Technical Report 397

LEVEL II

A TASK-BASED ANALYSIS OF INFORMATION REQUIREMENTS OF TACTICAL MAPS

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HUMAN FACTORS TECHNICAL AREA

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A task-based approach for specifying and analyzing map information requirements was developed and demonstrated. A review of selected literature concerning the mapping process included methods for selecting environmental data to be shown on a map. Seven tactical tasks, representing common battlefield functions performed by different users and echelons (e.g., determination of enemy avenues of approach by a G2 officer at the division level) were sampled and analyzed in depth. A military role-playing and doctrinal verification procedure was used to divide tasks into subtasks so that (Continued)

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corresponding information requirements could be specified. Each subtask (e.g., identification of obstacles to movement) in turn was broken down into basic tactical questions about the environment (e.g., "Are there any vegetated areas through which the enemy cannot pass?", "Are there any slopes enemy vehicles cannot climb?"). The data required to answer each question defined the information categories ~~(e.g., vegetated areas, s~~lopes) and levels of detail (e.g., tree spacing and trunk diameter, percent slope) necessary for successful task completion.

The resulting map-related information requirements were synthesized to generate representative map development guidelines. This synthesis--which emphasized information about vegetation, road networks, and built-up areas--was accomplished across tasks to identify those specific information needs which show either prominent commonality or uniqueness with respect to different tasks and user groups. Within the framework of these task-based comparisons, examples illustrate the types of implications that can be derived from the task-based analysis of information requirements.

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FOREWORD

The Human Factors Technical Area is concerned with aiding users/operators to cope with the ever-increasing complexity of the man-machine systems being designed to acquire, transmit, process, disseminate, and utilize tactical information on the battlefield. The research is focused on interface problems and interactions within command and control centers and is concerned with such areas as topographic products and procedures, tactical symbology, user oriented systems, information management, staff operations and procedures, sensor systems integration and utilization, and issues of system development.

Maps are an essential component for both planning and conducting military operations. In the planning phase, terrain and vegetation information affect many considerations, including mobility, vulnerability, concealment, and cover. In the conduct of military operations, maps are essential for navigation, self-location, and adjustment of fire, to name only a few. Despite the importance of maps to military operations, surveys indicate that many map users have difficulty with current military maps, particularly in terrain visualization and self-location. Many individuals cannot make the transfer from the map, which represents the terrain, to the actual terrain. The present publication is concerned with identifying and evaluating improved or new methods of portraying topographic information. The goal is to aid users to extract combat-relevant information faster and more accurately from hardcopy or electronically generated maps.

Research leading to improved maps and other topographic products is conducted as an in-house effort augmented through contracts with organizations selected for their specialized capabilities and unique facilities. The present study was conducted by personnel of Perceptronics, Inc., under Contract DAHC19-78-C-0018. This research is responsive to requirements of Army Project 2Q762722A765, and related to special requirements of Engineer Topographic Laboratories, Fort Belvoir, Va. Special requirements are contained in Human Resource Need 78-35, Topographic Products Design and Test Methodology.

JOSEPH ZEIDNER
Technical Director

A TASK-BASED ANALYSIS OF INFORMATION REQUIREMENTS OF TACTICAL MAPS

BRIEF

Requirement:

To make military maps more readable and informative in the performance of combat-related operations.

Procedure:

A task-based approach for specifying and analyzing map information requirements was developed. Seven tactical tasks representing common battlefield functions performed by different users and echelons were sampled and analyzed in depth. A tactical role playing and doctrinal verification procedure was used to divide tasks into operational subtasks. These subtasks were, in turn, broken down into basic tactical questions about the environment. The resulting map-related information requirements were synthesized to generate representative map development guidelines.

Findings:

The comprehensive map-related information requirements derived from the tactical tasks sampled appear to provide an objective, logical basis for identifying those specific needs (information categories and levels of detail) which show either prominent commonality or uniqueness with respect to different tasks and user groups.

Utilization of Findings:

The products of this analysis will contribute to a methodology which map makers will be able to apply to the map development process in order to create more effective user-oriented map products.

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1.1 Statement of the Problem

Hardcopy maps are an essential component of both the planning and conduct of tactical operations. In the planning phase, terrain and vegetation information impact on many considerations including: mobility, the degree of vulnerability to attack, concealment, and cover. In the operations phase, maps are essential for navigation, self-location, and adjustment of fire, to name only a few of the many uses. Despite the military importance of maps, surveys indicate that many map users have difficulty with current tactical maps, particularly in the areas of terrain visualization and self-location. Many individuals cannot make the transfer from the map, which is a representation of a geographic area, to the actual environment. Since the battlefield of the future has been characterized as having greater lethality and complexity than previously faced, it is vital that maps, as an integral part of the battlefield information system, be as useful as possible for military personnel. The goal of this research effort, therefore, was to develop a methodology which map makers could apply to map development in an attempt to create more effective user-oriented map products.

1.2 Technical Approach

1.2.1 Task-Based Methodology for Development of Map Information Requirements. The development of improved military map products requires the systematic analysis of specific map-related information needs. To accomplish this research goal, a task-based methodology was developed and applied, and its potential role in providing map development guidelines is illustrated. Chapter 2 gives the background and rationale for adopting this research strategy in the context of considerations concerning both the mapping process and tactical decision-making. Chapter 3 describes the methodological procedures employed and provides several examples of how they can be applied to the detailed analysis of representative, map-related tasks. Chapter 4 then systematically integrates the findings of these task analyses to illustrate the types of map-development implications and guidelines which can be derived from the task-based methodology. The following paragraphs provide a brief description of the topics covered in each of the report chapters.

1.2.2 Rationale for Task-Based Approach (Chapter 2). The first phase of the mapping process, which covers the generation and use of maps, entails the selection of data from the environment that should be represented on a map. Despite the criticality of this selection, systematic procedures for specifying map information content have been lacking in the cartographic literature (cf, Potash, 1977). Although conventional approaches to tactical map development have made progress in taking advantage of a general form of such a task-based structure when determining information requirements, additional work is necessary to explore the potential of increasing the specificity of the approach and extending its application. Toward this goal, the present effort was inspired.

The philosophy which is emphasized is that different task objectives may dictate different maps. Given the large set of map users, it is evident that the delineation of purpose requires the identification and dissection of particular tasks, in order to prescribe appropriate guidelines for map development. Traditionally, the military map maker has had less need for such detailed analysis, as maps were typically designed for multiple purposes. However, given the possibilities of the new mapping technology, and the corresponding expansion of map uses, it becomes critical for the map developer to investigate what map-related information is needed in each unique situation. By the same token, a careful consideration of user needs could support the improvement of map products.

1.2.3 Application of Task-Based Methodology (Chapter 3). Figure 1-1 provides an overview of the task-based methodology process. Since systematic rules for the specification of map information content have been lacking, the goal of this process was to develop a method for identifying user-required information to form a map content database. The database which was derived for a set of representative tactical tasks provides a complete accounting of the map-based information required to complete these tasks; and the analysis makes a distinction between information which is, or is not, currently available on conventional maps. The elements in the database were thus structured so that further analysis could lead to implications for map-development guidelines.

To demonstrate the application of the task-based approach to specifying information requirements, seven tactical tasks representing common battlefield functions performed by different users and echelons were sampled and analyzed; an example of one task studied is the *determination of* enemy avenues of approach for a Soviet motorized rifle unit by a G-2 officer at the division level. A military role-playing and doctrinal verification procedure was used to decompose tasks into constituent subtasks and to specify the information categories (e.g. concealment) and the respective level of detail (e.g., vegetation taller than three meters) needed to perform each subtask. As illustrated in Figure 1-2, the analysis of enemy avenues of approach is predicated on the identification of: (1) obstacles to movement; (2) areas sufficient for movement; and (3) cover and concealment potential of routes. Each of these define subtasks which, in turn, lead the user to ask a number of basic "questions" about the tactical environment. In the case of obstacles to movement, the user might ask, *"Are there any slopes which enemy vehicles cannot climb?"; "Are there any vegetated areas through which the enemy cannot pass?";* etc.

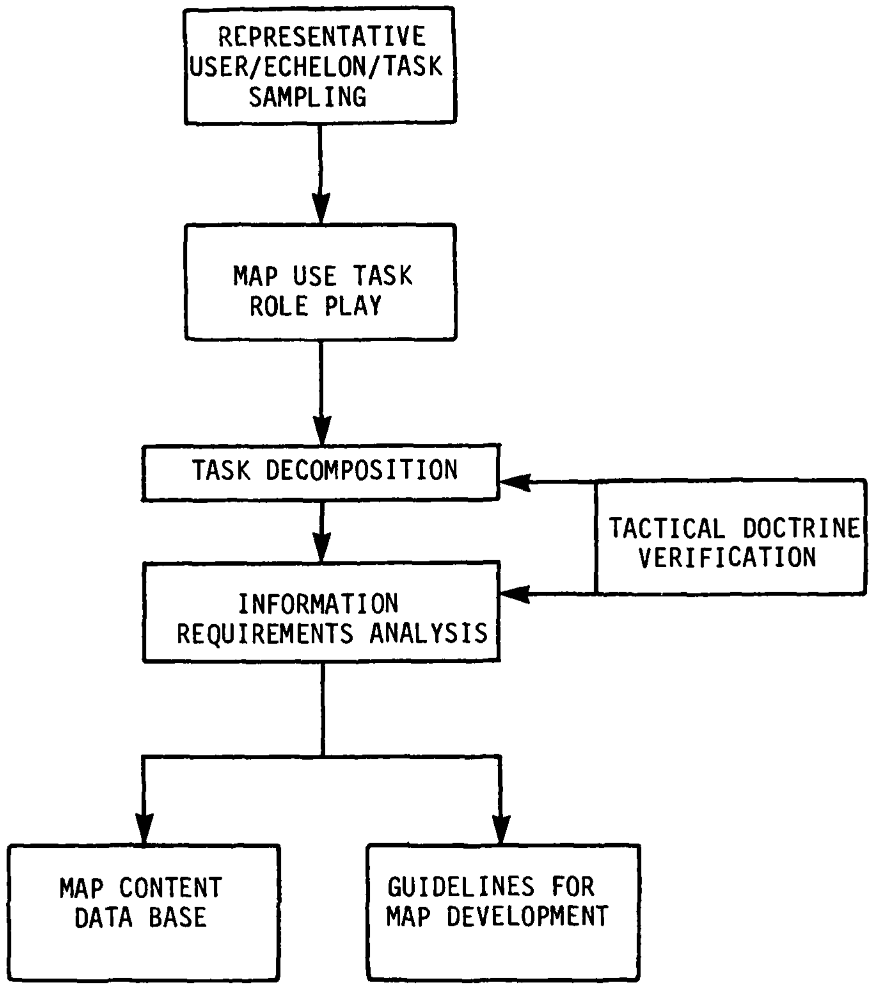

FIGURE 1-1.
TASK-BASED METHODOLOGY FOR DEVELOPMENT OF
MAP INFORMATION REQUIREMENTS.

The information required to answer each question defines the level of detail which should, ideally, be included on the map. The generation of "questions" in this task-based framework insures that the level of abstraction, at which each is stated, conforms to the tactical problem at hand; that is, the resulting "answers" prescribe the level of detail required for successful task completion. To the extent that task structures, such as the one illustrated in Figure 1-2, can be codified by tactical doctrine, the present approach can enable the identification of both the categories of information to be included on the map as well as the level of detail required by the user.

At present, the answers to many task-based questions are not evident from standard topographic or even special purpose map products. Such questions, therefore, may prove useful in uncovering information deficiencies of conventional maps as well as suggesting new requirements for future development efforts. A task-based approach, however, can most likely generate requirements that are not always amenable to graphic portrayal (e.g., timely weather information would be difficult to portray due to technical limitations). Thus, while some tactical questions may never be adequately answered by a map, a task-based analysis will offer the map maker a relatively complete inventory of what the user actually needs. In summary, an in-depth analysis of representative map use "questions" may prove to be a valuable technique for specifying detailed information requirements and, as a result, optimizing the match between user needs and the map content.

The description and results of each task analysis are presented in a separate exhibit which includes summary tables that highlight the component task information needs and point out related adequacies and inadequacies of the information content of standard topographic maps; an index to the exhibits appears on Page iii.

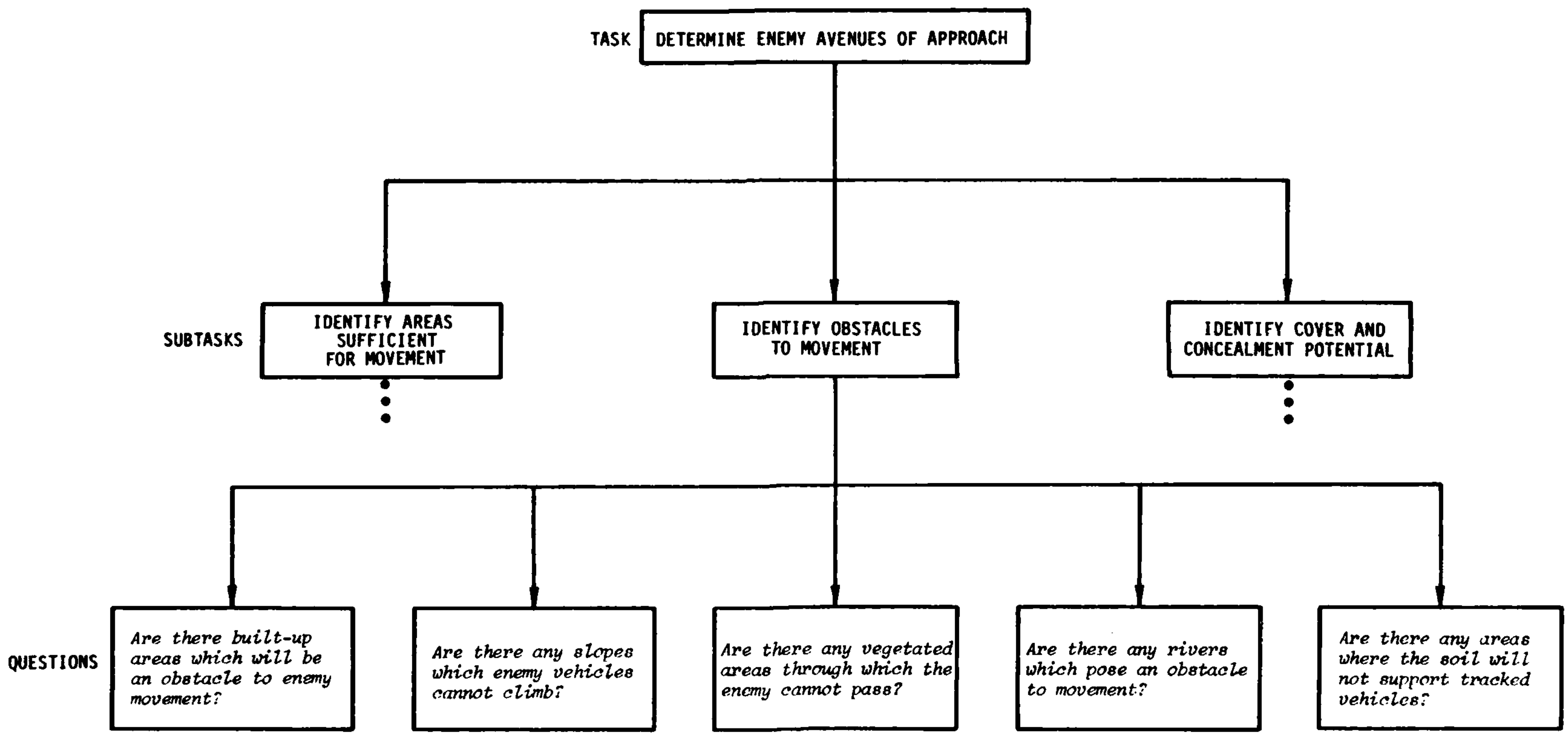

FIGURE 1-2. EXAMPLES OF TASK-BASED MAP USE "QUESTIONS."

