by the denominator of the photo scale to determine true distances.

(5) Estimate the number of vessel decks capable of carrying vehicles.

(6) Assume an automobile size of 2 by 6 meters and a weight of 2 tons.

(7) Estimate vehicle capacity for one deck of the vessel. Multiply this number by the number of decks.

(8) If all vessels do not have the same length and beam, measure and record each vessel separately.

33

Approach Conditions (Fords and Ferries).

a. Approaches are classified as easy when the following conditions are met.

- (1) The slope is 7 percent or less.
- (2) The surface is relatively smooth with no ruts, potholes, or other obstacles.
- (3) The width is at least 3 meters.
- (4) There are no sharp curves within 50 meters of the water's edge.
- (5) The surface is well drained or free of standing water.

b. Failure to meet all of the above conditions will result in the approach being classified as difficult.

34

Gallery, Snowshed Function: Both galleries and snowsheds are LOC related structures that are quite similar in design and function. Galleries are designed to protect road surfaces from soil and rock slides, and snowsheds are built to protect roads from snow avalanches. Because these structures are built in similar locations, i.e. mountainous terrain, and are similar in design, their function can be difficult to determine from aerial photography (table 6). In general, snowsheds are located at higher elevations because snow avalanche conditions prevail at higher elevations than do rock or landslides. In addition, areas of the terrain that are subject to landslides usually have indications of previous slide activity. These indicators appear as striations that are situated parallel to the direction of the slope. Vegetation patterns in a landslide area can also provide indications of previous slides. These patterns will be broken or discontinuous with fractured tree stems and with unvegetated slippage scars evident.

Study the area surrounding the structure for indications of landslides. Look for large outcrops of rock directly above a structure. Determine the elevation of the structure in relation to the mountain ridge line (low elevation = gallery, higher elevation = snowshed).

35

Depth of Tunnel Overburden:

- a. Orient photos of tunnel for stereo viewing according to Procedure #20. Use Procedure #19 to determine photo scale.
- b. Study both portals of tunnel and determine which portal has the lowest elevation.
- c. If vertical aerial photography is used, determine elevation of road structure that is adjacent to the tunnel portal of lowest elevation (Procedure #21-2).
- d. Locate the highest point on the terrain that is directly over the tunnel and determine its elevation using Procedure #21-2.
- e. Subtract the lowest elevation (Point A, figure 22) from the highest elevation (Point B, figure 22). This vertical distance also includes the vertical clearance of the tunnel. If this distance is known, it should be subtracted from the total vertical distance.

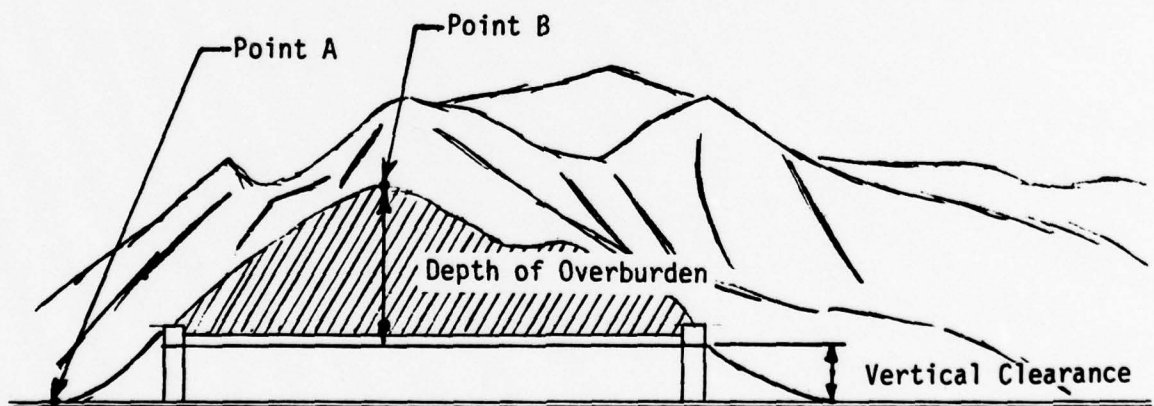


Figure 22. Depth of Overburden For Tunnels

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Appendix A. SPECIFICATIONS for the PREPARATION
of ROADS and RELATED-STRUCTURES FACTOR OVERLAYS

I. INTRODUCTION.

A. The purpose of this appendix is to specify the methods of recording the results of the roads analysis in the form of factor overlays and data tables.

B. The roads and related structures factor overlays will consist of two parts; (1) an overlay registered to a standard 1:50,000 scale map and (2) data tables describing feature conditions shown on the overlay.

C. In congested areas, the basic 1:50,000 scale overlay may be supplemented by overlays registered to larger scale maps. Where the larger scale supplements are used, the area covered by the supplement will be outlined and identified on the basic overlay.

D. Where a standard 1:50,000 scale map is not available as a base for the overlay, a base map at another scale may be used. If the base map selected exceeds 26 by 34 inches, it will be subdivided and two or more overlays prepared.

E. The data tables will be prepared on material of the same type and size as the overlay.

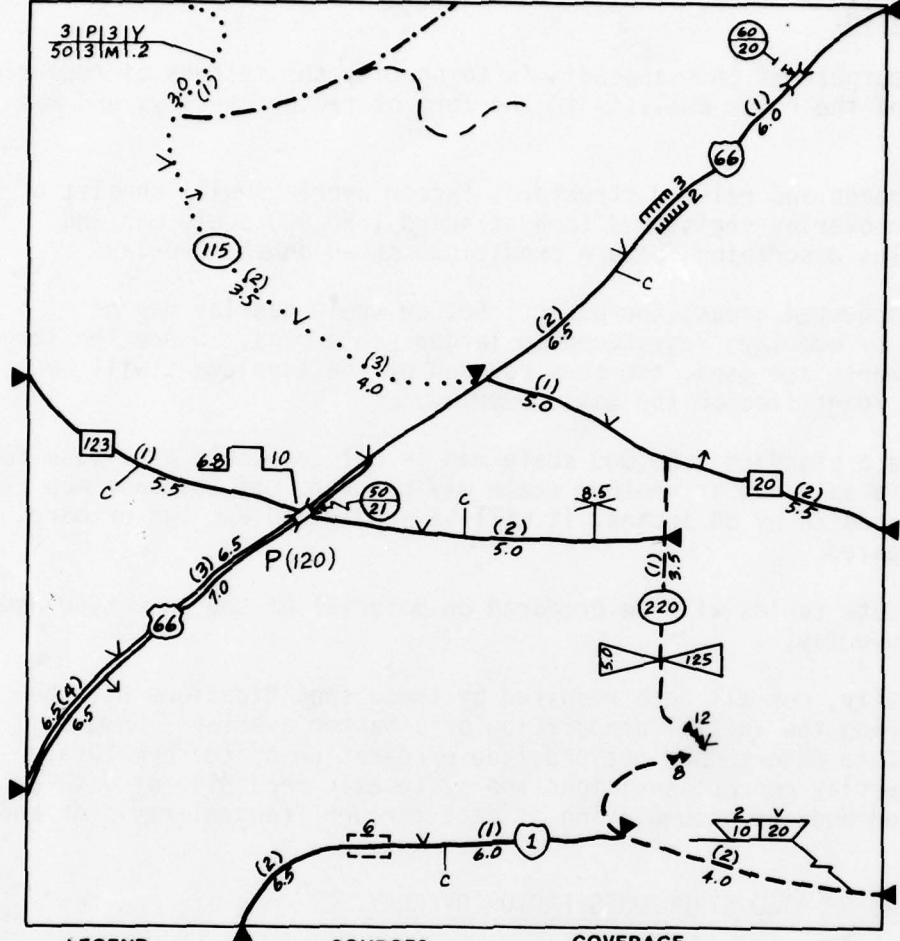
F. Normally, not all data required by these specifications will be available during the initial preparation of a factor overlay. However, lack of complete data should not preclude preparation of the overlays. The factor overlay concept envisions the systematic recording of data as it is acquired and the accumulating of data through frequent revision and update.

II. ROADS AND RELATED-STRUCTURES FACTOR OVERLAY.

A. An example of a factor overlay is shown in figure A1. Specifications for the format of the overlay are provided in figures A2 and A3. Figure A4 illustrates the format of Data Tables I through V.