1.2.4 Implications for Military Map Development (Chapter 4). The comprehensive map-related information requirements, derived for the tactical tasks sampled, were synthesized to identify those specific needs (information categories and levels of detail) which show either prominent commonality or uniqueness with respect to different tasks and user groups. In particular, emphasis was placed on map information requirements involving vegetation, road networks, and built-up areas. Within the framework of these task-based comparisons, the systematic projection of integrated guidelines for the development and evaluation of improved military maps is illustrated. In addition, reference is made to alternative, innovative methods of portraying map-related information. Rather than to be interpreted definitively as recommendations for what information should be portrayed on military maps, the guidelines given are intended to be examples of the types of implications that can be derived from the task-based analysis of map information requirements.

2. RATIONALE FOR TASK-BASED APPROACH

2.1 Introduction

Military maps provide representations of environments of military interest. Their primary purpose is to provide information about the area mapped so that a user can analyze the environment (e.g., terrain) well enough to plan and/or conduct operations within it. As such, the maps are designed to contain information at various levels of detail concerning selected elements in the environment. However, the user is rarely expected to rely upon the map alone in performing a task; rather, the user usually will combine use of the map with other sources of knowledge such as experience, reconnaissance, in intelligence (e.g., aerial photographs) and the like.

Therefore, one of the most basic problems in military cartography is deciding what features of the environment to include on a map. At the very outset, the map maker must answer two important questions:

(1) What categories of information should I include?
(2) What level of detail should I use?

A case in point is the map maker who decides to portray vegetation and is then faced with the question of whether to indicate various types of vegetation, and if so, at what level of detail. Such decisions are basic to the map-making process since they determine whether the final product will meet the map user's needs.

In addition, the size and complexity of the cartographic database indirectly regulates the perceptual clarity of the resulting map product. Unfortunately, there are at present no agreed-upon guidelines for the identification of essential cartographic information. The problem is particularly acute in the development of military maps where the amount of relevant tactical information can easily overwhelm even the experienced map user (cf Potash, 1976). The following excerpt from an Engineering Topographic Laboratories (ETL) survey of user requirements seems fairly typical:

> *"Most expressions regarding (map) data needs are usually couched in generalities whether the source is contained in the literature or is derived from personal communication. With few exceptions, critical threshold values of terrain-related effects on specific functions are vague or nonexistent." (ETL, 1973)*

The objective of this chapter is to provide the technical background for a task-based technique for identifying cartographic information requirements which may help overcome the limitations of previous user surveys. Briefly, the approach calls for the dissection of complex map use tasks into their corresponding subtask components, so that map information needs can be determined according to task-based requirements.

The present chapter continues with a general discussion of map development issues (Section 2.2) which will include review of relevant literature. The subsequent section focuses upon trends in current military map development (Section 2.3). Finally, the chapter ends with the summary and conclusion statements (Section 2.4).

2.2 Map Development Issues

The general problem of making a map is that of creating a representation that will allow an individual to gain information about a place and/or situation. To state this in the general case, map-making involves:

> *the use of a set of operations which translate information taken from the spatial environment into an organized representation, so that at a later date, this representation will be useful to us. (Downs and Stea, 1977, p. 62 -- underlining added for emphasis.)*

There are a number of critical issues implicit in this definition. One is the inherent choice of which information from the spatial environment will be included in a representation and which will not. Another is the necessary decision as to how this spatial information will be organized, by itself and in terms of its relations to the spatial environment. A third is the critical decision of how the "usefulness" or effectiveness of different choices of environmental information and styles of organization should be compared.

Maps are designed to be used. It is thus crucial that map makers consider, from the beginning, the needs of the ultimate map user. This requires that the map maker become a bit of a psychologist, so as to deal with the display of information within a human framework of comprehension and understanding. Kolacyn (1969) phrased this concern well when he suggested that a map must satisfy the consumer's needs and interests, that it must be easily readable and understandable, that it must be attractive, and that it must be emotive as well as rational. Muehercke (1972) echoed these sentiments when he asserted that maps should change their emphasis from *"physical to social,"* from *"interesting to relevant,"* and that, in order to fulfill their purposes, maps must be considered within a human context.

What does this mean to the map maker? First, it suggests a careful consideration of basic human perceptual and cognitive capabilities. Second, it requires an acknowledgement of the fact that many map users are not very well trained in map use. Third, it invites creativity in the design of maps that will insure, or at least enhance comprehension. Fourth, it dictates a consideration of the different limitations of map users; for example, poor spatial relations, short attention spans, and poor imagery. Finally, it calls for the personalization of maps wherever possible, and suggests the use of multiple representations to provide the redundancy required by most users.

2.2.1 A Process Model of Mapping

To better understand the aspect of the mapping process to which the present research is addressed, a look at a simple flow diagram would be helpful. Figure 2-1 presents an abstract model of the mapping process taken from Hooper (1979). Although this basic scheme was intended to describe mapping in general, it applies equally well to the fundamental processes involved in the development of military maps and their uses. In brief terms, the mapping process begins with the environment and ends with plans for action, based on maps, taken in this environment. Of particular interest, however, to the goals of this research is the very first portion of the model, namely the environment, the data base, and the transformational process of data selection that mediates between them. Because of the sequential nature of the development process, these first steps are of critical importance since all subsequent steps are based upon them.

2.2.2 The Environment

The environment consists of all the information that is available for sampling in making a map. It includes, for example, sets of elements (e.g., mountains, trees, rivers, bridges, soil, ditches, buildings, etc.), the locational relationships between elements (e.g., bridge placements, distances between trees, etc.), perceptual descriptions of elements (e.g., shape, size, height, color, etc.), and information concerning environmental change (e.g., climate and seasonal effects, wind, etc.). Information must be selected from this world to be mapped and then structured/organized to

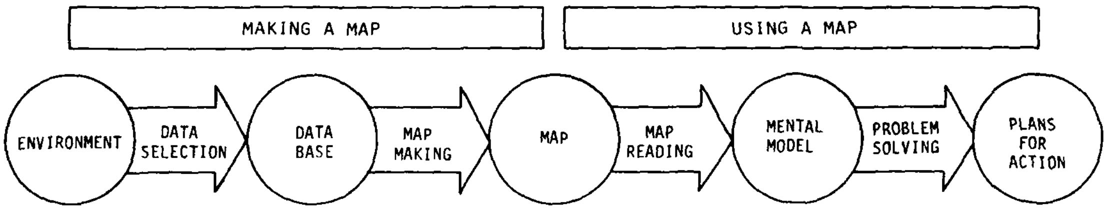

FIGURE 2-1. THE MAPPING PROCESS

establish a data base of those elements and element configurations that are to be portrayed on the map. The sampling and storage of environmental data rely on such practical techniques as aerial photographs (Berlin, 1971), ground level surveys, and the use of remote sensors (Ralsheusky, 1970; Price, 1975).

2.2.3 Selection of Data Base Elements

To be useful, data included in an environmental data base must be meaningful to a map user. Usually, it will be the function of the map maker to select which elements from the envrionmental data base are to be included in the map presentation, as well as to dictate how elements chosen for representation will be displayed to insure comprehension in particular instances. Unfortunately, however, there are no precise rules available for the choice of environmental elements or map elements in the desired form of:

> ...*if* there exists a particular environment X, to map for purpose Y, *then* include environmental elements e_1, e_2, ...e_n using representational elements r_1, r_2, ...r_n.

While we are awaiting the development of such systematic rules, map makers must continue to rely upon intuition, upon the examination of examples, and upon scattered research. In the following paragraphs, selected research relevant to the choice of environmental and map elements is discussed.

The simplest approach to choosing items for map representation is to include all known elements of an environment. In most situations this approach is impractical, either because of the costs of data gathering, or because of the limitations of the map presentation format. Yet, even if these obstacles were eliminated, a nonselective approach would be generally ineffective. The reason for this is that a map--especially a military map consulted in a battlefield situation--is used to support the accomplishment of a particular task be it planning, reconnaissance, self-navigation of whatever. And, of course, within the context of this task, some elements in the environment will be relevant and others will not. The specific map-use task, therefore, can be viewed as the guiding force in helping map developers select information for inclusion in the map data base. In fact, for most situations, it is the function of a map to develop conceptual understanding through selection of relevant attributes and presentation of appropriate information.

As an example, consider the inclusion of pictorial information in maps. Such information explicitly represents perceptual characteristics of an environment, in addition to its general spatial relations; it provides users with a realistic sense of an environment as well as a spatial characterization. Ancient maps included a large amount of pictorial information--at the extreme showing ships at sea, monsters, beautiful damsels, and fair young knights. Similarly, ancient Chinese scrolls represented entire journeys in detail. Many modern representations, including the maps in the Michelin Guides and the pictorial displays prescribed by Lo (1973), have continued this tradition. They show detailed, three-dimensional characteristics of objects, in addition to providing two-dimensional displays of their location. In many ways, these kinds of presentations subscribe to a non-selective approach to map making. Yet, it is important to note that these representations are not totally realistic nor all-inclusive. Just as pictorial maps accent selected locational attributes, these maps accent certain perceptual characteristics and not others. In addition, their very nature makes them ineffective for many purposes. Southworth (1970), for example, showed that though pictorial maps were preferred by map users, and though they worked well in tasks that required maps to be related directly to visual scenes, plan views of a city were more efficient for route planning than were pictorial maps, and they were easier to use for such tasks.

2.2.4 Map Information Abstraction

It seems, then, that in many instances of map making, environmental information should be abstracted; that is, there are instances in which details should be omitted and certain aspects emphasized, and all this should be done in due consideration of purpose. Wright (1947) suggested this in his comments which described the tasks of the geographer to be a portrayal which is done *"with aesthetic imagination in selecting the emphasizing aspects of the region that are distinctive or characteristic"* (p. 6). Imhof (1963) described this similarly as he stated that the cartographer's task is to *"transform, emphasize, eliminate, summarize, exaggerate, and enlarge certain things,"* and that *"in spite of the miniature detail, the map should highlight the principal focus of the landscape and also some characteristic details, and important features, such as main roads"* (p. 17). Potash (1977) further states that these processes of selection and emphasis operate currently in even the most standard map making, since features that are too small to be drawn to scale, for example, will be either deleted or magnified, depending upon their importance to the purpose of the map.

Within standard mapping practice there is a recognized need for information summarization or generalization. Rhind (1973) for example, describes a number of elaborate techniques for reducing line sinuosity (roads and rivers), feature transportation (a way to deal with overlapping features at small scales), amalgamation of data types (to show environmental data as categories), and feature elimination (which mainly relies on amalgamation). However, these generalizations have been developed to deal with scale changes, and to minimize drawing costs. It is not clear how effective these changes are for map users. Yet, Watson (1970) has provided a number of excellent examples which caution that generalizations must be based on the purpose of maps. He describes, for example, how information about the condition of road surfaces, height and density of vegetation, the availability of water, the composition and nature of the ground surface, and the traversibility of specific routes is lost with generalizations. And he asserts that this loss is *"to the detriment of the derived map and to the disadvantage of the map-user"* (p. 32). However, there are presently no well-documented rules for the inclusion or emphasis of particular environmental features in map presentations which can guide generalizations and make them beneficial to the user. This is partly due to the fact that maps have been typically made to serve multiple purposes. Because of practical considerations, therefore, the general rule has been to include anything that might be of use and which fits on the map. The technologies which allow the generation of more special-purpose maps are likely to force this issue to be attacked systematically.

From a military perspective, the abstraction process may provide an effective strategy for compressing discrete tactical and/or geographic concepts into larger conceptual chunks. For example, the availability of terrain concealment can be portrayed by two different graphic symbols to preserve a distinction between concealment for tanks and tactical operating centers; or more generally, a single symbol can be used to denote concealment for any tactical purpose. Since the geographic criteria for concealment are more restrictive for tanks or tactical operating centers, the availability of concealment as graphically portrayed may be necessarily diminished by a singular category. The point is that information abstraction erases conceptual distinctions in the interests of map simplification. However, the resulting conceptual data base may or may not afford an adequate degree of information specificity depending on the tactical purpose at hand.

The use of abstraction (to simplify map content) and emphasis (to highlight important features) has found widespread theoretical and empirical support. For example, Granda (1976) studied map-based tactical performance and showed that although detailed maps were preferred, no significant differences in performance, amount of information requested, or time taken for particular mapping tasks were observed between subjects using standard maps and those using reduced detail maps. Similarly, enhancement that made important features, such as rivers, roads and mountains appear distinct was shown to improve map performance, and to be preferred by map users (U.S. Army, 1974).

2.2.5 Specification of User Requirements

Once it is accepted that not all the available information needs to be represented, and instead information must be selected for particular purposes, the critical map-process task becomes the identification of relevant environmental elements to be portrayed. An approach to such identification is to simply ask map users what kinds of information they would like included on a map. This technique has been used often, and has generated a good amount of data. One study of pilots (Huizar, 1972, as cited in Potash, 1977) showed that pilots want information included in maps about the surfaces and widths of roads, apparently elements that they find important in navigation. They also want information about the amount of vegetative cover, because they can use this information in locating themselves. Another study of pilots (McGrath and Borden, 1969) observed that pilots request information that helps them to interpret contours; they asked for explicit descriptions such as "depressions," "cuts," and "fills" instead of contour lines or less specific descriptions. Pilots also indicated that water bodies, water courses, and paved roads were important to their orientation.

In studies of maps for common (i.e., nonmilitary) usage, Zannaras (1973) found that traffic lights, open spaces, churches, and shopping centers were important for navigation in urban areas, though the saliency of each of these features varied across different cities. Shepard and Adams (1971) in a study of British road users, found that hills, railways, bridges, turns and junctures were important features in the description of routes. In another study of British road users (forty percent of whom were lorry drivers), Astley (1969) found that these users would like eating facilities and other services marked on the map as well as road-worthiness. They would also prefer if unnecessary information, like churches and rivers and ancient monuments and railways were removed from the map. The lorry driver, in addition, would like heavy haulage maps to show low bridges, tight bends and weight restrictions. As Astley states, *"it seems from these results, that many current road-maps show more of the things road-users say they do not want than those they want"* (p. 130).

The studies which have elicited user judgments suggest that map makers should choose environmental elements based upon descriptions of mapping tasks and particular user perspectives. However, as argued by Farrell (1977), the validity of user statements of what information they need or prefer on their maps may be questionable, since it cannot be assumed that user preference and performance are positively related. In fact, studies which have correlated map content with user preferences have found the latter to be rather poor predictors of eventual map performance (e.g., Granda, 1976; see Farrell, 1977). Consequently, because of the difficulty of arriving at conclusive generalizations based on highly subjective data, other indicators of the importance of environmental elements should also be considered in the selection of information for inclusion on maps. One alternative method for selecting important environmental features is to determine which environmental information is perceived and remembered by people who move around effectively in a certain area. For example, as Lynch (1960) suggests, if residents of an area recall landmarks such as tall buildings and busy intersections, these should be included on a map to communicate the resident's view to the stranger. This approach was applied by Hooper and Cuff (1976); they selected perceptual features chosen by residents of the environment to be mapped. Although this method does not deal with the mapping tasks of particular users, it does provide map developers with some general guidelines for feature inclusion.

Probably, the most powerful and revealing method of establishing, or at least validating, user information requirements is via empirical studies of map-based performance. Already a number of studies are emerging in the military psychology literature which address relevant independent and dependent variables. For example: Wheaton, et al., (1967) assessed the effects of various map variables, including production techniques, on user localization and orientation accuracy as well as the speed and accuracy of feature identification; Granda (1976) investigated the level of map detail in task-performance time and level of ancillary information requested on tactical decision-making effectiveness; Farrell (1977) assessed the effectiveness of various terrain portrayal formats on user performance time and accuracy to complete the Relief Format Assessment Task; and Ciccone, Landee and Weltman (1978) compared the effectiveness of a computer-generated movie map versus a conventional map on map performance skills such as self-localization, orientation and topographic knowledge. Clearly, the results of such experiments can provide valuable data to support decisions concerning map information content and development.

2.3 Determination of Tactical Map Requirements

At this stage, it would be useful to turn from the discussion of maps in general to the specific topic of military map development. In approaching development guidelines for improved map products, a look at some current map-development trends within the Army might prove helpful. The large extent to which the Army is both concerned about and involved in map-related projects has been noted in a survey conducted by ARI researchers in 1978. In particular, reference will be made to efforts being performed by the U.S. Army Intelligence School (USAICS) and the Army Engineering Topographical Laboratories (ETL). USAICS is working on the creation of special-purpose overlays as instructional tools for students of military intelligence; these tools are part of a set of graphic aids termed "Intelligence Preparation of the Battlefield (IPB)." ETL, in parallel, has been researching the need for experimental products to support military geographic intelligence operations.

With respect to military cartography, concensus in the identification of geographical and/or tactical information requirements represents a fundamental problem. Conventional data collection efforts have focused on the identification of geographic features for general-purpose map use. More recently, battlefield information requirements have been developed on a case-by-case basis for specific user group functions (e.g., armor operations, ETL, 1973). The transition from multi-purpose to special-purpose map applications has produced a corresponding change in data base requirements. In addition to standard topographic information, special purpose products for military operations often portray the results of terrain intelligence analysis (e.g., avenues of approach). The rationale for this development is to simplify map interpretation and tactical inference by relieving the user of what is often a difficult mental transformation. Although the conversion of geographical information into terrain intelligence is not yet standardized, a number of procedures are widely accepted (IPB, 1977; FM 30-10).

2.3.1 Map Information Structure

The procedure developed by IPB outlines terrain factors relevant to various intelligence concepts. Each terrain factor is then decomposed into relevant subfactors, some of which are further divided into subelements. Figure 2-2 provides an example showing that the intelligence concept of "enemy avenues of approach" depends on information across several terrain factors. For illustrative purposes, one of these factors, vegetation, is broken down into its constituent terrain subfactors and subelements. Vegetation, of course, represents a terrain factor that is relevant to intelligence concepts other than "ground avenues of approach," for example, "cover," "concealment" and "obstacles."

In examining these new developments directed at portraying raw terrain data in terms of its implications for battlefield oeprations, it becomes evident that the process of information analysis takes on a hierarchical structure. In other words, the process proceeds in a top-down fashion extending from high-level tactical intelligence to concrete information items. At the top of the structure there are tactical concepts such as avenues of approach which are decomposed into factors like vegetation which in turn are broken down into subfactors such as vegetation spacing and size. Thus, the hierarchical arrangement of the structure proceeds from the abstract tactical concept to the specific details of the battlefield terrain which impact upon the concept. This structure can be termed task-based because the flow of information and its classification is arranged in accordance with the purposes that the information is called upon to serve. Each concept has associated with it task-related knowledge at various degrees of abstraction, and the basis for this knowledge is raw data about the terrain. For example, "concealment" can be expressed separately for men, equipment and installations, or alternatively, only terrain which affords concealment for all three can be identified. Higher

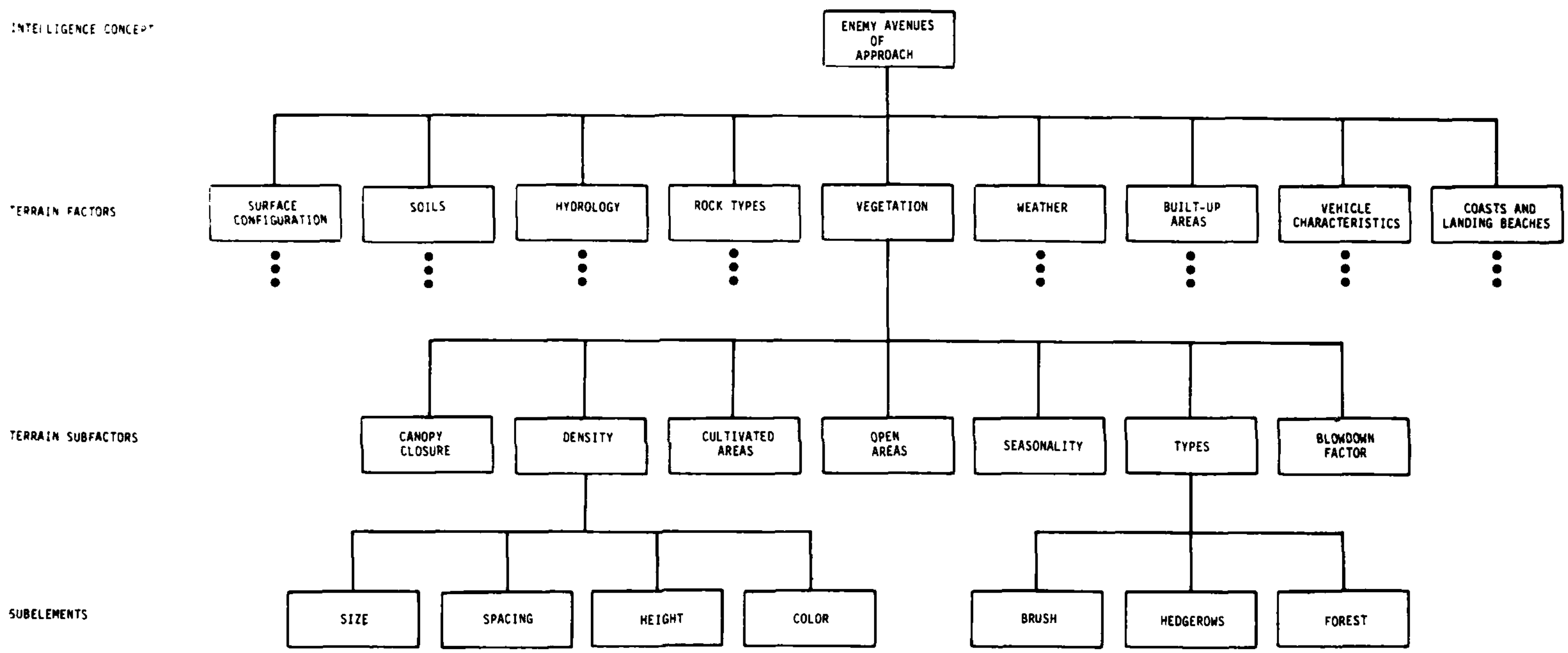

FIGURE 2-2. ILLUSTRATION OF TASK-BASED MAP INFORMATION STRUCTURE (ADAPTED FROM IPB, 1977).

levels of abstraction could result in increasingly simpler map information requirements which provide less specific information. In summary, the derivation of map-related tactical information requirements involves the specification of the level of information abstraction needed for the accomplishment of specific tasks (e.g., object concealment in general vs. concealment for men, equipment and installations in particular).

Furthermore, various concepts may be differentially relevant to different unit functions and tasks. For example, knowledge of obstacles to tracked vehicle movement may be useful to an armor unit but relatively useless to a planner assessing helicopter landing areas. In order to systematically assess the relevance of information to specific military operations, an in-depth analysis of requirements for specific tactical tasks is necessary.

2.3.2 ETL Map-Development Approach: A Case Study

In approaching the development of guidelines for special/general purpose and simplified map making, it would be helpful to examine a method the military has employed toward meeting this goal. The analysis of a current map development project which intended to improve upon cartographic products should offer insight into the potential advantages and disadvantages of a given research strategy. In addition, the discussion in this section can serve as a fitting backdrop for the presentation in the subsequent sections of the application of the task-based approach toward the development of guidelines for improved map design.

For several years, the Army Engineering Topographic Laboratories (ETL) has been researching the need for special purpose topographic products to support the use of existing general purpose maps in military operations.

One effort (ETL, 1973) focused on the development of experimental military geographic intelligence products necessary to support armor operations. The major premise of the project was that the subject content, format, and symbolization associated with the experimental products should be derived from knowledge of the functions or activities performed by armor operations.

Method

To determine the needed support materials, ETL began by delineating the organization and missions of an armor operation, which are, in general, offensive in nature and designed to close with and destroy the enemy. Since armor is a highly mobile, organizationally flexible force capable of quickly adapting to changing battlefield situations, an extensive amount of terrain-related data is needed to portray all armor activities. Displaying all of this information on one graphic (i.e., standard, special purpose or simplified map or overlay) would be overwhelming. A more functional approach would be to portray only the major activities of armor and the terrain-related data needed to support such operations.

The development of the experimental products was divided into two phases. Phase one involved a background analysis which was primarily intended to determine the major armor activities and the terrain-related information requirements necessary to support the operation. Phase two of the project dealt with the design and evaluation of the armor-related products.

Background Analysis

The technical approach included interviews of armor officers and observation of a field training exercise for student armor officers. Ascertaining user requirements of the armor operation provided a somewhat difficult task: In the field there is rarely a "pure" armor operation since the activity of cross-attaching with infantry to form combined arms teams is the normal practice; thus, a complete list of armor operations requiring terrain data included some elements common to both armor and infantry. Based on their analysis, however, ETL was able to determine the broad activities of an armor operation to be FIND, FIX, FIGHT and FINISH the enemy. A sublist of activities derived from the previous list included such items as locating sites suitable for defensive positions, locating potential ambush sites and evaluating fields of fire.

ETL conceptualized map-related information as either factual or interpretative inputs. Factual inputs can be determined from existing topographic maps, photographs, etc. An example of a factual input item is a "stream" which is known to be perrenial or intermittent. Interpretative inputs, on the other hand, may be viewed as the result of an evaluation. For example, vehicular cross country movement (CCM) is an interpretative input to a map. CCM represents the evaluation of slope, vegetation, soil, weather and their interactive relationship on the off-road movement capability of a particular vehicle. Additionally, there exists a vast amount of quantitative information which is useful in evaluating terrain information for specific activities. An example of quantitative data is the fact that a tank can negotiate a slope as steep as 60%; or further, if the slope is composed of sand, it will be impassable if greater than 30%.

Product Design

The second phase of the ETL project was concerned with the design of the armor-related map products. Several experimental products were prepared involving a standard topographic on the front side (either 1:50,000, 1:100,000, or 1:250,000) and special purpose graphics presentations on the back side. Thus, the front of each of the experimental instruments contained varying amounts of factual input items. For example, all of the front maps contained detailed bridge information; however, the inclusion of additional features, such as weather and slope conditions, varied from map to map. The back of four of the maps served to display interpretative items. CCM was displayed on the back of all of the maps; however, the inclusion of additional relevant features, such as obstacles, cover and concealment, again varied from map to map.

Experimental-Product Evaluation

Following the preparation of the experimental products, an evaluation of each of the maps was made on the basis of a user survey of faculty and students of the Armor School at Fort Knox, Ky. The evaluation of the content and design of each map was addressed by a separate questionnaire where respondents were asked to rate each information item (e.g., "portrayal of slope;" "information on soils") as "very useful," "useful" or "not needed." Additionally, respondents rated the improvement, or lack of improvement, resulting from the design changes compared with conventional maps. The following is a summary of the evaluation results concerning map information requirements:

(a) Information pertaining to movement problems (barriers, corridors, fords, streams, bridges and roads) was considered very useful by respondents.

(2) Interpretative interpretations or predictions (e.g., CCM, % canopy closure, fields of fire, line-of-sight) were considered useful but not essential.

(3) Highlighting of high ground was considered very useful for reconnaissance work as was the portrayal of slopes.

(4) The experimental products most favored by the respondents were:

(a) A 1:50,000 scale map portraying high ground, hydrography, bridges, fords, terrain units, and avenues of approach.

(b) Four 1:50,000 graphics portraying (1) road network drainageways, bridges and fording sites; (2) CCM and high ground; (3) generalized slope and vegetation; (4) cover and concealment.

The results of this evaluation provided the guidelines for the formulation of a second generation experimental product. The second generation graphic consisted of a standard topographic map on the front and four special purpose graphics on the back. The four graphics addressed: (1) vegetation and maneuver; (2) terrain and sensors; (3) photomap; (4) line of transportation. The field testing and preference evaluation of these products will further refine the map requirements and preferences for armor units.