B. Specifications for the symbols to be used on the factor overlays are contained in table A1 as a guide only. Precise compliance with the specified dimensions of the symbols is not necessary. Positioning of the symbols, however, should conform with mapping standards. Where the symbols cannot be positioned with mapping accuracy because of deficiencies in the source material, the actual accuracy will be clearly specified in the coverage diagram or reliability statement.

LSAETL INDIANHEAD ROADS & RELATED STRUCTURES 5424 III R 734 JULY 1979

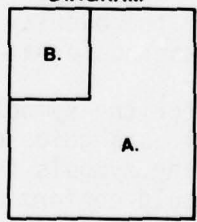


LEGEND

SOURCES

- A. USAF Air Photos, 1976
- B. Va. Dept. of Highways Route Map 1978.

COVERAGE DIAGRAM

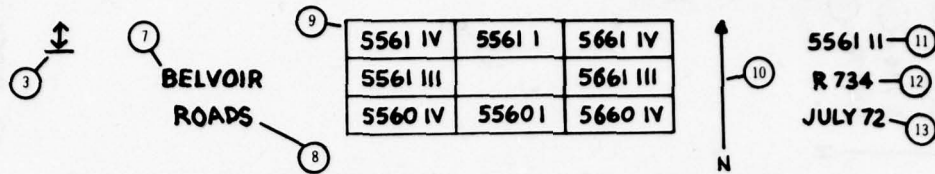


INDEX

1	2
4	3

Figure A1. Sample Factor Overlay

1: 50,000
USAE:TL



1. Factor maps will be drawn on stable base translucent film base (.004" to .007" thick) not exceeding 660 x 860mm (26 x 34 inches).
2. Only black ink will be used. All lines must be at least .09mm (.004") wide. No character will be less than 2mm high.
3. A clear area at least 2cm wide will be allowed on all edges. No lines, letters, symbols, or other data will be placed in these clear areas.
4. The scale of the factor map will be placed in the upper left corner adjacent to the clear area. Letters will be 4mm high.
5. The data file identification code will be placed 2mm below the scale; letters will be 4mm high. The data field subtitle (if appropriate) will be placed in parenthesis to the right of the I.D. code.
6. The identification of the organization preparing the overlay will be placed 2mm below the data file code.
7. Title of the base map to which the factor overlay is registered will be centered at the top of the sheet. Letters will be 6mm high with the top of the letters at least 16mm above the realine.
8. The data field name will be centered 2mm below the sheet name. Letters will be 6mm high.
9. An index to adjoining sheets will be placed in the upper right corner. Letters will be 3mm high separated by a 3mm vertical distance.
10. A true north arrow 16mm long will be placed just to the right of the index to adjoining sheets.
11. The sheet number of the base map will be placed in the upper right corner to the right of the north arrow and in line with the scale (4). Letters will be 4mm high. The words "sheet number" will be omitted. If the base map is oversized and has been subdivided the identification of the part will be placed in parenthesis to the right of the sheet number.
12. The series number of the base map will be placed 2mm beneath the sheet number in letters 4mm high. The words "series number" will be omitted.
13. The month and year of the preparation or revision of the factor map will be placed 2mm beneath the series number in letters 4mm high.
14. The top neatline of the map will be positioned approximately 20mm beneath the top clear area. Sheets with the longest dimension north-south will be centered. Sheets with the longest dimension east-west will be positioned so the left neatline falls 1cm inside the clear area.
15. Tick marks will be placed on the four outermost grid intersections so as to form a rectangle. Each leg of the tick mark will be 6mm long.
16. A metric bar scale will be centered beneath the bottom neatline. Numbers will be 2mm high.
17. An index of the parts of the subdivided sheet will be placed in the lower right corner of each part. To avoid encroaching on space required for legends and other explanatory data this index will be kept small.
18. A coverage or reliability diagram will be placed to the left of the index whenever a variety of sources are used or the quality of the data varies.
19. All overlays will be punch registered to the base map and to each other. Sheets with the long axis north-south will be registered in left clear area. Sheets with the long axis east-west will be registered in the top clear area.
20. Areas with a greatest dimension less than 2mm at the scale of the map will not be delineated. Areas with a greatest dimension less than 8mm will be identified by lead lines.
21. Marginal areas are identified as either A, B, C, or D. When preparing legends area A will be completely used before recording data in B, area B before C, and area C before D.

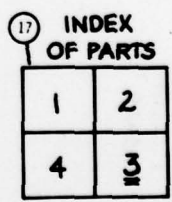
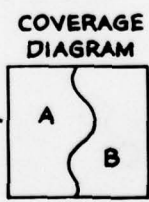
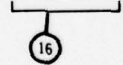
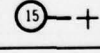


Figure A2. Format for Factor Overlays with Long Axis N-S

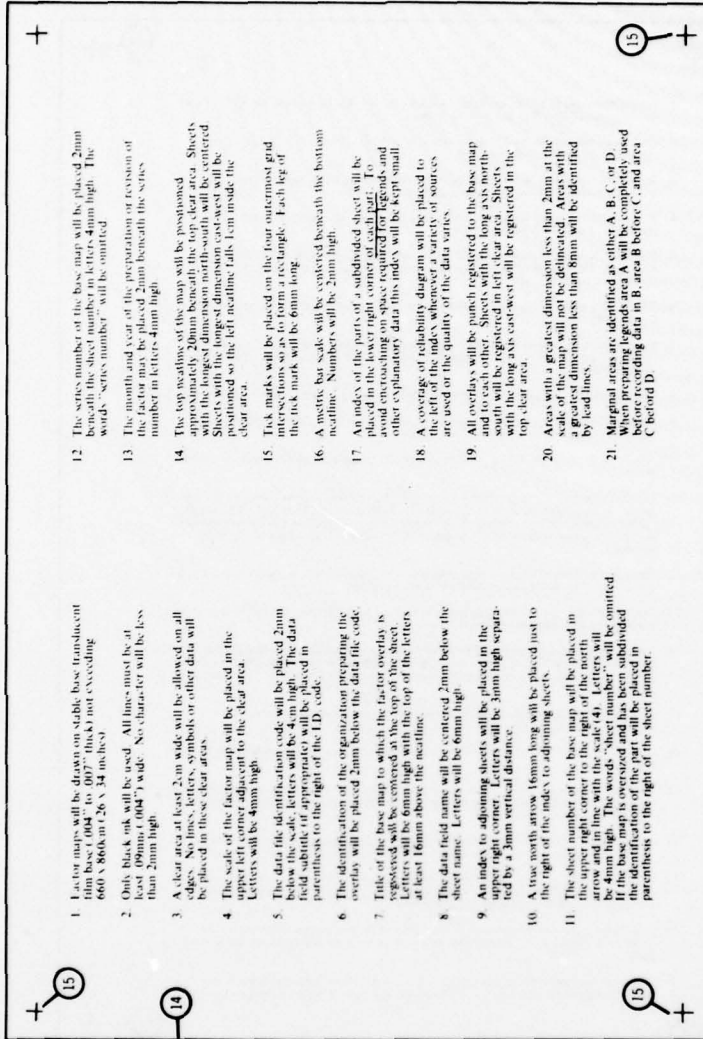
1:50,000
USAE/TL

3

7 BELVOIR
ROADS

5561 IV	5561 I	5661 IV
5561 III		5661 III
5560 IV	5560 I	5660 IV

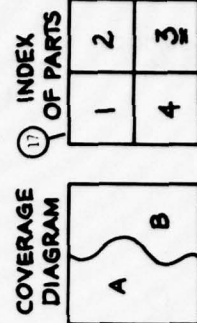
10 5561 II
R 734
JULY 72



19

21

19



21 A

Figure A3. Format for Factor Overlays with Long Axis E-W

DATA TABLE I-ROADS

1 ROAD NO.	2 SEG NO.	3 SEGMENT UTM	4 NO. CUL.	5 SURF MATL	6 COND.	7 WIDTH (M) TRAVELED WAY		8 MEDIAN		9 SHOULDERS		10 OBSTACLES		11 CROSS SECTION OR COMMENT
						a.	b.	WIDTH (M)	MATL	WIDTH (M)	MATL	UTM	TYPE	
Md State 223	1	146780	3	pb	good	7.0		N.A.		2.0	gravel	124692	Stone Wall	
	2	551234	6	pb	good	6.0		N.A.		2.5	gravel	162321	Bridge	
	3	523611	2	rb	good	6.0		N.A.		2.0	gravel	367982	Rock Cut	