Comments

The ETL project offered a plausible preliminary approach toward establishing a methodology for developing special purpose products to support military operations, and a number of interesting results were obtained with practical implications for military map design. However, user preference for map information was indicated for generalized, interpretive information rather than for highly detailed factual information. One armor officer who was interviewed pointed to the apparent weakness of this approach by stating: *"It is more realistic to indicate that cross country movement for tracked vehicles is difficult due to thick woods, rather than indicating an M113 can go 10 km/hr over certain terrain."*

The ETL methodology did not provide a specific echelon context in which the respondents evaluated map information. Specifically, echelon (e.g., Corps, division, etc.) and user designation (e.g., S-3, G-1, Commander, etc.)

were not defined. As pointed out by Wheaton, Zavala and Van Cott (1967):

> *"Maps are utilized differently at various command levels. At required regimental or battalions staff levels, maps may be primarily utilized for operations planning and the "mapping" of strategies. At the company or platoon level, however, a much more detailed, tactically oriented use of the map may be required. Similarly, an infantry company and a company of engineers may be assumed to use a map for altogether different purposes and in substantially different ways."*

Since, the objectives and nature of map use can be expected to differ markedly across echelon of command and user group (even within the same military unit, e.g., armor), the specification of information requirements must take user distinctions into consideration. Thus, a systematic analysis of map information requirements should span a range of map-dependent tasks and users.

Furthermore, to determine user preference, ETL utilized a three-item classification scheme in which respondents were asked to rate items as either "very useful," useful," or "not needed." This type of categorization provides a rather insensitive measure of preference, and an additional problem is that the term useful has two dimensions. One may view usefulness of an information item in terms of the criticality of the information. On the other hand, usefulness may be viewed as the frequency of usage of the item of information. Thus, by employing the broad classification of usefulness, it was not possible to distinguish to which dimension respondents were replying.

Perhaps, the most important comment that can be made with respect to the ETL study is that map-related information requirements were determined in a relatively context free manner. Although, the domain of military operations was specified (i.e., armor), the elicitation and evaluation of information requirements was performed independent of any specified tactical task. Hence, the expression of data needs may have been too vague because the scenario for data collection specified task requirements in a very general rather than in a very specific manner.

Despite the shortcomings noted above, the ETL project offered a significant advance toward the development of improved user oriented map products. By developing products to support specific military operations, the research effort focused attention on fulfilling map user needs. Utilizing the efforts of the ETL project as a basis, future research may further refine techniques for determining more specific user-based map information requirements. As demonstrated in the next chapter, one way of accomplishing this goal is to start with somewhat general tasks and then decompose each into its specific constituent subtasks; the latter can then be used as a basis for specifying map information requirements.

2.4 Summary and Conclusions

A basic problem in developing improved military map products is deciding what information to include in the map content. Historically, map content has been determined by the preferences of map makers and users. Such an approach, because of its subjectivity, does not offer sufficient aid to the map maker in developing a product which will assist the user in the performance of map-related tasks. In order to define such requirements, a task-based methodology for isolating key items of battlefield information appears especially appropriate. The goal is to establish a clear linkage between the functional content in which maps are used and the content offered to the user.

To put the matter more simply, military maps must provide battlefield decision-makers with ready "answers" to complex tactical "questions."

The problem, therefore, becomes one of deciding what information is needed to answer these questions. For example, the map user may need to identify potential enemy avenues of approach. This task may be stated in question form as "Where can I expect the enemy to come from?" Having identified a tactical question that the map is to help "answer," the problem remains of deciding how much information detail to include. Thus, in response to a question about enemy advance, maps might represent the answer at different levels of information specificity, including, for example, all off-road as well as on-road avenues of approach, or only off-road approaches. At a still more detailed level, the user may want to distinguish the type of size unit which could be supported on each avenue (e.g., motorized rifle regiment vs. armor platoon) and may, therefore, need to know avenue widths, lengths, soil strength, etc. Each of these different levels of information detail might conceivably be appropriate, depending upon tactical circumstances.

3. APPLICATION OF TASK-BASED METHODOLOGY

3.1 Overview

To demonstrate the potential effectiveness of the task-based approach to determining military map development guidelines, several examples of its application are provided in this chapter. These examples are based on the sampling and analysis of representative map-related tasks which are commonly performed on the contemporary battlefield by selected users at different echelons. While the discussions presented in this chapter do not address all key map users at all relevant echelons, the selections are intended to be representative of typical user-task combinations. For each combination, an in-depth analysis is provided of the information requirements associated with adequate completion of the map-related task. The implications and conclusions drawn from these analyses are then presented in the subsequent chapter.

3.2 Task Selection Criteria

The modern battlefield is characterized by new sophisticated weaponry with far greater lethality than available in past decades. While the weaponry has undergone extreme change, the battlefield functions have remained pretty much the same. The range of functions handled by the commander and coordinating staff of the modern battlefield include: Command, Personnel (G-1/S-1), Intelligence (G-2/S-2), Operations (G-3/S-3), Logistics (G-4/S-4). Across these battlefield functions and the associated echelons of command, several important specifically defined tasks are performed which require the direct utilization of map-related information.

Since our goal was to apply the task-based methodology to illuminate general adequacies and shortcomings of available standard topographic maps, we tried to select tasks across as wide a range of function and echelon as possible. The sample therefore includes representation of:

(1) battlefield functions from command through logistics;
(2) echelons from corps through company;
(3) G and S coordinating staffs.

In addition, tasks were considered only if they conformed to all of the following general criteria:

(1) require a relatively substantial amount of map-related information;
(2) frequently performed by basic units with common tables of organization and equipment (TOE);
(3) reflect current staff organization and tactical doctrine as described in FM 100-5 (Operations);
(4) do not require large amounts of specialized information unique to a user group.

Thus, examples of two tasks included are the determination of enemy avenues of approach by the G-2 (Division) intelligence officer and the selection of a one-ship helicopter landing zone by an S-3 (Battalion) operations officer. Examples of tasks which were not included would be image interpretation tasks (performed by the Military Intelligence Battalion) because, although they rely heavily upon maps, they require uncommon data-intensive, event-intensive information not usually needed by other analysts.

3.3 Method of Information Specification

The first step toward the development of map information requirements involved tactical role playing, in a manner similar to that employed by Bowen, Halpin, Long, Lukas, Mullarkey and Triggs (1973). A tactical scenario was developed which defined the Where, Who, When, and What of a battlefield setting. Specifically, Federal Republic of Germany (FRG) was selected as the battlefield area, since the region provided a variety of terrain information. The friendly unit selected for use in the scenario was a mechanized infantry unit whose composition is that which is most commonly found on the battlefield. A Soviet motorized rifle force was chosen to represent the enemy contingent with its size varied as a function of the echelon of the role player. For example, a Division G-2 would be concerned with a battalion and regiment size enemy force; however, had a Battalion S-2 task been selected for analysis, the enemy force size of concern would have been companies and platoons. The time frame of the battlefield was defined as D-Day minus 6 days (meaning that there were approximately 6 days to anticipated action) because it allows sufficient time for a thorough analysis to be conducted of the battlefield situation. Since combined arms team doctrine emphasizes the active defense, this posture was adopted for the scenario.

To summarize, the following battlefield context was specified:

Where:	FRG (area of Hof)
Who:	Friendly forces - mechanized infantry unit Enemy forces - Soviet motorized rifle unit
When:	D-Day minus 6 days; fair weather, clear skies, mild weather condition
What:	Defensive posture; approximately 4-1 enemy to friendly ratio.

Given the scenario discussed above, the military expert was then assigned a user role (e.g., G-2), and echelon (e.g., division). The expert was supplied with two standard topographic maps of FRG (1:50,000 scale, 1:250,000 scale), acetate overlays and grease pencils. At this point the user was given a task to complete. For example, the G-2 was ordered to determine the likely enemy avenues of approach into the division area of responsibility. Figure 3-1 shows the completed overlay for enemy avenues of approach. Informal notes were taken of the comments and procedures employed by the G-2 to complete this task. After completion of the exercise, the notes were analyzed so as to provide useful details and insights concerning the information requirements (procedures and considerations) involved in the military task.

A role-playing exercise of this nature can present some difficulties when the expert is performing a familiar task. In particular, the expert may frequently be unable to relate many of the detailed elements and mental computations which are instinctively performed with respect to the task. Consequently, an observer[1] participated in the exercise in order to attempt to draw from the expert the very basic components involved in the completion of the tactical task. As an example, in determining the enemy avenues of approach, the expert, with the help of the observer, decomposed the information requirements into three subtasks: (1) to specify obstacles to enemy movement; (2) to determine areas of sufficient size for enemy movement; and (3) to identify the cover and concealment potential of the latter areas. The analysis then proceeded at the subtask level.

Each subtask was decomposed into its most basic information content; for example, obstacles to enemy movement were decomposed into slope, soil, vegetation, river and built-up area obstacles. Each information item was then analyzed to determine the minimum level of detail required (e.g., what detail is necessary to determine a slope obstacle to tank movement?).

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[1]First author of this report

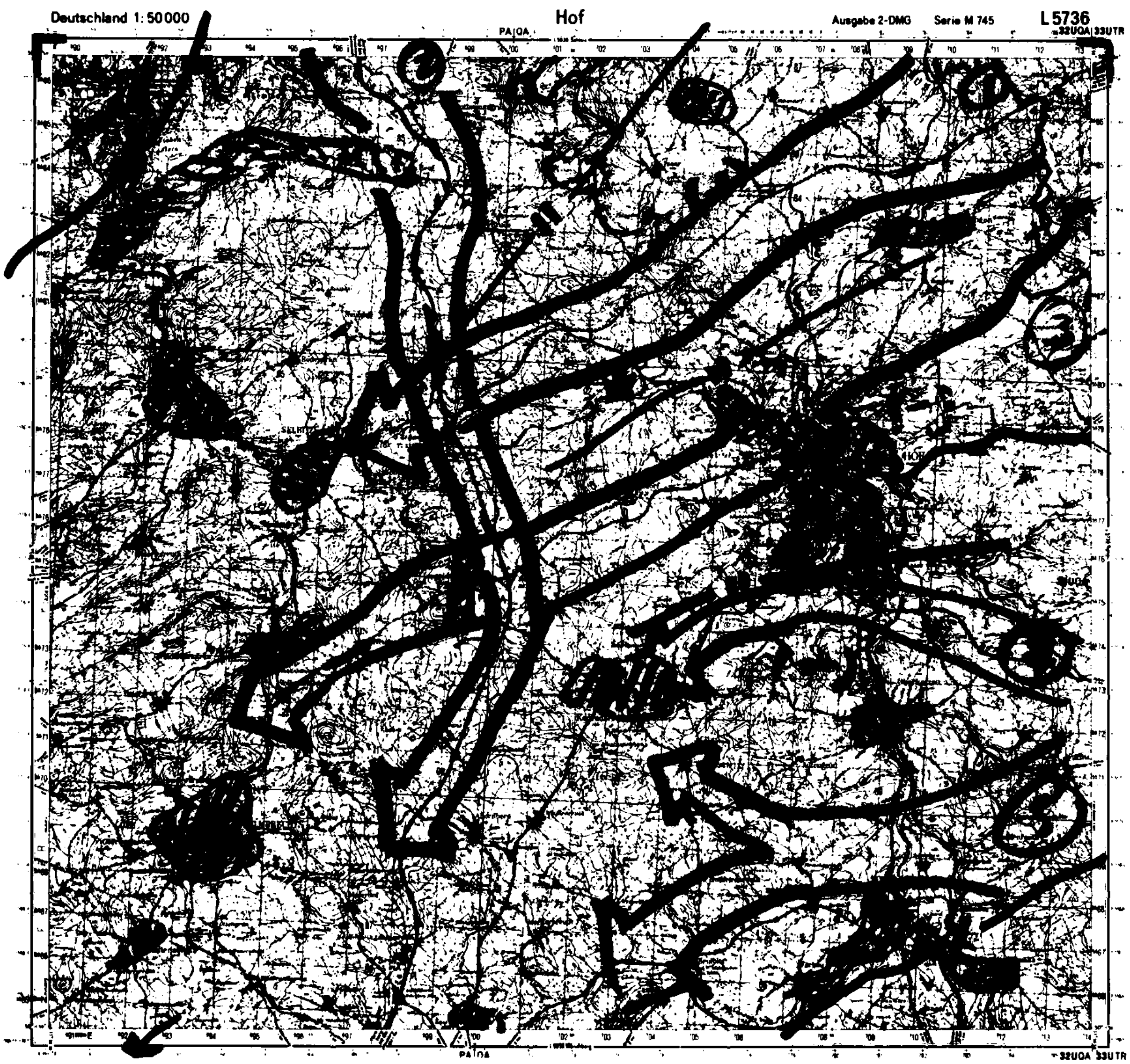

FIGURE 3-1. OVERLAY FOR ENEMY AVENUES OF APPROACH

Once the analysis of the exercise was completed it was reviewed by the expert and revisions were made. An iterative process of review and revision was continued until the final product reflected a complete and meaningful task analysis acceptable to both the expert and the observer.

The task analysis was then subjected to military literature verification. In some instances direct verification was possible. For example, the slope obstacle to tracked vehicles information provided by the expert was confirmed in Tactics, Techniques and Concepts of Antiarmor Warfare (FM 23-3, 1972) as the maximum slope ascending capability for specific vehicles. Thus, specific and direct verification was made. A discrepancy arose in this case when another source (Intelligence Preparation of the Battlefield, 1977) specified a different percent slope as an obstacle. Such a discrepancy was noted in the information detail requirements, and both specifications and their sources are listed.

While an attempt was made to obtain direct verification of all information detail reported in this document, it was not always possible. In those cases where direct verification was not available, inference from current military doctrine served as the guideline. For example, according to one contemporary tactician, "*if you can be seen* [on the battlefield] *you can be hit; if you can be hit, you can be killed*" is a major force in military doctrinal teaching. However, specifications of vegetation heights which provide concealment are not available in the military literature. Thus, the height of the object being concealed provided the information detail requirements specified by this analysis. For example, concealment of the Soviet T-62 was based on the height of the vehicle including the turret.

This research effort relied primarily upon the expertise of one military tactician.[2] Although the approach used to specify information requirements

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[2]Major Dennis R. Foley, former Tactics Author/Instructor at the U.S. Army Command and General Staff College (Ft. Leavenworth, Kansas).

was based on the judgment of only one user, the level of detailed analysis required a concentrated focus of intellectual effort for which no standard operating procedures yet exist. By employing the role-playing technique in the context of a simulated scenario, the analyst appeared to be able to develop an adequate mental model of the hypothetical task situation, which increased the validity of his judgments. Nevertheless, it is recognized that there are variations in the information and methods employed for map-related task performance among users.

As the expert went along, it became evident that many of the specified information needs were inspired from experience in commanding actual combat operations, as opposed to being derived only from a deep understanding of classical military doctrine. Thus, it might be said that the approach used here combined a little of both information elicitation perspectives mentioned in the brief discussion of relevant literature (Section 2.2); namely, user expectation (what should be needed?), and user experience (what was actually needed?). Nevertheless, it should be pointed out that the overriding concern of this *information analysis* is not no much item-by-item accuracy, but rather the demonstration that detailed functional requirements can be meaningfully determined for very specific tactical tasks and their decomposed subtasks.

Some of the information detail requirements specified in the analyses to follow cannot, by current state-of-the-art cartographic techniques, be graphically portrayed in a practical way. For instance, the difficulties inherent in the portrayal of up-to-date weather information, as well as contour deviations of one meter are recognized. However, to have limited user information requirements to information which can be currently gathered and portrayed would most likely have rendered the knowledge obtained by this effort incomplete in a very short period of time. One value of the task-based approach is its sensitivity to user needs, independent of the problems of obtaining and portraying information. Thus, some of the user

TABLE 3-1

TASKS SELECTED FOR ANALYSIS

USER	ECHELON: CORPS	DIVISION	BRIGADE	BATTALION	COMPANY
COMMANDER					EXHIBIT F: Prepare a company level defensive *fire plan* (p. 3-68)
PERSONNEL (G-1)	EXHIBIT G: Select Prisoner of War Collection sites (p. 3-77)				
INTELLIGENCE (G-2)		EXHIBIT A: *Determine* enemy avenues of approach (p. 3-13)			
OPERATIONS (G-3)		EXHIBIT D: Determine primary and alternate locations for DTOC (p. 3-51)			
LOGISTICS (G-4)	EXHIBIT B: Determine main supply route (p. 3-31)				
S-3 AIR (OPERATIONS)			EXHIBIT C: Select a *one-ship heli*copter landing zone (p. 3-41)		
CAV SQUADRON (INTELLIGENCE)				EXHIBIT E: Plan a reconnaissance route (p. 3-59)	

information needs may not be able to be met now; yet as cartographic techniques improve, the potential for portrayal of such information should become more realistic (e.g., see Weltman, 1979).

3.4 Task Identification and Presentation

A total of seven tactical tasks were selected for analysis. These tasks are defined in Table 3-1, which shows how they span the range of echelons and users considered, and provides an index to their reference in the text. Seven different user groups are represented (commander, G-1, G-2, G-3, G-4, S-3, and cav squadron), and there are two tasks each at the corps and division levels, and one task each at the brigade, battalion and company levels. The description of each task analysis is presented separately in the form of a separate exhibit, labeled from A to G. The order of presentation of exhibits is pretty much according to the extent of map-related information required by the respective task, with the tasks presented first having the most comprehensive map information requirements.

3.5 Exhibit Format

The format for the task analyses presented on the following pages is the same for each of the seven user-task combinations. The title page of each exhibit identifies the relevant user designation, echelon of command, and tactical task; in addition, a hypothetical problem statement from the user is provided. An analysis begins with a brief background section explaining the general nature of the map-use task under consideration; this section includes a table specifying the breakdown of the main task into component subtasks and the relevant map use questions. Next, each subtask is discussed separately in terms of the information categories and levels of detail required for successful accomplishment of the task. In particular, information categories are decomposed into specific data requirements (i.e., level of datail needed).

TABLE 3-2. INDEX TO MAP INFORMATION CATEGORIES

INFORMATION CATEGORY:	PAGE REFERENCE:
BREAKTHROUGH ATTACKS	3-29
BRIDGES	
Load-Bearing Capacity	3-38, 3-67, 3-83
Overhead Clearance	3-39, 3-84
Width	3-39, 3-84
BUILT UP AREAS	
Building Size, Height, Type	3-85
Location	3-28, 3-67
CLIMATIC CONDITIONS	3-29, 3-63
FENCES	3-48
RIVERS/STREAMS	
Current Speed	3-39, 3-84
Depth	3-27, 3-39, 3-84
Slope of Approach	3-39, 3-84
Vertical Banks	3-27
Width	3-27
ROAD NETWORKS	
Classification	3-38, 3-66, 3-83
Condition	3-38, 3-66, 3-83
Curves	3-40
Gradients	3-40
Narrowing	3-40
Width	3-38, 3-66, 3-83

A summary table is then provided which includes the following highlights for each subtask component (i.e., information category). First, the minimum level of detail (i.e., classification) for required information is specified, and doctrinal references are given. Those minimum level of detail requirements not portrayed on currently-used standard topographic maps are italicized to distinguish them from presently available information items. Selective explanatory comments are added which are designed, for the most part, to identify and justify instances where conventional maps do not meet the user requirement details as specified by the sampled task. In addition to the index to the exhibits (Table 3-1), Table 3-2 provides, for the user's convenience, an alphabetic index to the information categories uncovered across tasks in the analyses.

3.6 Exhibit A

USER: TACTICAL OPERATIONS CENTER (TOC) INTELLIGENCE SECTION

ECHELON: DIVISION

TASK: DETERMINE ENEMY AVENUES OF APPROACH FOR A SOVIET MOTORIZED RIFLE UNIT (REGIMENT OR BATTALION)

PROBLEM STATEMENT:

"I can't tell where the enemy can drive his tanks."

3.6.1 Background

The assessment of enemy avenues of approach is especially important since it represents one of the most complex and yet critical duties of the intelligence staff. The minimum information required to evaluate enemy avenues of approach will vary with the prominent feature of the battlefield terrain. For example, a G-2 evaluating enemy avenues of approach into the Hof area of West Germany is not likely to be concerned with an analysis of cover and concealment. He would be aware of the fact that Soviet doctrine emphasizes movement along the fastest route toward our command, control and communication centers. Thus, the G-2 would concentrate his attention on the identification of obstacles along road networks leading to enemy objectives. If, on the other hand, the battlefield was located in the Middle East and road networks were not a prominent terrain feature, an in-depth analysis of other terrain features, such as cover and concealment, would be required.

In determining routes the enemy is likely to travel, it is first necessary to determine those routes the enemy is unlikely to travel due to terrain constraints. As the G-2 eliminates those areas where the enemy cannot move, he begins to narrow down the areas in which the enemy is capable of moving. Having identified specific obstacles of enemy movement, the analyst then moves on to consider various attributes of each potential route. For example, he must evaluate the size of the force each route will support. Finally, an analysis of cover and concealment is necessary.

An in-depth analysis follows of the procedures used by intelligence personnel to identify likely enemy avenues of approach. Three major subtasks are involved in the analysis:

(1) Identify obstacles to movement.
(2) Identify areas sufficient for enemy movement.
(3) Identify areas of adequate cover and concealment.

Each of these subtasks can, in turn, be further subdivided into still more basic map use questions. An overview of this extended question-based task analysis is presented in Table 3-3.

3.6.2 *Subtask A1: Identify Obstacles to Movement*

The G-2 begins the analysis of likely enemy avenues of approach with the identification of obstacles to enemy movement. The elimination of areas which prohibit tank movement aids in the determination of likely paths of enemy movement.

Slope as An Obstacle to Movement

Inconsistencies exist within the military literature as to how steep a slope must be before it can be considered an obstacle to enemy movement. Currently, 45% slope is accepted as the upper limit for tracked vehicle movement (IPB, 1977; FM 5-36, 1970). However, available data indicates that the Soviet T62 (their main battle tank) is actually capable of ascending

TABLE 3-3

OVERVIEW OF QUESTION-BASED
TASK ANALYSIS FOR
EXHIBIT A

USER: Intelligence Section

ECHELON: Division

TASK: Determine enemy avenues of approach

SUBTASK:	MAP USE QUESTIONS:
A1 Identify obstacles to movement	A1.1 *Are there any slopes enemy vehicles cannot climb?*
	A1.2 *Are there any areas where the soil will not support tracked vehicles?*
	A1.3 *Are there any vegetated areas through which enemy vehicles cannot pass?*
	A1.4 *Are there any rivers which pose an obstacle to enemy movement?*
	A1.5 *Are there built-up areas which will be an obstacle to enemy movement?*
A2 Identify areas sufficient for enemy movement	A2.1 *Where are enemy battalion and regiment size zones of action?*
	A2.2 *Are there areas of sufficient size to support enemy battalion or regiment breakthrough attack?*
A3 Identify cover and concealment adequacy of avenues of approach	A3.1 *Where are the areas providing concealment for enemy tracked vehicles?*
	A3.2 *Where are the areas providing cover for enemy tracked vehicles?*

a slope gradient of 50% and that the Soviet BMP (their armored personnel carrier) is capable of ascending slopes up to 62%. These estimates, however, do not differentiate between the possible effects of bare versus vegetated slopes. Maggart (1978) states that a bare slope of 60% will constitute an obstacle to tracked vehicle movement and that this will be reduced to 32% if the slope contains closely spaced trees of .14 meter trunk diameters.

Regardless of the exact slope one defines as an obstacle to movement, the procedure for determining slope remains the same. The absence of direct slope information on a standard topographic map requires the calculation of slope from contour lines and elevation notations provided on the map. Analysis begins by selecting two points along the avenues (generally, one on either side of the width of the avenue). For each point contour lines must be counted and elevation located. The vertical difference and horizontal distance between the two points must be measured. The values derived are then put into a mathematical formula and the result of the calculation is the percent slope between the two points selected. Additional sets of points are chosen along the avenue and the computations are repeated until a picture of the slope emerges and the slope obstacles are identified. The exact number of points sampled will depend primarily upon the time available for the completion of the overall analysis of likely enemy avenues of approach.

Soil as An Obstacle to Movement

The evaluation of soil trafficability is a rather complicated and time-consuming process, yet it can be vital to a complete movement analysis. There are two basic indices considered in soil trafficability. The first index is concerned with a specific type of vehicle (vehicle cone index), the other index is concerned with the nature of the soil (rating cone index). The first consideration in the analysis is to identify specific enemy vehicles for evaluation, since the analysis revolves around soil trafficability for specific vehicles. For example, if avenues of approach are being considered for a motorized rifle unit, the specific vehicles of concern would be the Soviet T62 and BMP. Each vehicle has a vehicle cone index which reflects the minimum soil strength required for that vehicle to complete 50 passes over the soil (this approximates the movement of a battalion). The analyst can locate the vehicle cone index for enemy vehicles in the technical intelligence files.

Once the vehicle cone index for the vehicle has been determined, the next key informational item in the analysis is the soil rating cone index. This index reflects the capacity of the soil to sustain traffic. Determination of the rating cone index requires actual field testing of the soil. Since this information is not provided on the standard topographic map, the analyst must look to other sources. Generally, an attempt is made to locate an expert on the soil conditions of the area. These experts might be local authorities (e.g., territorial and/or civil engineers) or members of the Engineer Topographic Battalion.

Before completing a soil evaluation the analyst must consider the impact of current and predicted climatic conditions on the soil. Snow, ice or rain may alter the trafficability of the soil as well as any conclusions concerning likely avenues of approace. Thus, consultation with Air Force Weather is necessary to obtain specific forecasts for the area in question.

The comprehensiveness and completeness of the soil evaluation will primarily depend upon two factors. The first factor is locating the required information. This is of particular concern when attempting to gather reliable and accurate information about soil strength (i.e., rating cone index). The second factor which will impact on the analysis is the time available to complete the task of identifying the likely avenues of approach.

Hence, the more time and resources available to the analyst the more likely it is that a comprehensive soil evaluation can be completed.

Vegetation as An Obstacle

Within the battlefield terrain, various types of vegetation constitute an obstacle to the movement of tracked vehicles. Specifically, trees with trunk diameters in excess of .22 meters will stop the movement of a medium tank. In addition, tree spacing of less than 6.1 meters will prevent tracked vehicle movement. Standard topographic maps provide certain classifications of vegetation. In general, standard topographic maps allow for the differentiation of vineyards, orchards, scrub and woods-brushwood. However, a wooded area may or may not be an obstacle to movement depending upon the tree trunk diameters and the tree spacing. The level of detail portrayed on the standard map is insufficient for determining vegetation obstacles.

Since the required information is not available on the standard map, the analyst must determine this information from other sources. A variety of sources may be consulted, including aerial and sensor reconnaissance findings, local authorities, and intelligence spot reports. Conducting a ground reconnaissance for the area may also be necessary. Thus determining vegetation obstacle information requires both time and resources if the analysis is to be completed.

Rivers as Obstacles to Movement

When the battlefield terrain includes rivers, the analyst must determine if any features of the rivers pose an obstacle to movement. There are numerous features of rivers, any one of which may make a specific area of the river an obstacle. One feature to consider is the river depth. A river deeper than 1.4 meters, for example, will cause the Soviet T62 to stop and install its snorkeling outfit. This time-consuming activity would slow the advance of an attacking force and possibly make them more vulnerable to detection. Hence, when determining likely enemy avenues of approach, river crossings which require enemy tanks to snorkel may be considered an obstacle to movement. Another feature which could present an obstacle to movement is the river width. River widths in excess of 5.5 meters require bridging, which is another time-consuming effort and hence, an obstacle to enemy movement. In addition, tanks have a limited vertical height-climbing capability of 1.2 meters. Therefore, vertical bank heights of 1.2 meters will pose an obstacle to movement.

The river information contained on a standard topographic map is limited to the location and direction of flow of the river, although some maps also contain fording sites. To ascertain sufficient information to locate river obstacles, the analysis relies upon a variety of sources other than the standard map. Interpretation of ground and aerial photographs, as well as sensor information, may provide useful data. Another source of information would be reports available from local authorities concerning rivers in the area. Review of various weather-related reports and tables may provide seasonal estimates of river depths for the area. If necessary, a ground reconnaissance of the area could be conducted to determine the necessary information. Ground reconnaissance, however, requires both time and manpower. As in the case with other types of obstacle analysis, the comprehensiveness and completeness of river obstacle analysis will depend upon the resources and time available to the analyst.

Built-Up Areas as An Obstacle to Movement

An enemy avenue of approach which requires movement through a built-up area is generally viewed as an unlikely route of movement. Hence, an analysis of likely enemy avenues of approach requires the location of built-up area.

Specifically, any built-up region of at lease one square kilometer in area is regarded as an obstacle to movement. Additionally, smaller built-up areas may be viewed as obstacles if two or more are located less than one kilometer apart.

Small scale standard topographic maps (e.g., 1:250,000) provide outlines of major built-up areas, as well as specific detail such as isolated farms. Larger scale maps (e.g., 1:50,000) provide the location of all built-up areas, regardless of size. Thus, the analyst is required to search the map and locate those areas which are considered obstacles to movement. The knowledge of all built-up areas, regardless of size, is excessive detail for the analysis of obstacles to movement. This represents a potential area where standard topographic maps may be simplified without sacrificing necessary information.