DATA TABLE II-BRIDGES

1 ROAD NO.	2 SEG NO.	3 BRIDGE NO.	4 BRIDGE UTM	5 LOAD CLASS				6 NO. SPANS	7 TOTAL LENGTH (M)	8 SPAN CHARACTERISTICS					9 FEATURE CROSSED	10 BYPASS COND.	11 SKETCH OR COMMENT
				WHEEL		TRACK				CONST. MATL a.	CONST. TYPE b.	ROAD WIDTH c.	O.H. CLEAR d.	U.B. CLEAR e.			
				→	←	→	←										
Va State 123	5	1	532114	105	40	65	25	2	124	MC	Slab	7.0m	unlimited	10m	wind river		
	6	2	131695	85	30	40	20	1	83	CS	Beam	6.5m	unlimited	9.5m	railroad; route 223		

DATA TABLE III-FORDS

1 ROAD NO.	2 SEG NO.	3 FORD NO.	4 FORD UTM	5 CROSSING LENGTH (M)	6 WIDTH (M)	7 DEPTH (M)		8 VELOCITY (M/HR)		9 BOTTOM CONDITIONS	10 APPROACHES	11 CROSS SECTION AND PROFILE
						PERIOD	DEPTH	PERIOD	VEL			
Macon Co. 7	8	1	432194	10	17	AUG	1.0	MAY	0.9	CS	difficult (Swampy ground, both banks)	

DATA TABLE IV-FERRIES

1 ROAD NO.	2 FERRY NO.	3 FERRY UTM	4 TYPE	5 NO. VESSELS	6 LENGTH (M)	7 LOAD CLASS (each)	8 CROSSING LENGTH (M)	9 APPROACH CONDITIONS		10 FEATURE CROSSED	11 TERMINAL LAYOUT
								Left	Right		
N.C. State 34	1	321235	V	1	32	95	3400	Easy	Easy	Herring Bay	

DATA TABLE V-TUNNELS, GALLERIES, SNOWSHEDS

1 ROAD NO.	2 SEG NO.	3 STRUCT NO.	4 FUNCTION	5 PORTAL UTM	6 LENGTH (M)	7 OVERBURDEN DEPTH (M)	8 ROADWAY WIDTH (M)	9 VERT. CLEAR.	10 HORIZ. CLEAR.	11 LINING MATL.	12 BYPASS COND.	13 CROSS SECTION AND PROFILE
W. Va 304	6	3	tunnel	134632	600	49	7.0	10.0m	8.0m	Concrete	Impossible (Steep rocky slopes)	

Figure A4. Data Table I, II, III, IV & V

TABLE A1. SYMBOL SPECIFICATIONS FOR ROADS AND RELATED STRUCTURES





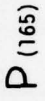


No.	FEATURE	SYMBOL	SPECIFICATIONS
ROUTE CATEGORIES & IDENTIFICATION			
1.	U. S. Interstate, Federal Routes, Autobahns, or Equivalent		Pickett Template #1168 Symbol 3/8" high
2.	Federal Main Routes, U. S. Routes, or Equivalent		Pickett Template #1168 Symbol 3/8" high
3.	State Route or Equivalent		Pickett Template #1168 Symbol 1/4" x 3/8"
4.	County Route or Equivalent		Pickett Template #1263 Symbol 1/4" x 3/8"
5.	Parking Lots, Rest Areas, and Parks; (165) Indicates length of Parking Lot in Meters		Letter .2", numbers .1"
6.	Emergency Drive-off		Arrow .2" long.
7.	Roadway Width (In Meters)		Numbers .15"

Table A1. SYMBOL SPECIFICATIONS FOR ROADS AND RELATED STRUCTURES (CONT.)


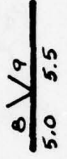






No.	FEATURE	SYMBOL	SPECIFICATIONS
8.	Limit of Route		Triangle, solid .2"
9.	Limit of Road Segment (Change in Roadway Characteristics) Figures 8 & 9 are Road Segment Numbers		"Y" .2" on a side
10.	Type X, Dual Highway, All-weather, Non Frost Susceptible		Solid double line .05"
11.	Type X, Route, All-Weather, Hard Surface, Non Frost Susceptible		Single solid line .05"
12.	Type Y, Route, All-Weather, Loose or Light Surface, Locally Frost susceptible		Dashed line .05" dash .2" space .1"
13.	Type Z, Route, Fair-Weather, without surface, or Lightly Metalled		Dotted line Dots .05" spaced .1"
14.	Track		Dash: 2" x .025", Dot .05", space .1"
15.	Trail		Dash line, dash .1" x .025, space .1"

TABLE A1. SYMBOL SPECIFICATIONS FOR ROADS AND RELATED STRUCTURES (CONT.)


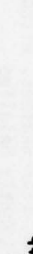
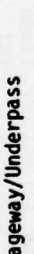
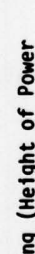
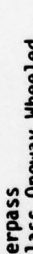

No.	FEATURE	SYMBOL	SPECIFICATIONS
16.	Steep Grade (Arrows Point up hill)		Arrowheads .1" triangle
17.	Constriction Left: Width Right: Length (meters)		Numbers .1" high
18.	Covered Passageway/Underpass a) Arch b) Box Left: Horizontal Right: Vertical		Numbers .1" high
19.	Level Crossing (Height of Power Line = 5.5 meters)		Circle diameter .4" Numbers .1" high
20.	Bridge or Overpass A. Load Class Oneway Wheeled *Non-Military Load Class Shown B. Bridge ID No. C. Bypass Cond. - Easy Difficult Impossible		Circle diameter .4" Numbers .1" high
21.	Fords A. Ford Number		Numbers .1" high Arrow points to Ford

TABLE AT. SYMBOL SPECIFICATIONS FOR ROADS AND RELATED STRUCTURES (CONT.)

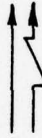
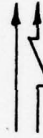
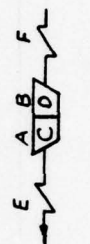

No.	FEATURE	SYMBOL	SPECIFICATIONS
B.	Ford Type		
	1. A - Vehicular		
	2. P - Foot		
	3. D - Deepwater, Tank		
	4. S - Swimming Vehicles		
C.	Stream Velocity (Meters Per Second)		
D.	Seasonal Limitations		
	1. X - None		
	2. Y - Significant		
E.	Length (Meters)		
F.	Width (Meters)		
G.	Bottom Type		
	1. M - Mud		
	2. C - Clay		
	3. S - Sand		
	4. G - Gravel		
	5. R - Rock		
	6. P - Artificial		
H.	Depth (Meters)		
I.	Arrow Points to Ford Location		
J.	Approach Conditions, Left Bank		
	1. Easy		
	2. Difficult		
K.	Approach Conditions, Right Bank		
	1. Easy		
	2. Difficult		
22.	Ferries		
	A. Ferry Number		

TABLE A1. SYMBOL SPECIFICATIONS FOR ROADS AND RELATED STRUCTURES (CONT.)

No.	FEATURE	SYMBOL	SPECIFICATIONS
B.	Ferry Type 1. V - Vehicular 2. F - Foot 3. M - Military		Width .2", Length to scale Number .1" high
C.	Military Load Classification		
D.	Dead Weight Capacity		
E.	Approach Condition, Left Shore 1. Easy 2. Difficult		
F.	Approach Condition, Right Shore 1. Easy 2. Difficult		
23.	Tunnel (With ID number)		Width .2", Length to scale Number .1" high
24.	Gallery or Snowshed		Width .2", Length to scale Number .1" high
25.	Culverts		Letter .1"
26.	Cuts and Fills (Height to Nearest Meter)		Numbers .1" Tick Length to scale

C. Road Category and Identification (Symbols 1, 2, 3, and 4, table A1):

A road category is defined as that network of roads maintained by a particular level of government, for example United States 1 (U.S. #1) or Virginia 123. The category will be identified on the overlay by the particular symbol enclosing the identification (ID) number. Category and ID numbers are not shown for tracks or trails.