3.6.3 Subtask A2: Identify Areas Sufficient for Enemy Movement

The preceding analyses of obstacles to movement will yield a picture of the areas where the enemy may advance and maneuver in a relatively unrestricted manner. The next step in the analysis is to determine the enemy force size which may be able to utilize those areas. When determining the force size which may attack along an avenue of approach, a useful guideline is enemy doctrine. While enemy doctrine may not be adhered to in an absolute sense, it does represent the idealized way in which the enemy would like to fight. For example, if a Soviet regiment is to conduct a breakthrough attack there is a specific frontage width which is desirable for this action. Thus, the analyst must be familiar with attack frontage widths for various size units as specified by enemy doctrine. In general, the intelligence analyst will be concerned with areas of potential action for the two enemy echelons below his own. Specifically, a division analyst will focus his attention on areas which can support Soviet battalions and regiments.

Zones of Action

A zone of action is the area of responsibility for a specific tactical unit. Soviet attack zones of action, as noted by Maggart (1978), are 2 to 3 kilometers for a battalion, and 5 to 8 kilometers for a regiment. Thus, the analysis will compare the doctrinal frontage widths with those of the available avenues of approach. A standard topographic map does not provide direct information about frontage widths. Completion of this subtask requires the results of the previous subtask (i.e., identification of obstacles to movement). Thus, having already eliminated areas of restrictive movement, the analyst need only to measure the widths of the remaining areas and compare these with the doctrinal frontages.

Breakthrough Attacks

Soviet breakthrough attacks concentrate the largest size force in the smallest areas. Soviet breakthrough attack frontages, as noted in Maggart (1978) are 1 to 1.5 kilometers for a battalion and 2 to 4 kilometers for a regiment. The analyst will compare the widths of the available avenues of approach with doctrinal frontages, the identification of these avenues will be carried out in the same manner as stated for the determintation of zones of action. To reiterate, a standard topographic map alone will be insufficient for readily locating possible breakthrough attack areas.

3.6.4 Subtask A3: Identify Areas of Adequate Cover and Concealment

While ease of movement and maneuverability are prime considerations of avenues of approach, cover and concealment may also play a key role. In a battlefield area, protection from fire and observation are important considerations. In general, a slower approach makes units more vulnerable to observation and fire. Thus, an analysis of enemy avenues of approach requires an assessment of the cover and concealment adequacy of the routes.

The assessment requires knowledge of the object to be covered and concealed, since an area which may conceal a foot soldier may not conceal a tank. The initial task description required avenues of approach for a motorized rifle unit, thus, cover and concealment will be considered for an armored personnel carrier and battle tank.

Specific note should be taken that cover and concealment are not the same thing. A given area may provide concealment but not cover. For example, tall grass may conceal a tank, but offers no protection to the tank if it is fired upon. Hence, the evaluations of cover and concealment are carried out separately.

Concealment

Concealment is defined as protection from observation. Concealment may be provided by specific vegetation features as well as climatic conditions. For example, tall grass and woods may conceal a tank as may dense fog and snow drifts.

Vegetation which could provide concealment for a tank must be greater than 3.7 meters in height. The standard topographic map does not directly portray vegetation height information. The vegetation classification (i.e., woods, scrub, vineyards, orchards) may provide an indication of the concealment potential of an area. In general, woods are likely to be able to conceal a tank, though this conclusion may in some instances be erroneous. An accurate analysis would require the review of aerial photographs, sensor reports and direct field observation. As in other instances, the comprehensiveness of the analysis will be dependent upon the available time and resources.

In addition to vegetation, various climatic conditions may offer concealment for a tank. For example, a route which contains dense fog during specific times of the day could provide concealment for an advancing unit. Currently, standard topographic maps do not provide weather information. The analysis of weather-related concealment must rely upon historic, current and projected climatic conditions of the area which may be provided by Air Force Weather. This information may serve to indicate when and where climatic concealment conditions, such as dense fog, may be expected.

Cover

Cover is generally defined as protection from the effects of fire. Terrain which allows a tank to be in a hull-down position provides cover. For example, cover may be provided by ditches, rocks or folds in the ground. A standard topographic map (1:50,000 scale) contains 10-meter contour intervals with supplementary 5-meter intervals. Unfortunately, a ditch providing cover for a tank would not be visible on a standard map. The lack of necessary detail on a standard map requires the analyst to order ground reconnaissance of the area if this information is to be ascertained.

A map which would provide the analyst with the minimum level of detail necessary to assess cover would require contour intervals of 1 meter. However, it is unlikely that this level of detail could be legibly portrayed on a standard 1:50,000 scale map, although this detail might be legible on a 1:10,000 scale map. The inherent problem with the use of such a scale map at the division level would be the number of maps required to portray the echelon's area of interest and responsibility. An alternative strategy might be for this detailed information to be included in the database of TOS terrain file. The storage of this information would allow ready access to the necessary level of detail required to assess cover.

There is an additional dimension of battle cover which requires consideration. This dimension involves the line of sight potential of an area providing cover. From a tactical standpoint it is essential for a tank in a hull-down position to have sufficient line of sight to fire its weaponry. The primary interference with line of sight is vegetation. Unfortunately, the exact vegetation height which will interfere with the firing of a weapon will depend on the contour of the area. For example, the line of sight of a tank situated just below the crest of a hill could be hindered from firing by 1-meter-height vegetation on the top of the hill. This same vegetation would not interfere with the line of sight if located further down the hill. Thus, specifying a given vegetation height as interference to line of sight might be misleading, and in some cases, inaccurate.

Currently, standard topographic maps do not provide direct vegetation height information. Some indication of heights may be derived from the vegetation classifications on the standard maps. For example, woods, in most cases, are taller than scrub vegetation. However, this information is lacking in specificity and might be misleading or inaccurate. Thus, an accurate analysis of vegetation heights must rely on other sources, such as field observation and interpretation of aerial reconnaissance photographs to ascertain the necessary information.

The comprehensiveness of the analysis of cover adequacy will depend primarily upon the time and resources available to the analyst. When time or resources are limited, the analyst may have to make his "best guess" about the cover adequacy; however, when time and resources are available, an accurate, comprehensive study is feasible.

3.6.5 Summary

Table 3-4 provides a summary of the information requirements for the task covered in Exhibit A.

TABLE 3-4

INFORMATION REQUIREMENTS FOR G-2/DIV/AVENUES OF APPROACH

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
A1.1	Bare slopes which are impassable to enemy tracked vehicles.	*Slopes greater than 50%* (maximum slope ascending capability of Soviet T62*, FM 23-3).	Contour intervals and elevation notations from which slope may be calculated are provided.
		Slopes greater than 62% (maximum slope ascending capability of Soviet BMP, FM 23-3).	
		Slopes greater than 45% (NO GO slope category, IPB).	Slope in excess of 45% is defined as the NO GO category for a slope overlay in the IPB draft report. This obstacle definition is not consistent with the maximum slope ascending capability of either the Soviet battle tank or the armored personnel carrier. The IPB report is unclear as to whether this obstacle definition is to apply to bare or vegetated slopes.

*The maximum slope ascending capability of the Soviet T70 is unavailable at this time; when this information becomes available the minimum level of detail requirements should reflect this vehicle as well as the T62 and BMP.

TABLE 3-4 (CONTINUED)

INFORMATION REQUIREMENTS FOR G-2/DIV/AVENUES OF APPROACH

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
A1.1	Vegetated slopes which are impassable to enemy tracked vehicles.	*Slopes equal to or greater than 32%, which contain closely spaced trees of .14 meters trunk diameters* (The vegetation itself is not an obstacle). (Maggart, 1978).	Sufficient detail to identify vegetation as an obstacle is not provided.
A1.2	Soil which will not support tracked vehicle movement.	*Soil Rating Cone Index (RCI)* (FM 30-10).	RCI information is difficult to obtain due to time and resource limitations and, as a result, is often omitted from terrain analysis.
		Vehicle Cone Index (VCI) requirements: Soviet T62 49 Soviet BMP 40 (FM 23-3; FM 30-10).	The VCI for specific vehicles is found in technical intelligence files. The portrayal of this information could present some difficulties, since there is a VCI rating for each vehicle.
		Climatic conditions which may alter soil evaluation (e.g., ice, snow, rain) (FM 30-10).	The graphic portrayal of up-to-date weather information may not be feasible due to inherent variability in climatic conditions. The portrayal of general weather conditions on soil trafficability might be possible and certainly useful.

TABLE 3-4 (CONTINUED)

INFORMATION REQUIREMENTS FOR G-2/DIV/AVENUES OF APPROACH

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
A1.3	Vegetation areas which stop movement of enemy tanks.	*Tree trunk diameters greater than .22 meters* (IPB; (Maggart, 1978) *Tree spacing of less than 6.1 meters* (IPB; Maggart, 1978).	The identification of wooded areas is possible with conventional maps. However, when considering the movement of tanks, knowledge of the location of woods does not indicate whether or not a tank can move through the area. Trees with trunk diameters of less than .22 meters can be toppled by tanks, thus are not considered obstacles to tank movement.
A1.4	Rivers which require the installation of special equipment for crossing (i.e., snorkel outfit).	*Rivers greater than 1.4 meters in depth* (FM 23-3).	Currently, conventional maps specify only river locations and the direction of the water flow. Some maps also contain notations of potential fording sites but do not specify the vehicle which may cross there.
A1.4	Rivers which require bridging to cross.	*River widths in excess of 5.5 meters* (FM 23-3). *Vertical river banks greater than 1.2 meters in height* (FM 23-3).	Determination of river obstacles to enemy movement requires the consultation of other sources of information.

TABLE 3-4 (CONTINUED)

INFORMATION REQUIREMENTS FOR G-2/DIV/AVENUES OF APPROACH

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
A1.5	Built-up areas.	Built-up areas equal to or greater than 1 sq. km in area (MOUT, draft). Two or more built-up areas (less than 1 sq. km in area) less than 1 km apart (MOUT, draft).	Standard 1:50,000 scale maps provide detail of all built-up areas regardless of size. This level of detail may exceed minimum information requirements. Standard 1:250,000 scale maps provide outlines of built-up areas as well as isolated farms. This level of detail seems adequate for task completion.
A2.1	Zones of action: Area of responsibility of a specific tactical unit.		
	Battalion	*2 to 3 km frontage* (Maggart, 1978).	Standard topographic maps do not provide direct information about widths of potential approach routes. However, an obstacle to movement analysis is a necessary prerequisite to the graphic portrayal of this information. In addition, the required level of detail varies as a function of enemy force size. Hence, the portrayal of this information would necessitate numerous maps to reflect the various enemy force sizes.
	Regiment	*5 to 8 km frontage* (Maggart, 1978).	

TABLE 3-4 (CONTINUED)

INFORMATION REQUIREMENTS FOR G-2/DIV/AVENUES OF APPROACH

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
A2.2	Breakthrough attack: Concentration of the largest force into the smallest area.		Standard topographic maps do not provide direct information about widths of potential approach routes. However, an obstacle to movement analysis is a necessary prerequisite to the graphic portrayal of this information. In addition, the required level of detail varies as a function of enemy force size. Hence, the portrayal of this information would necessitate numerous maps to reflect the various enemy force sizes.
	Battalion	*1 to 1.5 km frontage* (Maggart, 1978).	
	Regiment	*2 to 4 km frontage* (Maggart, 1978).	
A3.1	Concealment: Terrain which prevents enemy from being seen.	*Vegetation greater than 3.7 meters in height* (FM 23-3)	The vegetation classifications provided on standard maps offer some indication of concealment potential; however, they lack the specificity required for an accurate assessment
		Climatic conditions conducive to concealment (e.g., dense fog, snow drifts) (IPB).	Because of the inherent variability of weather, portrayal of this information may not be feasible.

TABLE 3-4 (CONTINUED)

INFORMATION REQUIREMENTS FOR G-2/DIV/AVENUES OF APPROACH

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
A3.2	Cover: Terrain which allows a tank to be in a hull-down position with adequate line of sight.	*Contour deviations of 1 meter* (FM 23-3).	1:50,000 scale maps contain 10 meter contour intervals. 1:250,000 scale maps contain 50 meter contour intervals. Neither of these scales satisfies minimum level of detail requirements. Portrayal of 1 meter contour intervals would necessitate a change in map scale if the portrayal were to be legible. This would require, however, numerous additional maps to display a division area of interest. Detailed information of this nature might be a candidate for inclusion in a TOS terrain data file.
		Vegetation heights which interfere with line of sight (specific heights are dependent upon the contour of the area) (IPB).	An indication of height may be derived from the vegetation classification provided on a standard map. This information, however, lacks the specificity required for an accurate evaluation.

3.7 Exhibit B

USER: TACTICAL OPERATIONS CENTER (TOC) G-4

ECHELON: CORPS

TASK: DETERMINE MAIN SUPPLY ROUTE (MSR)

PROBLEM STATEMENT:

> *"I'm not sure if this road will hold up under the traffic I intend to put on it."*

3.7.1 Background.

The effectiveness of a combat force is largely dependent upon its combat service support. Since weapons systems and their crews must be maintained and supported, even the most sophisticated weapon can be of no value without ammunition. The role of combat service support is to arm, fuel and fix the weapon systems, and to sustain the crew. Thus, the role of combat service support is critical to success on the battlefield.

A detailed analysis follows of the map-related tasks involved in the selection of a corps' main supply route (MSR). The two major subtasks involved in the completion of this task are:

(1) Identify possible supply routes.

(2) Locate potential ambush sites along the possible routes.

As shown in Table 3-5, each of these subtasks may be further divided into more basic questions.

TABLE 3-5

OVERVIEW OF QUESTION-BASED
TASK ANALYSIS FOR
EXHIBIT B

USER: TOC G-4

ECHELON: Corps

TASK: Determine main supply route (MSR)

SUBTASK:	MAP USE QUESTIONS:
B1 Identify possible supply routes	B1.1 *Which roads can be used by a supply convoy?*
	B1.2 *Which bridges can be used by the supply convoy?*
	B1.3 *Are there any river crossings which pose an obstacle to the convoy?*
B2 Locate potential ambush sites along possible routes.	B2.1 *Where are the areas along the routes where the convoy will be forced to slow down?*
	B2.2 *Where are the areas along the routes which are likely enemy ambush sites?*

3.7.2 Subtask B1: Identify Possible Supply Routes

Before selecting a supply route, the G-4 will first determine the location of units requiring supplies and the type of supplies needed. Generally, corps will supply the division support command (DISCOM). Frequently, however, corps will be required to deliver special throughput (bypassing DISCOM and directly servicing particular units). For example, corps may be required to supply attack helicopters directly. Once the G-4 has ascertained the needs and location of the units, the routes to these units must be determined.

Road Networks

An existing road network is generally a preferred supply route, since it is faster than cross-country routes. A basic requirement of any route selected is that it be able to support the heaviest vehicles which are likely to use it. Hence, the road must be able to support class 60 vehicles, due to the necessity for recovery of armored vehicles. This information is not provided on the standard topographic map. To ascertain this information, other sources such as local authorities or ground reconnaissance will have to be consulted.

The main supply route (MSR) will be a heavily travelled road with traffic frequently flowing in both directions. In addition, wide loads will often be carried on the MSR. Thus, the width of the road is an important consideration in route selection. Some conventional maps note road width by the number of lanes. Other maps indicate width categories (e.g., 4-6 meters, more than 6 meters). These classifications, however, lack the required specificity. For example, two-way traffic of tracked vehicles requires a road width of over 8 meters; neither method of portrayal provides this information. Thus, alternative sources such as reconnaissance must be consulted to ascertain road widths.

An additional consideration about the potential routes is their condition, because road condition relates to the impact of weather on trafficability. Currently, standard topographic maps provide road classifications such as all, fair and dry weather roads. This type of classification is frequently adequate for the task.

Bridges

When potential routes cross bridges, it is necessary to know certain types of information about them. Specifically, the load-bearing capacity of bridges must be such that it can support class 60 vehicles. Conventional maps do not indicate load-bearing capacity information. However, some maps do classify bridges based on their basic type of construction (e.g., wood, concrete, stone). This type of classification scheme may provide an indirect indication of the load-bearing capacity. However, an analysis based on this classification information might be misleading or inaccurate. To determine the load-bearing capacity, a reconnaissance of the bridge would be necessary.

In addition to load-bearing capacity, the completed analysis requires the width and overhead clearance of each bridge specified. Before a route is chosen, it is necessary to know that the convoy can "fit through a bridge." This information is not available from the standard topographic map. Hence, other sources, such as a bridge reconnaissance, must be conducted to ascertain this information.

Rivers/Streams

When a route being considered as the MSR crosses an unbridged river or stream, hydrographic information is required. Specifically, river depth, current speed and the slope of approach must be ascertained. Since trucks will be one of the prime users of the MSR, the hydrographic information should reflect their fording capabilities. The fordable river depth for trucks is .75 meters, and the maximum percent-of-slope for their approach is 33%. Additionally, the speed of the current may affect trafficability, and a complete analysis requires this information. The standard topographic map provides limited river and stream information; specifically, river and stream locations and direction of current flow are portrayed. To ascertain the required information, a reconnaissance will be conducted if time and resources are available.

3.7.3 Subtask B2: Locate Potential Ambush Sites Along Possible Routes

As previously noted, combat service support is a vital part of the battlefield, and the safety of its supply route is critical. Thus, when choosing a main supply route, careful consideration must be given to those areas along the route where an enemy ambush could occur. While ease of movement is a prime concern of the route, equally important is the fact that potential ambush sites should be minimized. In general, an ambush site will be selected at a point along the route where traffic is slowed and concealment of the enemy is possible. Thus, the analysis will consider both of these factors when locating potential ambush sites along the routes.

Gradient

The gradient of potential routes is an important consideration. A supply convoy traveling up a road gradient of more than 7% is forced to reduce speed, and as a convoy slows it becomes an easier target for an ambush. Thus, a complete analysis of possible supply routes must take into account the road gradients of the available routes. This information, however, is not available on the standard topographic map. Other sources, such as a route reconnaissance, will generally provide the necessary information.

Road Curves

The radii of curves along potential routes is another consideration of the supply route. A radii of curvature of less than 30 meters will cause a speed reduction by the convoy. Hence, a curve of this type presents the danger of a potential ambush site. Thus, when selecting a supply route the analysis requires the location of such curves along the possible routes. Again, this detailed information is not provided on the standard topographic map. Conducting a route reconnaissance, if possible, will provide the necessary level of information detail.

Narrowing of Road

The narrowing of a road can pose a problem to the supply convoy. Since the MSR will generally carry double flow traffic, a road narrowing to less than 8 meters is likely to cause a choke point. At such a point traffic will slow, thus making the convoy vulnerable to enemy ambush. The general classifications of roads on standard topographic maps (i.e., number of lanes; categories of widths) generally apply to the entire road, and the location of areas of road-narrowing is not provided. Thus, to ascertain the specific location of where a road narrows along a route requires that a route reconnaissance be conducted. Reconnaissance of this type can be carried out only if time and manpower are available.

Concealment

Concealment, in the context of this discussion, refers to an area near a route where the enemy could be hidden from the view of the convoy. The evaluation of concealment will usually be done simultaneously with the locating of traffic slowing-points. For example, if there is a heavily wooded area adjacent to an uphill grade of the route, this area would be identified as a potential ambush site. In general, vegetation greater than 3.7 meters in height along a road is likely to be a site of a potential enemy ambush. Standard topographic maps, while not providing specific vegetation height information, do provide useful classifications. Thus, a conventional map will show a wooded area and provide an indication of the concealment potential. The level of information detail, however, lacks the specificity required for a comprehensive and complete analysis. More specific information may be provided by aerial reconnaissance photographs and ground reconnaissance reports. As previously stated, reconnaissance requires both time and manpower which may or may not be available for the analysis.

3.7.4 Summary

Table 3-6 provides a summary of the information requirements for the task covered in Exhibit B.

TABLE 3-6

INFORMATION REQUIREMENTS FOR G-4/CORPS/MAIN SUPPLY ROUTE

QUESTION REFERENCE NUMBER	CATEGORY		MINIMUM LEVEL OF DETAIL	COMMENTS
B1.1	Road networks:			
		Classification	*All roads capable of supporting class 60 vehicles* (FM 5-36).	Road classification is required to identify roads capable of supporting supply convoy vehicles.
		Width	*Specified in meters* (FM 5-36).	The MSR will generally have two-way traffic and carry wide loads. Road widths are currently indicated on conventional maps by numbers of lanes or categories of widths (4-6 meters, more than 6 meters). However, neither method fulfills the necessary specificity required by this task.
		Condition	Weather impact on road trafficability (IPB).	Currently, this information is adequately portrayed.
B1.2	Bridges:			
		Load-bearing capacity	*All bridges capable of supporting class 60 vehicles* (FM 5-36).	Currently, standard topographic maps provide bridge classification information: stone, concrete, wood. This type of categorization, while providing an indication of bridge strength, is not specific. Bridges along the MSR must be capable of supporting the loads being carried.

TABLE 3-6 (CONTINUED)

INFORMATION REQUIREMENTS FOR G-4/CORPS/MAIN SUPPLY ROUTE

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
B1.2	Bridges:		
	Width	*Specified in meters* (FM 5-36).	Bridge widths and overhead clearances are required to determine if the MSR convoy can "fit" through the bridge. This determination is not possible from conventional map since the information portrayed is limited to the location and construction type of the bridge.
	Overhead clearance	*Height specified in meters* (FM 5-36).	
B1.3	Rivers/streams:		
	Depth	*Depths greater than .75 meters* (FM 5-36).	Conventional maps currently provide limited information about rivers. River and stream locations and the direction of current flow are portrayed. Some maps provide the location of potential fording sites, but it is not specified for what type of vehicles this information is intended. There are different fording capabilities among vehicles; for example, a tank can cross a river which is 1.4 meters deep, but a truck cannot. Thus, fording sites should reflect specific vehicle limitations (if possible).
	Current speed	*Specified in meters-per-second* (FM 5-36).	
	Slope of approach	*Slopes greater than 33%* (FM 5-36).	

TABLE 3-6 (CONTINUED)

INFORMATION REQUIREMENTS FOR G-4/CORPS/MAIN SUPPLY ROUTE

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
B2.1	Road Gradients	*Gradients greater than 7%* (FM 5-36).	Generally, this type of information would be available from a route reconnaissance report. This information is necessary to determine slowing points of route which make the convoy vulnerable to ambush.
B2.1	Road curves	*Radii of curvature of less than 30 meters* (FM 5-36).	
B2.1	Narrowing of road	*Areas of road that narrow to less than 8 meters* (FM 5-36).	Two general classifications of road widths, number of lanes and categories of widths, usually apply to the entire road and areas of narrowing, and these classifications are not denoted on conventional maps. This information would be obtained from a reconnaissance report. This information must be determined, since road narrowing will cause the convoy to reduce speed.
B2.2	Concealment	*Vegetation equal to or greater than 3.7 meters in height* (FM 5-36).	General classifications of vegetation (e.g., woods, scrub) provide an indication of height. This portrayal method lacks the specificity required for a complete and accurate assessment of the concealment potential area along the MSR.

3.8 Exhibit C

USER: AVIATION OFFICER OR S-3 AIR

ECHELON: BRIGADE

TASK: SELECT A ONE-SHIP HELICOPTER LANDING ZONE

PROBLEM STATEMENT:

"I can't tell if I can safely land a helicopter here."

3.8.1 Background

A basic fact of today's battlefield is that the helicopter has become an indispensible part of our ability to travel rapidly and efficiently. It is the messenger of the modern battlefield as well as the light logistics vehicle for inter-headquarter use. Therefore, selection of landing zones for a command post (CP) or a headquarters is an important task. For the brigade, the selection of landing zones within the rear area for use of command and liaison rotary wing aircraft is usually done by the unit's Aviation Officer, who is often double-hatted as the unit's Aviation Unit Commander. In those cases where there is no organic or attached aviation unit, then this function is carried out by the unit's S-3 Air Officer.

Regardless of the individual conducting the analysis (and his type or echelon, for that matter), the considerations and information requirements are the same because the requirements of rotary wing aircraft are rather specific in their surface and size needs for takeoff and landing. The general description of this task is to select a landing zone to be used by the unit's command and control aircraft and to be used by those aircraft servicing brigade headquarters. Additionally, other personnel, not assigned to the unit, may have occasion to land and take off from the helicopter pad.

An analysis and discussion follows of the procedures and considerations of the selection of some or all of the one-ship landing zones used in a non-aviation unit of brigade size. The major subtasks in the selection of such landing zones are:

(1) Identify surface conditions adequate for landing zones.
(2) Identify landing zones which are of adequate size.

As displayed in Table 3-7, each of these subtasks can be further subdivided into still more fundamental map use questions.

3.8.2 Subtask C1: Identify Surface Conditions Adequate for Landing Zone

The area under consideration as a possible landing zone must be free of existing obstacles which would prevent takeoffs and landings. It must also be free of debris which would be picked up by the wash of the rotors and become a dangerous missile. Additionally, slope must be considered as an obstacle to landing, since excessive slopes can cause the craft to tile and even up-end. One additional consideration must be that the surface be strong enough to support the craft.

Obstacles Unsuitable for Helicopter Landings

A helicopter landing zone must be free of debris which can become dangerous to personnel as well as the aircraft itself. When debris strikes the aircraft or is taken into the engine compartment it results in what is called "FOD" or foreign object damage. The surface should be free of

TABLE 3-7

OVERVIEW OF QUESTION-BASED
TASK ANALYSIS OF
EXHIBIT C

USER: Aviation Officer or S-3 Air

ECHELON: Brigade

TASK: Select a one-ship helicopter landing zone:

SUBTASKS:	MAP USE QUESTIONS:
C1 Identify surface conditions adequate for landing zones.	C1.1 *Are there areas containing debris which pose an obstacle to helicopter landings?*
	C1.2 *Are there any slopes which would be an obstacle to helicopter landings?*
	C1.3 *Are there areas where the soil will not support the weight of the helicopter?*
C2 Identify landing zones which are of adequate size.	C2.1 *Are there obstacles to turning rotor blades?*
	C2.2 *Is there enough area for separate takeoff and landing paths?*

obstructions such as large rocks, logs, tall grass, ditches, fences, telephone or power poles and telephone or power lines. Thus, to accurately identify obstructions requires the location of ditches greater than 3 meters in width and 2 meters in depth as well as areas containing a predominace of rocks or grass heights in excess of 1.5 meters.

The level of information detail notes above is not normally found on standard topographic maps. However, there is a likelihood of finding some map entry which would indicate the presence of telephone/power poles and lines. Although this information may indicate the presence of such poles and lines, it does not give the exact locations of each of the poles. Standard topographic maps also note the presence of masonry walls or fences yet not portray their specific location. Hence, the analysis of the terrain must look to sources other than the standard topographic map for the detailed information required. This information could be obtained by a visual reconnaissance of the area under consideration. Other sources of the information include aerial photographs and sketches made by a reconnaissance patrol.

Slope as as Obstacle to Helicopters

The area under consideration for use as a possible landing zone must not have a slope which exceeds 15%. The slope restrictions extend along the entire length of the glide path for the landing approach and along the route used for takeoff (if they are different). Usually, these two flight corridors are different, since the preferred method of both take-off and landing is into the wind.

The individual selecting such landing zones must have a map which allows him to calculate the slope from the horizontal distance given to scale compared to the vertical deviation indicated by actual elevations given in contour intervals. A topographic map which gives the reader contour lines and elevation notation allows the calculation of slope along the landing and takeoff corridors.

Surface Conditions Which Will Not Support Helicopters

Changeable surface conditions are a primary consideration in the selection of a landing site. If flooding conditions adversely affect the otherwise acceptable surface, then that area must be dismissed as a candidate site. A helicopter needs surface conditions which are sufficient to support the weight of the helicopters which will use the landing zone. Standard topographic maps provide only surface data on gross categories. Examples are intermittent streams which fill or flood their banks during a wet season or swampy areas which remain that way year-round.

As with other characteristics, the standard topographic map is insufficient in the detail afforded the user who is trying to determine specific load-bearing data for aircraft. Other sources would have to be consulted, or visual reconnaissance would have to be conducted to determine the bearing capacity of the soil under consideration.

3.8.3 Subtask C2: Identify Landing Zones Which Are of Adequate Size

Assuming that the analyst has adequate knowledge of the characteristics of the aircraft he anticipates using, he must then determine if there is sufficient rotor blade clearance at the landing zone. Normally-used command and control helicopters require about the same clearance for rotors and share approximately the same requirements in other dimensions of landing zone characteristics. The general characteristic of uninterrupted rotor blade clearance throughout landing, touchdown and takeoff is the first consideration of the analyst. If this characteristic is not present or cannot be cleared by troop effort or demolition, then the landing zone will not be adequate.