D. Road Classifications and Materials (Symbols 10 through 15, table A1):

The classifications for roads, tracks and trails, which are specified in TM S-1 and FM 5-36^{4, 5} are summarized below.

Type X: All-weather road, hard surface, not susceptible to frost action, with reasonable maintenance passable throughout the year to an unlimited volume of traffic.

Type Y: All-weather road, loose or light surface, locally susceptible to frost action, with reasonable maintenance kept open in all weather, but sometimes only to a limited volume of traffic.

Type Z: Fair weather road, without surface or lightly graveled, becomes quickly impassable in adverse weather, cannot be kept open by maintenance short of reconstruction, limited volume of traffic.

Track: Traveled ways over a natural roadbed, with little or no improvement, usually not maintained.

Trail: Natural traveled ways not wide enough to accommodate wheeled or tracked vehicles.

E. Segment End Point (Symbol 9):

1. A segment is defined as that portion of a route characterized by uniform load bearing, traffic capacity, and width. End points of segments are portrayed by nodes along the route at which any of the following conditions occur:

- (a) Change in the number of lanes.
- (b) Change in surface material.

⁴Defense Mapping Agency Hydrographic/Topographic Center, "Specifications for Military Maps," Vol. I, TM S-1.

⁵Defense Mapping Agency Hydrographic/Topographic Center, "MGD - Roads and Road Structures," FM 5-36.

(c) Point at which route crosses the neatline of the factor overlay.

(d) International boundary crossings in the case of all roads.

(e) State boundary crossings in the case of state and county roads.

(f) County boundary crossings in the case of county roads.

2. Segments will be numbered sequentially within each route, i.e. I-95, segments 1, 2, 3, 4; VA-236, segments 1, 2, 3, etc.

F. Width of Traveled Way (Symbol 7): The width of traveled way indicates the total width of road surface available for use by traffic. This does not include shoulders or medians, which may or may not exist. Accuracy must be to the nearest 0.5 meter. Width is shown for both sides of dual roads.

G. Grade (Symbol 16): The maximum gradient of each segment is symbolized by arrows placed at the bottom and top of the grade, whenever the grade is greater than 7 percent. The arrowheads will be positioned so that the flat end of the first arrowhead marks the bottom of the grade and the pointed end of the second arrowhead marks the top of the grade. The actual grade in percent will be recorded adjacent to the first arrowhead.

H. Constriction (Symbol 17): Constrictions are defined as reductions in the width of the traveled way that are below minimum requirements (7.0 meters). The figure on the left side of symbol tells the available width of traveled way and the figure on the right side gives the length of the constriction.

I. Turn Out, Rest, and Park Areas (Symbol 5): These are defined as prepared areas adjacent to the roadway that can be used by vehicles as stopping points so as not to block the roadway itself.

J. Emergency Drive-Off Areas (Symbol 6): These are defined as unprepared areas adjacent to the roadway where vehicles can drive off the road in an emergency. Such areas are characteristically flat without steep banks, fences, or other obstacles that would hinder departure from the road.

K. Bridge or Overpass Identification Number and Load Classification (Symbol 20): ID numbers are applied sequentially within a factor overlay, with the sequence continuous within each route. The load classification shown will be for one-way wheeled vehicles. Other categories of load classifications are recorded in Data Table II (figure A4).

L. Bridge or Overpass Bypass Conditions (Symbol 20): Bypasses are local detours along a specified route that enable traffic to avoid an obstruction. Bypasses are classified as easy, difficult, or impossible. Each type of bypass is represented symbolically on the line extending from the bridge symbol to the map location and defined as follows:

1. Bypass Easy. The obstacle can be crossed within the immediate vicinity of the bridge by a U.S. 2½ ton, 6 x 6, truck (or NATO equivalent) without work to improve the bypass.

2. Bypass Difficult. The obstacle can be crossed within the immediate vicinity of the bridge, but some work will be necessary to prepare the bypass.

3. Bypass Impossible. The obstacle can only be crossed by one of the following methods:

- a. Repair of existing bridge.
- b. Construction of a new bridge.

M. Bridge or Overpass Length and Width (Data Table II): The length and width are recorded on Data Table II and are not placed on the map.

N. Covered Passageways (Symbol 18): Covered passageways are structures that cross above the roadway. They may be road, railroad, or streetcar underpasses or passageways through or under buildings. Where the structure is a road overpass, both symbols 18 and 20 will be used so as to describe both the overpass and the underpass clearances.

O. Fords (Symbol 21):

1. A ford is defined as a location in a water barrier where the physical characteristics of the current, bottom, and approach enable the passage of personnel and/or vehicles and other equipment whose suspension systems remain in contact with the bottom.

2. ID numbers are applied sequentially within a factor overlay, starting in the upper left corner and reading to the left and downward.

3. Approach conditions are symbolized for each bank as easy or difficult.

a. Approach easy: The approach poses no problems because of slope, surface condition, or drainage.

b. Approach difficult: Approach must be used with caution because of steep slopes, degraded surface, or poor drainage.

P. Ferries (Symbol 22):

1. A ferry is defined as a floating vehicle that conveys traffic and cargo across a water barrier.
2. ID numbers are applied sequentially within a factor overlay, starting in the upper left corner.
3. Approaches are treated in the same manner as for fords.

Q. Tunnels, Galleries,* and Snowsheds (Symbols 23 and 24):

1. This category of feature is defined as any structure, other than overpasses, that roof the road, regardless of length.
2. ID numbers will be assigned sequentially within the map sheet. The same tunnel number cannot appear twice within the same map sheet.
3. Bypass conditions are treated in the same manner as for bridges.

R. Culverts (Symbol 25): Culverts are structures, conduits, or pipes less than 5 meters long that are used to carry water beneath roadways.

S. Cuts and Fills with Heights (Symbol 26): The conventional symbol for cuts and fills will be supplemented by a number indicating the height or depth of the feature in meters. Vertical or near-vertical features, such as retaining walls, will be symbolized by the escarpment symbol supplemented by a metric height number.

T. Level Crossings (Grade Crossings) (Symbol 19): Symbolize all points at which the route crosses a railroad at grade without passing through an underpass or over an overpass. Where the railroad is electrified, the clearance beneath the catenary (in meters) will be recorded above the symbol.

III. DATA TABLES.

A. General. A series of five data tables keyed to the overlay features will be used to provide additional, more detailed information. These data tables are illustrated in figure A4. If possible, the five data tables should be placed on one individual sheet, but if too many entries make this difficult, two or more sheets may be used. Metric dimensions are required, and the metric unit of measurement will be stated along with the source of the data, i.e. map, report, title, etc.

*Galleries are structures similar to snowsheds, but are designed to protect a road from landslides instead of snowslides.

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ARMY ENGINEER TOPOGRAPHIC LABS FORT BELVOIR VA
TERRAIN ANALYSIS PROCEDURAL GUIDE FOR ROADS AND RELATED STRUCTU--ETC(U)
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ETL-0205

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2 of 2

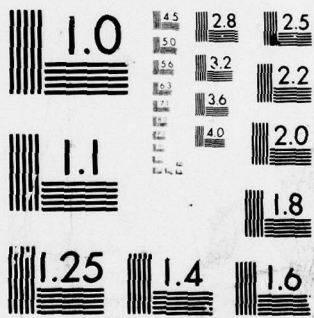
AD
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END
DATE
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2-80

DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

B. Data Table I, Road Information

1. Column 1; Road or Route Category and Number. The information will be spelled out and entered in order.

2. Column 2; Segment Identification Number. Segments are numbered consecutively within each route.

3. Column 3; Segment UTM Coordinates. UTM coordinates ($\pm 10m$) of the beginning point of each road segment will be recorded.

4. Column 4; Number of Culverts in Each Road Segment. Record the total number of culverts in the segment.

5. Column 5; Road Surface Material. Record proper symbol from information below.

SYMBOL	MATERIAL	ROUTE TYPE
k	Concrete	Type (X); generally heavy duty
kb	Bituminous (asphaltic) concrete (bituminous plant mix)	Type (X); generally heavy duty
p	Paving brick or stone	Type (X) or (Y); generally heavy duty
pb	Bituminous surface on paving brick or stone	Type (X) or (Y); generally heavy duty
rb	Bitumen penetrated macadam, waterbound macadam with superficial asphalt or tar cover	Type (X) or (Y); generally medium duty
r	Waterbound macadam, crushed rock or stabilized gravel	Type (Y); generally light duty
l	Gravel or lightly metalled surface	Type (Y); generally light duty
nb	Bituminous surface treatment on natural earth, stabilized soil, sand-clay or other select material	Type (Y) or (Z); generally light duty

SYMBOL	MATERIAL	ROUTE TYPE
b	Used when type of bituminous construction cannot be determined	Type (Y) or (Z); generally light duty
n	Natural earth stabilized soil, sand-clay, shell, cinders, disintegrated granite, or other select material	Type (Z); generally light duty
v	Various other types not mentioned above	Classify (X), (Y), or (Z) depending on the type of material used. (Indicate length when this symbol is used.)

Source: U.S. Army, "Route Reconnaissance and Classification," FM 5-36, 1970.

6. Column 6; Road Condition. Enter good, fair, poor, or under construction based on surface condition.

7. Column 7; Width of Traveled Way. The width of surfaced area is measured for each road. Measurement does not include shoulders. Separate entries are made for each side of dual roads.

8. Column 8; Median Width and Type of Material. The median strip separating dual highways is measured between the surfaced areas of each road. Identify type of median material, i.e. soil, concrete, etc.

9. Column 9; Shoulder Width and Material. Enter the width of both shoulders and identity of construction material, i.e. soil, concrete, etc.

10. Column 10; Obstacles and Constrictions. Enter the UTM coordinates of obstacles and road constrictions symbolized on the factor overlay. Identify type of constriction or obstacle, e.g. washout, damaged structure, narrow bridge, etc.

11. Column 11; Road Cross Section. A dimensioned, representative cross section of the road segment will be drawn in this column when practical.

C. Data Table II, Bridges:

1. Column 1, Road Identification Number. Record route number and category of route on which the bridge is located.

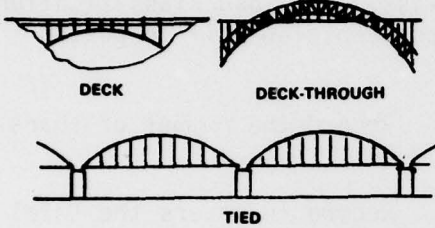
2. Column 2; Road Segment Number. Record the road segment number in which the bridge is located.
3. Column 3; Bridge Identification Number. Bridge number will be assigned in sequence within the overlay. The sequence of numbers will be continuous along each route.
4. Column 4; Bridge UTM Coordinates. UTM coordinates ($\pm 10m$) of the bridge center will be recorded in this column.
5. Column 5; Bridge Military Load Class. The load classifications, one way and two way, for both wheeled and track vehicles will be posted where known.
6. Column 6; Number of Bridge Spans. Record the number of spans forming the bridge.
7. Column 7; Total Length of Bridge. Record in meters the total length of the bridge (between abutments).
8. Column 8; Bridge Span Characteristics (for each span).
 - a. Record the type of bridge construction material (figure A5).
 - b. Record the type of bridge construction (figure A5).
 - c. Record the width of the bridge traveled way (± 0.5 meters).
 - d. Record the overhead clearance distance (± 0.5 meters).
 - e. Record the underbridge clearance distance (± 0.5 meters).
9. Column 9; Feature Crossed. Record the name of the obstacle(s) crossed by a bridge as indicated on the best available topographic map. Record the bypass condition.
10. Column 10; Bypass Condition. Record the bypass condition as indicated on the overlay and describe the distance, direction, type, and condition of the bypass.
11. Column 11; Sketch of Bridge Cross Section and Profile. A dimensioned profile and cross section of the bridge will be drawn in this space.

D. Data Table III, Fords.

1. Column 1; Road Identification Number. Record the road or route number and category.



ARCH (open spandrel)



DECK

DECK-THROUGH

TIED

TYPES OF ARCH BRIDGES



PARKER



KING



INVERTED KING



QUEEN



INVERTED QUEEN



THROUGH HOWE



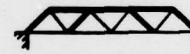
DECK HOWE



THROUGH PRATT



DECK PRATT

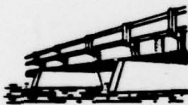


THROUGH WARREN

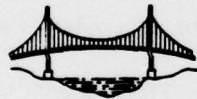


DECK WARREN

TYPES OF TRUSS BRIDGES



GIRDER



SUSPENSION



SLAB



BEAM



ARCH (CLOSED SPANDEL)



FLOATING

GENERAL BRIDGE TYPES

PIERS	SUPERSTRUCTURE			
	WOOD	STEEL	CONCRETE	MASONRY
WOOD	WW	WS	WC	WM
STEEL	SW	SS	SC	SM
CONCRETE	CW	CS	CC	CM
MASONRY	MW	MS	MC	MM

CONSTRUCTION MATERIAL CODES

Figure A5. Bridge Types

2. Column 2; Road Segment Number. Record the ID number of the road segment that contains the ford.
3. Column 3; Ford Identification Number. The ford ID numbers will be assigned consecutively within the map sheet, with all fords along a route numbered in sequence.
4. Column 4; Ford UTM Coordinates. The UTM coordinate (± 10 meters) will be stated for the center of the ford.
5. Column 5; Ford Length. Record the crossing length of the ford, waterline to waterline, in meters.
6. Column 6; Ford Width. Record the width of the ford in meters.
7. Column 7; Ford Depth. Record the maximum depth of the water in meters during periods of high and low water; specify the periods.
8. Column 8; Velocity. Record the maximum and minimum stream velocities in meters per second and the months during which they normally occur.
9. Column 9; Bottom Characteristics. Determine the bottom characteristics of the ford and record one of the following: M-mud, C-clay, S-sand, G-gravel, R-rock, or P-artificial paving.
10. Column 10; Approach Conditions. Record the approach conditions for each bank as indicated on the overlay. If the approach is difficult, describe the conditions that make it difficult.
11. Column 11; Cross Section and Profile of Ford. A dimensioned sketch of the ford will be drawn in this column.

E. Data Table IV, Ferries.

1. Column 1; Road Identification Number. Record the road or route number and category of the route on which the ferry is located.
2. Column 2; Ferry Identification Number. An ID number will be assigned to each ferry location. The sequence begins in the upper left corner and progresses to the right and down within each route.
3. Column 3; UTM Coordinate of Ferry Terminals. UTM coordinates ($\pm 10m$) will be entered for each terminal.
4. Column 4; Ferry Type. Record the type of ferry: V - Vehicular; F - Foot; M - Military.
5. Column 5, Number of Vessels. Record the number of vessels in active use.

6. Column 6, Ferry Length. Record the length of each ferry.
7. Column 7, Ferry Load Class. Record the capacity-load class of each ferry.
8. Column 8; Length of Crossing. The length of the normal crossing will be reported to the nearest meter.
9. Column 9; Approach Conditions. Record the approach conditions for each bank as indicated on the overlay. If either approach is difficult, describe the conditions that make it difficult.
10. Column 10; Feature Crossed. Record the name of the obstacle crossed by the ferry as indicated on the most recent topographic map.
11. Column 11; Terminal Layout. Prepare a dimensioned sketch of each ferry terminal.

F. Data Table V, Tunnels, Galleries, and Snowsheds.

1. Column 1; Road Identification Number. Record the road or route number and route category along which the structure occurs.
2. Column 2; Road Segment Number. Record the number of the road segment that contains the structure.
3. Column 3; Structure Identification Number. The ID number will be recorded as indicated on the factor overlay.
4. Column 4; Function of Structure. Record a one-word description of the function of the feature (i.e. tunnel, gallery, or snowshed).
5. Column 5; UTM Coordinates of Structure Portals. Record the UTM coordinates ($\pm 10m$) of both portals of the structure.
6. Column 6; Structure Length. Record the total length of structure.
7. Column 7; Depth of Overburden (Tunnels). This entry applies only to tunnels and states the maximum depth of the overburden to the nearest meter.
8. Column 8; Width of Roadway. Record the width of the roadway within the structure.
9. Column 9; Vertical Clearance. Record the vertical clearance of the structure.
10. Column 10; Horizontal Clearance. Record the horizontal clearance of the structure.

11. Column 11; Construction or Lining Material. A short statement of the construction materials is required in the case of galleries and snowsheds. Tunnels require a lining-material statement.

12. Column 12; Bypass Condition. Record the bypass condition as indicated on the overlay, the distance and direction to the bypass, the type of bypass, and the conditons that make its use difficult.

13. Column 13; Cross Section and Profile Sketch. A dimensioned cross section will be sketched in this column.

APPENDIX B. IMAGERY SOURCES
B-1. SOURCES OF AERIAL IMAGERY

U. S. GOVERNMENT AGENCIES

Aerial Photography Field Office
Agricultural Stabilization and Conservation Service
Department of Agriculture
Western Laboratory
2222 West 2300 South
P.O. Box 30010
Salt Lake City, UT 84125

Defense Intelligence Agency
ATTN: DIAAP-10
Washington, DC 20315

Worldwide survey photography held by DMAHTC
6500 Brookes Lane
Washington, DC 20315

Bureau of Land Management
Department of Interior
Washington, DC 20240

Cartographic Archives Division
National Archives (GSA)
Washington, DC 20408

EROS Data Center
U. S. Geological Survey
Sioux Falls, South Dakota 57198

National Cartographic Information Center (Headquarters)
Geological Survey
Department of Interior
Reston, VA 22090

NCIC-Mid-Continent
USGS, 1400 Independence Road
Rolla, Missouri 65401

NCIC-Rocky Mountain
USGS, Topographic Division
Stop 510, Box 25046
Denver Federal Center
Denver, Colorado 80225

NCIC-Western
USGS, 345 Middlefield Road
Menlo Park, California 94025

National Ocean Survey
Department of Commerce
Washington Science Center
Rockville, Maryland 20852

Soil Conservation Service
Department of Agriculture
Federal Center Building
East-West Highway and Belcrest Road
Hyattsville, Maryland 20781

Tennessee Valley Authority
Maps and Surveys Branch
210 Haney Building
Chattanooga, Tennessee 37401

EASTERN US FOREST SERVICE PHOTOGRAPHY

Chief Forest Service
U.S. Department of Agriculture
Washington, DC 20250

WESTERN US FOREST SERVICE PHOTOGRAPHY

Region

- 1 Federal Building, Missoula, MT 59801
- 2 Federal Center, Building 85, Denver, CO 80025
- 3 Federal Building, 517 Gold Ave. SW, Albuquerque, NM 87101
- 4 Forest Service Building, Ogden, UT 84403
- 5 630 Sansome St., San Francisco, CA 94111
- 6 P.O. Box 8623, Portland, OR 97208
- 10 Regional Forester, JS Forest Service, P.O. Box 1628,
Juneau, AK 99801

Technology Application Center
The University of New Mexico, Code 11
Albuquerque, New Mexico 87131

STATE AGENCIES

Arizona Highway Department
Administrative Services Division
206 South 17th Avenue
Phoenix, Arizona 85007

State of Arkansas Highway Department
Surveys, 9500 New Denton Highway
P.O. Box 2261, Little Rock, Arkansas 72203

State of Nebraska
Department of Roads
14th and Burnham Streets
Lincoln, Nebraska 68502

State of Ohio
Department of Highways
Columbus, Ohio 43216

Oregon State Highway Division
Salem, Oregon 97310

Virginia Department of Highways
Location and Design Engineer
1401 East Broad Street
Richmond, Virginia 23219

State of Washington
Department of Natural Resources
600 North Capital Way
Olympia, Washington 98501

Southeast Michigan
Council of Governments
1249 Washington Boulevard
Detroit, Michigan 48226

Illinois Department of Transportation
2300 South - 31st Street
Springfield, Illinois 62734

Southeastern Wisconsin Regional Planning Commission
916 North East Avenue
Waukesha, Wisconsin 53186

Wisconsin Department of Transportation
Engineering Services
4802 Sheboygan Avenue
Madison, Wisconsin 53702

Indiana Highway Department
608 State Office Building
Indianapolis, Indiana 46204

COMMERCIAL FIRMS

Aerial Data Service
10338 East 21st Street
Tulsa, Oklahoma 74129

Aero Service Corporation
4219 Van Kirk Street
Philadelphia, Pennsylvania 19135

Air Photographics Inc.
P.O. Box 786
Purcellville, Virginia 23132

Alster and Associates, Inc.
6135 Kansas Avenue, NE
Washington, DC 20011

Ammann International Base Map & Air Photo Library
223 Tenth Street
San Antonio, Texas 78215

Burlington Northern Inc.
650 Central Building
Seattle, Washington 98104

Cartwright Aerial Surveys Inc.
Executive Airport
6151 Freeport Boulevard
Sacramento, California 95822

H. G. Chickering, Jr.
Consulting Photogrammetrist, Inc.
P. O. Box 2767
1190 West 7th Avenue
Eugene, Oregon 97402

Fairchild Aeromaps Inc.
14437 North 73rd Street
Scottsdale, Arizona 85254

Grumman Ecosystems Corp.
Bethpage, New York 11714

Henderson Aerial Surveys Inc.
5125 West Broad Street
Columbus, Ohio 43228

Walker and Associates Inc.
310 Prefontaine Building
Seattle, Washington 98104

Western Aerial Contractors, Inc.
Mahlon Sweet Airport
Route 1, Box 740
Eugene, Oregon 97401

L. Robert Kimball
615 West Highland Avenue
Ebensburg, Pennsylvania 15931

Lockwood, Kessler & Bartlett, Inc.
One Aerial Way
Syosset, New York 11791

Mark Hurd Aerial Surveys, Inc.
345 Pennsylvania Avenue South
Minneapolis, Minnesota 55426

Merrick and Company
Consulting Engineers
2700 West Evans
Denver, Colorado 80219

Murry - McCormick
Aerial Surveys Inc.
6220 24th Street
Sacramento, California 95822

Photographic Interpretation Corporation
Box 868
Hanover, New Hampshire 03755

Quinn and Associates
460 Caredean Drive
Horsham, Pennsylvania 13044

Sanborn Map Company, Inc.
P.O. Box 61
629 Fifth Avenue
Pelham, New York 10803

The Sidwell Company
Sidwell Park
28W240 North Avenue
West Chicago, Illinois 60185

Surdex Corporation
25 Mercury Boulevard
Chesterfield, Missouri 63017

Teledyne Geotronics
725 East Third Street
Long Beach, California 90812

United Aerial Mapping
5411 Jackwood Drive
San Antonio, Texas 78238

CANADA

National Air Photo Library
Surveys and Mapping Building
615 Booth Street
Ottawa, Canada K1A 0E 9

B-2. SOURCES OF GROUND IMAGERY

U. S. Army Imagery Interpretation Group
Bldg 213, Washington Navy Yard
Washington, DC 20374

Defense Intelligence Agency
ATTN: RPP-3
Washington, DC 20301

U. S. Army DARCOM Service Support Activity
Audio-Visual Presentations Division
Room 1C13, Pentagon
Washington, DC 20310

APPENDIX C. FOREIGN MAPS

The symbology used in the production of FRG and USSR maps is presented in tables C1 and C2, respectively. These maps, when available for your area of interest, can be used either to obtain primary source material or to augment the data obtained from U.S. maps. Both of these countries produce military maps at scales of 1:50,000 and 1:25,000. The amount, detail, and accuracy of the information presented will, of course, vary with the scale and date of publication. A study of the symbology presented in tables C1 and C2 will reveal that these maps provide considerably more information on roads, road surface materials, and bridge construction characteristics than is presently available on U.S. maps.

If 1:50,000-scale foreign maps are available for your area, they can be substituted directly for the U.S. maps, and with the help of either table C1 or C2, the Analyst will be able to produce the required factor overlay by following the methods provided in the Topographic Map Analysis Section.

When maps of scales other than 1:50,000 are available, the Analyst can either adjust the scales photographically or, more simply, record the information directly from the foreign map to the U.S. map overlay.

TABLE C1. FEDERAL REPUBLIC OF GERMANY MAP SYMBOLS
FOR ROADS AND RELATED STRUCTURES WITH ENGLISH TRANSLATIONS
(1:50,000 SCALE)

Zeichenerklärung		Legend	
Verkehrsnetz		Communications	
	E 4		<i>autobahn; parking area; under construction</i>
	<i>Autostraße, mit oder ohne Mittelstreifen</i>		<i>dual highway, with median or center line only</i>
	E 4 10		<i>route number</i>
	<i>Fern-, Bundes- bzw. Hauptstraße, 6 m oder breiter</i>		<i>trunk road, federal main road, main road, 6 m wide or more</i>
	<i>Nebenstraße, 4-6 m</i>		<i>secondary road, 4-6 m wide</i>
	<i>Fahrtweg, befestigt</i>		<i>road, light surface</i>
	<i>Fahrtweg, unbefestigt</i>		<i>road, loose surface</i>
	<i>Feld- und Waldweg</i>		<i>fair weather road, loose surface</i>
	<i>Fußweg, Pfad, Klettersteig, Wattenweg</i>		<i>footpath, climbing path, track across tidal flats</i>
	<i>Straßentunnel, Eisenbahntunnel</i>		<i>tunnel, road and railroad</i>
Topographische Einzelzeichen		Other Topographical Details	
	<i>Damm, Deich: befahrbar, nicht befahrbar</i>		<i>embankment, dike, practicable, impracticable</i>
	<i>Einschnitt, Bäume entlang von Straßen</i>		<i>cut, roads tree lined (for traffic)</i>
Brücken und Gewässer		Bridges and Hydrography	
	<i>Eisen-, Stein- oder Betonbrücke</i>		<i>iron-, stone or concrete bridge</i>
	<i>Hebe- oder Drehbrücke</i>		<i>lift or swing bridge</i>
	<i>Holzbrücke</i>		<i>wooden bridge</i>
	<i>Steg</i>		<i>footbridge</i>
	<i>Eisenbahnfähre</i>		<i>train ferry</i>
	<i>Wagenfähre</i>		<i>vehicle ferry</i>
	<i>Personenfähre</i>		<i>passenger ferry</i>
	<i>Furt</i>		<i>ford</i>
	<i>Landungsbrücke</i>		<i>landing stage</i>
	<i>Talsperre</i>		<i>dam (across a valley)</i>
Grenzen		Boundaries	
	<i>Staatsgrenze</i>		<i>international boundary</i>
	<i>Landesgrenze</i>		<i>boundary between "Länder"</i>
	<i>Regierungsbezirksgrenze</i>		<i>boundary of "Regierungsbezirk"</i>
	<i>Kreisgrenze</i>		<i>boundary of "Kreis"</i>
	<i>Standort- und Truppenübungsplatzgrenze</i>		<i>boundary of training area</i>
	<i>Naturschutzgebietsgrenze</i>		<i>boundary of nature reserve</i>

TABLE C2. UNION OF SOVIET SOCIALIST REPUBLIC MAP SYMBOLS
FOR ROADS AND RELATED STRUCTURES WITH
ENGLISH TRANSLATIONS

SYMBOL	FEATURE	DEFINITION
	Super Highways	8 — Width of one lane in meters 2 — Number of lanes Surfacing material: II — cement-concrete, a — Asphalt-concrete; Embankment — (4) Height of embankment (meters).
	Improved Highways	8 — Width of surfaced area (meters) 10 — Width of road from ditch to ditch (meters). Surfacing material: A — Asphalt-concrete, II — Cement-concrete, Бр — Block, Кн — Clinker; Depressions — (5) Depth of depression (meters).
	Highways	5 — Width of surfaced area (meters) 8 — Width of entire road (meters) Surface Material: Б — Cobble stone, Г — Gravel, К — Crushed stone, Шт — Slag, (σ) — Plantings, Ш — Broken stone.
	Improved Dirt Roads	8 — Width of road (meters) Dashed line indicates a road that is difficult to negotiate.
	Roads Under Construction	1. Super Highways 2. Improved Highways 3. Highways 4. Improved dirt roads
	Misc Highway Symbols	1. Bridges across insignificant obstacles, culverts. 2. Road segments with steep grades of 8 percent or more.

TABLE C2 (cont)



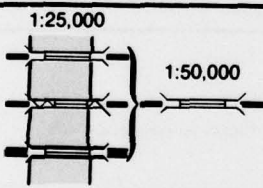


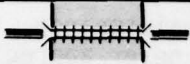
SYMBOL	FEATURE	DEFINITION
.....	Winter Roads	
=====	Wooden Surface Roads	
=====	Fascined Sectors of Roads	
=====	Stone Walls	
===== A/B =====	Change in Road Surface Material	
===== 5 =====	Kilometer Post	
	Road Bridge Over Railroad	K: Stone 155-6: Length and Width (meters) 80: Load Capacity (tons)
	Railroad Bridge Over Highway	np: Passage Beneath 5: Vertical Clearance (meters) 9: Width (meters)
	Draw and Swing Bridges	Single Symbol used at 1:50,000

TABLE C2 (cont)

SYMBOL	FEATURE	DEFINITION
	Grade Crossing	
	Tunnel	8 — Vertical clearance (meters) 12 — Width 350 — Length
	Aquaduct	
	Double Decked Bridge	1: Highway under railroad 2: Highway above railroad
	Wood Bridge Metal Bridge Masonry or Concrete Bridge	Single Symbol used at 1:50,000
	Mountain Pass	5043.0 Elevation (meters)
	Dirt Roads	
	Field and Forest Roads	
	Pack Trails	Also roads difficult to negotiate
	Foot Path	

TABLE C2 (cont)

SYMBOL	FEATURE	DEFINITION
	Floating	
	Double Decked Masonry or Concrete	
	Chain and Rope	
K8 $\frac{370-10}{60}$	Bridge Characteristics	K: Material 370: Length (meters) 10: Width 60: Load Class 8: Under Clearance

GLOSSARY OF HIGHWAY TERMS

abutment - The support at either end of a bridge.

aggregate - Natural or processed material, such as crushed rock, sand, slag, and shell, used with or without artificial binder as material for the subbase, base, or wearing course of a road. Aggregate in a surface course is often called "road metal."

all weather road - Any road which, with reasonable maintenance, is passable throughout the year to a volume of traffic never appreciably less than its dry-weather capacity.

approach span - A roadway supported on a bridge substructure adjacent to the main bridge spans.

arch bridge - A bridge that consists of an arch and a floor system.

arch culvert - A culvert that is similar in design to an arch bridge.

bascule span - A movable span that is opened by raising one end.

base course - A layer of material placed upon and compacted on the prepared subgrade of a road.

bitumen - Any bituminous material (asphalt or tar products).

bituminous pavement - A wearing surface of a road that is made of a mixture of asphalt and tar products (bitumens) and aggregate.

bituminous surface treatment - A road surface made by applying a liquid bitumen to the base course, or an old surfacing, and immediately adding aggregate. A course less than 1-inch thick is considered a bituminous surface rather than a pavement.

box culvert - A culvert with a square or rectangular cross section.

bridge span - The superstructure that extends over the gap between ground supports.

cantilever bridge - A bridge that has beams, girders, or trusses that extend toward each other beyond their means of support, and which are joined together either directly or by a suspended span.

catenary - A cable suspended between two points (as in a suspension bridge).

causeway - A section of road raised on an embankment of fill, usually across marshy ground or a shallow body of water.

civilian load class - Most common measure of road bridge capacity, expressed in tons of a vehicle that the bridge will support safely.

clear span - The distance between faces of a span's supports (piers or abutments), measured at the top of the support. For concrete or masonry arch bridges, the measuring points are the spring lines of the arch.

combined bridge - A bridge (usually a long structure) composed of different types of spans.

concrete - A mixture of cement, coarse and fine aggregate, and water.

continuous span bridge - A structure that passes over three or more gaps without a structural break at intermediate supports.

corduroy road - A road built over soft ground and composed of logs or planks laid crosswise or perpendicular to the road directly on the soil or on wood stringers or sleepers.

crib piers - A bridge support built of logs in the form of a crib with the bottom of the pier wider than the top, sometimes filled with stone.

critical span - The span which determines the bridge class. It is the span with the lowest safe load-carrying capacity.

cross section - A vertical cutting of a road at right angles to its axis, showing all structural elements of the road.

crown - The vertex of the arched surface of a road; also the difference in elevation between the centerline and the edge of the traveled way.

culvert - A small bridgelike structure serving as a transverse drain under a road. For intelligence purposes, the term is applied to all bridge-like road structures less than 20 feet in length.

dip - A paved ford used for crossing wide, shallow arroyos or washes in semiarid regions where the construction of bridges is impractical.

earth surface - Natural soil that has been graded to form a surface for traffic.

fair-weather road - A road which tends to become impassable in bad weather and which cannot be kept open by normal maintenance. It has a surface of natural or stabilized soil, sand, clay, shell, cinders or disintegrated granite.

fascine - A long cylindrical bundle of wooden sticks bound together at intervals and used for filling ditches or strengthening revetments.

ferry (cable) - A ferry that is attached to a continuous cable that extends across a stream. Power to operate the cable is supplied either by someone on the ferryboat who pulls on the cable or by a motor that operates the cable by means of gears attached to one of the pulleys.

ferry (current-operated) - A ferry held in the stream by an anchor well upstream from the crossing site; as the ferry moves from shore to shore, it describes an arc of a circle the center of which is the anchor.

ferry (powered) - A ferryboat that is propelled by its own engine.

fixed bridge - A bridge with a superstructure that is designed to remain in one position.

flexible pavement - A pavement made of bituminous or earth stabilized material.

floor system - Portion of the bridge superstructure that carries the roadway and transmits the load to the main supporting members. It usually consists of stringers, floor beams, and a roadway (wearing surface).

footing - Part of the substructure of a bridge which rests directly on the ground, spreading the load over a sufficient area of soil so that the structure does not sink into the ground.

ford - A shallow place in a stream where the bottom permits the passage of personnel or vehicles.

foundation - The ground beneath the footing of a bridge.

gallery - Any sunken or cut passageway covered at the sides as well as overhead; it usually has a series of openings along one side for light and ventilation.

girder bridge - A bridge supported by two or more parallel girders with transverse floor beams.

gravel surface - A surface composed of a compacted layer of well-graded gravel.

half-through bridge - A bridge with the deck at or near the bottom edge of the main supporting members; it has no overhead bracing.

heavy expedient road - A log or plank road used on muddy and swampy ground in areas where timber is abundant.

horizontal alinement - The horizontal location and direction of the center line of a road; it includes curves and tangents (straight sections).

horizontal clearance - The distance available to pass a load that extends laterally beyond the wheels of a vehicle.

hot-mix bituminous concrete - A mixture of coarse aggregate, fine aggregate, mineral filler, and bitumen that is proportioned and mixed at a central mixing plant.

lift span - A movable span which is opened by raising it vertically at both ends while maintaining it in a horizontal position.

limited all-weather road - A road which, with reasonable maintenance, can be kept open in bad weather to a volume of traffic which may be considerably less than its dry-weather capacity. This type of road does not have a waterproof surface.

log-tread road - A road built over soft ground and made by planks, logs, sandbags, mats or brush laid directly on the soil or on wood stringers or sleepers along the wheel track.

metaled road - A road the surface of which is composed of gravel, broken stone (crushed rock), slag, or shell formed with or without water or artificial binder.

military load class - Common measure of road bridge capacity, expressed in tons of a military type vehicle that the bridge will support safely.

mixed-in-place bituminous - A mixture constructed by mixing bitumen with aggregate directly on the road base; it is known as "road mix."

movable bridge - A bridge with at least one span which can be moved from its normal position to permit the passage of vessels.

oil-earth surface - A surface made by coating ordinary earth roads with oil in order to reduce dust and to lessen the tendency to soften in wet weather.

overall (superstructure) bridge length - Length from abutment to abutment, including the parts of abutments covered by the ends of spans.

penetration macadam - A surface made by adding a penetration coat of bitumen to an aggregate, after the latter has been spread over the base course. It is known as "tar-mac."

pier - Intermediate ground supports of a bridge between abutments.

pile bent - Intermediate ground support for a bridge, consisting of a row of four or six vertical members called piles that are driven into the ground, capped and cross braced.

pile pier - Intermediate ground support for a bridge, consisting of two pile bents braced to one another.

pipe culvert - A culvert made of corrugated metal, concrete, cast iron, or vitrified clay. Its cross section may be round, elliptical, or flattened on the bottom.

plank road - Road used in muddy and swampy ground where timber is abundant; it consists of planks laid directly on the soil or on wood stringers or sleepers.

ponton (floating) bridge - A temporary bridge that is supported by low flat-bottomed boats or other floating structures.

prestressed concrete bridge - A bridge that has the principal steel reinforcing bars of its main members subjected to tensile stress and, consequently, the enclosing concrete to compressive stress. Prestressing counteracts stresses imposed upon these members by an applied load.

retractile span - Span that is opened by rolling it directly back from the opening along a horizontal track of some type.

ribbon tread - Planks of roadway laid diagonally across the stringers to distribute a load longitudinally over the deck and provide both a wearing surface and a smooth bridge surface.

rigid pavement - Concrete, brick, or stone block pavement that distributes loads over a wide area of the subgrade; thus reducing stresses.

rock asphalt - Type of bituminous surface consisting of natural rock impregnated with a bitumen.

sand-clay surface - Mechanically stabilized soil surface in which a natural or artificial mixture of sand and clay is graded and drained.

seal coat - An application of bitumen and fine aggregate or granular material to the surface of a road to fill voids and prevent the entrance of water.

skew bridge - A bridge in which the long axis of one or more of the structural elements (piers, abutments) is not perpendicular to the center line of the bridge.

shoulder - The portion of a roadway between the edge of the traveled way and a bordering ditch or embankment.

slab bridge - A bridge in which the main members are reinforced or prestressed concrete slabs serving as the floor and resting directly on the abutments or piers; it has no stringers under the slab.

snowsheds - Structure providing protection from snowslides for an exposed section of road; it usually is open on one side.

span length - The distance between adjacent substructure elements, the measuring points being the centers of piers and the inner (river) face of abutments.

stabilized soil surface - Mixtures of aggregate, soil, and a stabilizing agent (cement, calcium chloride, bitumen) used to provide a base course for the support of a thin bituminous surface.

stone block pavement - A pavement consisting of stones that are cut or formed into blocks; they generally are laid on a rigid base.

stringer (beam) bridge - A bridge in which the main supporting members are longitudinal spanning stringers (beams), upon which the flooring rests.

subgrade (subbase) - The shaped and compacted foundation on which the base course of a road is built.

substructure - The piers (or bents) and abutments which comprise the ground support for a bridge, including the footing of the supports.

superstructure - The spanning part of a bridge (bridge span and floor system), including all of the structure resting on the substructure.

surface course (traveled way) - Top layer of material covering the base course or subgrade between the shoulders, used for traffic of vehicles; it is also called traveled way.

suspension bridge - A bridge which has its roadway suspended from cables or chains that pass over towers and are securely anchored at both ends of the suspended spans.

swing span - a movable span which is opened by turning it in a horizontal plane on a pivot system usually located at or near its center.

through bridge - A bridge with the deck on a level with the lower edge of the main supporting members which are connected by lateral bracing over the roadway.

transporter bridge - A rare type of bridge in which the traffic is carried in a cage or car shuttling across the obstruction, the cage being suspended from an overhead bridging member. Sometimes termed a ferry bridge.

trench method of construction - Method used in the construction of subgrade; the earth excavated to form a trench is pushed to the side of the road to form retaining shoulders.

trestle bents - A bent consisting of a cap and sill and four or more posts with transverse bracing across the posts.

trestle piers - Two or more bents placed close together and braced to one another.

truss bridge - A bridge consisting of top and bottom cords with an intervening framework of diagonal, vertical, or horizontal elements transmitting the roadway loads to the substructure.

tunnel bore - The interior of a tunnel; it may be semicircular, elliptical, horseshoe, or square with an arched ceiling.

tunnel liner - Material (masonry or concrete) lining the interior of a tunnel.

tunnel portal - Entryway for a tunnel, usually made of masonry or of concrete.

underbridge clearance - The distance from the water level or the ground to the lowest part of the superstructure.

vertical alinement (profile) - The longitudinal rate of slope of the center line of a road, expressed in percent, indicating the vertical rise or fall in feet per 100 feet horizontally.

vertical clearance - The distance available for the passage of vehicles between the roadway and the lowest overhead obstruction.

water-bound macadam - Type of road surface made by spreading coarse aggregate in a layer and rolling it in place, superimposing fine aggregate which is rolled and broomed into the coarse aggregate until both are thoroughly keyed in place, and then binding the two types of aggregate together with water.