Obstacles to Turning Rotor Blades

An area of 52 meters in diameter, cleared to the ground, is the standard clearance for the safe landing, touchdown, loading/unloading and takeoff of utility and reconnaissance helicopters. To determine this information the analyst requires detailed data concerning both the height and type of vegetation in the area. The rationale for the latter information is simply to determine if the area can be cleared by hand. Thus, the current classifications provided, such as woods, is totally insufficient for this determination. For example, teak tree trunks may only be a meter in height but cannot be cleared by hand. Conventional maps do not contain vegetation height information, except indirect evidence provided by the vegetation classification previously mentioned. To determine the obstacles to turning rotor blades, therefore, the analysis requires both vegetation heights specified in 1-meter increments, as well as a vegetation classification which will provide an indication of the hand-clearing capability of the area.

An area of 20 meters and cleared to within .9 meters of the ground is required beyond the 52 meters as an additional apron for the unobscured approach to the touchdown and takeoff points. The same problem described above is encountered when an analyst tries to determine this information from a standard topographic map. To acquire this information the analyst must seek sources other than the standard topographic map, such as aerial photographs and visual reconnaissance of the area.

Separate Takeoff and Landing Paths

Takeoff and landing paths are those flight routes used by a helicopter. For safety reasons, it is preferrable to have separate takeoff and landing paths for the crafts. The paths selected should be of a width of 76 meters to allow for the safe approach and departure of rotary wing aircraft. Paths of less than 76 meters in width present a clear danger to the aircraft and its crew and cargo. Additionally, these paths must have a ground vegetation structure permitting at least a 1 to 5 climb ratio, (meaning at least 5m horizontal clearance for each 1m of vertical lift).

Determining the path widths available from a standard topographic map presents problems similar to those mentioned previously; thorough analysis requires both vegetation heights and the type of vegetation. Currently, standard topographic maps do not provide the information detail required to make this determination. While the slope of an area can be determined from the contour intervals and elevation notations on the standard topographic map, vegetation height will alter this assessment of climb ratio. Since vegetation height information is not provided by conventional maps, a complete analysis requires that other sources be consulted. Thus, once more, aerial photographs and visual reconnaissance are needed to complete an accurate assessment.

3.8.4 Summary

Table 3-8 provides a summary of the information requirements for the task covered in Exhibit C.

TABLE 3-8

INFORMATION REQUIREMENTS FOR S-3 AIR/BDE/HELICOPTER LANDING ZONE

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
C1.1	Obstacles unsuitable for helicopter landings.	*Ditches greater than 3 meters in width and 2 meters in depth* (FM 31-20, FM 100-20).	Ditches of unspecified size are provided on some maps. Determination of a ditch as an obstacle to helicopter landings requires the location of ditches exceeding a specific size. Thus, sources other than a map must be consulted.
		Grass heights in excess of 1.5 meters (FM 31-20, FM 100-20).	The general vegetation classification portrayed on standard maps may provide an indication of height, but it lacks the specificity required for obstacle determination.
		Areas containing a predominance of rocks (FM 31-20, FM 100-20).	While the location of stone quarries are noted on standard maps, this task requires information on any area which contains a predominance of rocks. Hence, the required information to determine obstacles for helicopter landings is not provided.
		Fences on any type of construction (FM 31-20, FM 100-20).	Some maps provide notation of presence of masonry walls or fences. However, for an accurate determination of landing zone obstacles requires knowledge of exact locations of all fences (construction type is not important for this task).

TABLE 3-8 (CONTINUED)

INFORMATION REQUIREMENTS FOR S-3 AIR/BDE/HELICOPTER LANDING ZONE

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
C1.1	Obstacles unsuitable for helicopter landings.	*Telephone poles and lines; power poles and lines* (FM 31-20, FM 100-20).	Presence of telephone and power lines and poles are generally provided on maps. However, this information is insufficient for determining obstacles to landings. An accurate assessment of this task requires the specification of each pole and line location.
C1.2	Slope as an obstacle to helicopter landings.	*Slopes in excess of 15%* (FM 31-20).	The information required to calculate slope, namely, contour intervals and elevation notation, are provided.
C1.3	Soil which will not support helicopters.	*Load-bearing capacity of soil* (e.g., capable of supporting skids of UH-1) (FM 101-5).	The load-bearing capacity of soil is generally derived from direct field testing. Once this information is ascertained, it would have to be compared to the soil-bearing capacity required for the specific helicopter(s) which would be using the landing site.

TABLE 3-8 (CONTINUED)

INFORMATION REQUIREMENTS FOR S-3 AIR/BDE/HELICOPTER LANDING ZONE

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
C2.1	Obstacles to turning rotor blades.	*Vegetation heights in 1 meter increments* (FM 31-20). *Specific type of vegetation* (or vegetation categorized on the basis of clearability) (FM 31-20).	This information is vital to the determination of helicopter landings. For safety reasons, it is necessary to have an area 52 m in diameter cleared to the ground, circumscribed by a 20 m area cleared to .9 m above the ground.
C2.2	Area for separate takeoff and landing paths.	*Vegetation heights in 1 meter increments* (FM 31-20). *Specific type of vegetation* (or vegetation categorized on the basis of clearability) (FM 31-20).	This information is required to ascertain the safety for the approach and departure of helicopters. Specifically, a path 76 m in width must be clearable.
		Slope of entire path (FM 31-20).	Helicopter takeoff requires a 1-to-5 climb ratio. Thus, the interaction between slope and vegetation height must be assessed. Contour intervals and elevation notation allow slope determination. In the absence of specific vegetation height information, an assessment cannot be made concerning the path's acceptability for takeoffs and landings.

3.9 Exhibit D

USER: OPERATIONS SECTION

ECHELON: DIVISION

TASK: DETERMINE PRIMARY AND ALTERNATE LOCATIONS FOR DIVISION TACTICAL OPERATIONS CENTER (DTOC)

PROBLEM STATEMENT:

"I don't know if I can conceal the division TOC in this area."

3.9.1 Background

Division Tactical Operations Center (DTOC) is the centralized area which controls and coordinates the tactical operations of the division. The primary responsibility of DTOC is to direct, control and coordinate combat and combat support operations. These centers are vital to the command and control of the battlefield.

Before the G-3 looks at a map to begin evaluating likely DTOC locations there are certain restrictions which will dictate some of the parameters required for the site. First, DTOC must be relatively close to the division's lines of communications. Also, the physical size of the site required will be dependent upon the number of troops requiring communication with the center. A vital consideration is the scheme of maneuver and fire support. While DTOC must be forward enough to communicate with the troops, it should not be in the middle of the battlefield. Thus, when the G-3 looks at a topographic map to determine possible DTOC sites he will eliminate some areas due to the constraints stated above.

As will become apparent to the reader, this task has relatively few information requirements compared to other tasks presented; in fact, it consists of only one subtask which is identical to the main task. The decision to include the task is based primarily on the fact that this is a vital, representative and frequently performed battlefield task. Additionally, while this task focuses upon the division echelon, the information requirements do not differ for corps TOC or battalion TAC CP site selections. The primary difference among echelons is the actual physical size of the area required. Thus, it should be apparent that the site-selection for the DTOC represents a task which is repeatedly performed by operations sections from corps to battalion. A detailed analysis follows of the map-related procedures involved in the selection of possible locations of a DTOC. The one subtask involved, as depicted in Table 3-9, can be further subdivided into its basic map use questions.

3.9.2 Subtask D1: Determine Potential Locations for DTOC

Because of vital control and coordination functions performed by DTOC, it is imperative that the center be able to perform its duties. The G-3 must consider the security potential of the sites, in terms of natural cover and concealment from air observation. Also, the G-3 must avoid areas which contain obstacles to electronic emissions and areas where the soil will not support DTOC activities.

Gross Surface Configurations

The analysis of gross surface configuration of an area is a primary concern for two reasons; availability of natural cover, and the absence of natural obstacles to electronic emissions. Unfortunately, these land features are frequently at odds with each other. For example, high ground may provide

TABLE 3- 9

OVERVIEW OF QUESTION-BASED
TASK ANALYSIS FOR
EXHIBIT D

USER: Operations Section

ECHELON: Division

TASK: Determine primary and secondary locations for the Division Tactical Operating Center (DTOC)

SUBTASK:	MAP USE QUESTIONS:
D1 Determine primary and alternate locations for DTOC	D1.1 *In general, what does the surface of the area look like ?*
	D1.2 *Are there areas of soil which will not support DTOC activity?*
	D1.3 *Are there areas that provide concealment from enemy air observation?*

cover for DTOC, however, it may hinder transmission and reception of communications. Specific heights which hinder electronic communication will not be delineated here, since documents specifying electronic warfare capabilities are classified. However, the primary consideration of the analyst for this task is areas of high ground. For this information, the standard topographic map seems adequate. Contour lines and elevation notations provide a sufficient picture of the gross surface configuration of the areas evaluated for this task.

Soil Supportability

The evaluation of possible DTOC sites requires considerations about the type of soil in the area. It is necessary that the site be able to support the traffic associated with the DTOC. Thus, the evaluation will require the determination of the vehicle cone index for the largest vehicles which will be in the DTOC area. This information may be found in TOE files.

Once the required vehicle cone index has been determined, the analysis requires the soil rating cone index of each potential site. A comparison of the vehicle cone index and the soil rating cone index will determine which of the possible sites will support the heaviest vehicles of the DTOC. To ascertain the rating cone index of soil, the results of actual field tests are required. Since this information is not provided on the standard topographic map, completion of the analysis requires that other sources be consulted. For example, the necessary information might be provided by local authorities or members of the Engineer Topographic Battalion. If the information is unavailable from these sources, however, a ground reconnaissance of the area would be necessary.

An additional consideration involves the impact of climatic conditions upon the supportability of the soil. For example, heavy rains could alter supportable soil to unsupportable condition. Standard topographic maps do not provide weather-related information. While up-to-date weather information does not easily lend itself to hard copy map portrayal, soil trafficability under general weather conditions might be feasible. Portrayal of this information would be useful to the analysis of potential DTOC site locations.

Concealment from Air Observation

Concealment from air observation is a very important consideration of potential DTOC locations. Since DTOC is a priority target of the enemy, it is vital that the location be as concealed as possible. Extensive use is made of camouflage at DTOC; however, in addition, natural concealment is desirable. Canopy closure is the primary characteristic of terrain which concerns the probability of detection from the air. An area providing at least 50% canopy closure would be a desirable location for DTOC. Canopy closure can provide concealment for electronic devices such as antennas, as well as concealment for vehicles and personnel. Wooded areas are prime locations of canopy closure.

The analysis of areas providing concealment from air observation requires the determination of specific types of information. Once the location of a wooded area is ascertained, a determination of the spacing of the trees, their height and seasonality must be considered. Specifically, it must be determined if the spacing of the trees is greater than 6.1 meters, since this will provide less than 50% canopy closure. In addition, an estimate of the tree heights in meters and the seasonality must be determined. The seasonality--whether the growth is evergreen or deciduous--is important, since the canopy closure of a deciduous forest, for example, will be affected by the time of year. Once spacing, height and seasonality are ascertained, an estimate of the percent of canopy closure afforded by an area may be estimated.

The standard topographic map does not provide direct concealment or canopy closure information. The vegetation classifications available on conventional maps allow identification of wooded locations; however, specificity concerning tree spacing and heights is not provided. Other sources of information, such as reconnaissance reports, must be consulted to determine this information. Some standard topographic maps do, however, provide notations of the seasonality aspects of vegetation, and these appear sufficient for this aspect of the task.

3.9.3 Summary

Table 3-10 provides a summary of the information requirements for the task covered in Exhibit D.

TABLE 3-10

INFORMATION REQUIREMENTS FOR G-3/DIV/DTOC LOCATION

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
D1.1	Gross surface configuration	Contour intervals of 10 meters with supplementary intervals of 5 meters (FM 24-1).	Currently available on 1:50,000 scale standard topographic map.
D1.2	Soil supportability	*Soil Rating Cone Index* (RCI) (FM 30-10).	Consultation with other sources is required to determine whether soil will support the DTOC operation. This information is generally difficult to obtain, and frequently requires direct reconnaissance observation when time and resources are available.
		Vehicle Cone Index (VCI) *Requirements:* Foot soldiers 20 (FM 30-10)	The VCI for specific vehicles, personnel and equipment may be found in Tables of Organization and Equipment (TOE). Portrayal of this information on a standard topographic map may present difficulties, since there is a VCI for each vehicle.
		Climatic impact on soil supportability (IPB).	While the portrayal of up-to-date weather information does not appear feasible, the portrayal of general weather conditions on soil trafficability might be possible and certainly useful.

TABLE 3-10 (CONTINUED)

INFORMATION REQUIREMENTS FOR G-3/DIV/DTOC LOCATION

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
D1.3	Concealment from air observation: Canopy closure	*Tree spacing of less than 6.1 meters* (FM5-36, IPB).	Vegetation classifications allow the identification of wooded areas.
		Tree height estimates in meters (FM5-36, IPB).	Consultation with other sources, such as ground reconnaissance, is required to determine the vegetation height information.
		Seasonality (IPB).	Sufficient detail is provided on 1:50,000 scale maps.

3.10 Exhibit E

USER: CAV SQUADRON

ECHELON: BATTALION

TASK: PLAN ROUTE FOR A RECONNAISSANCE MISSION OF POSSIBLE DIVISION TACTICAL OPERATION CENTER (DTOC) LOCATIONS

PROBLEM STATEMENT:

> *"I can't tell where I should move my Sheridan so it would not be seen by the enemy."*

3.10.1 Background

Reconnaissance is a constant activity of both friendly and enemy forces of the battlefield. As such, reconnaissance is one of the most critical tasks performed on the battlefield. The objectives of the reconnaissance missions are to obtain information about enemy activities and terrain, as well as to verify and update information portrayed on a standard topographic map. Additionally, a "recon" provides various user groups with the detailed information they require and cannot obtain from the standard topographic maps. For example, when the intelligence section requires vegetation obstacle information (as in the assessing avenues of approach) a reconnaissance of the area will be ordered. Thus, the individuals in the field will report those areas where the vegetation constitutes an obstacle to movement.

Ground reconnaissance missions are of three types: route, zone and area. Route reconnaissance attempts to gain information concerning the enemy, obstacles, route conditions and critical terrain features along the route. This type of reconnaissance, due to its techniques and requirements, can be performed more quickly for the same size area than for other types of reconnaissance. The objectives of zone reconnaissance are to obtain detailed route information, as well as information concerning the enemy, obstacles and key terrain within a specified zone. Zone reconnaissance is more thorough and time-consuming than route reconnaissance. The third type of mission, area reconnaissance, is the most thorough and time-consuming of all. In addition to gathering route, obstacle and enemy information, area reconnaissance determines detailed terrain-related information, such as areas of cover and concealment. Area reconnaissance extends the information available from the standard topographic map and provides the users with the level of information detail they require to complete their tasks.

The selection of the type of reconnaissance mission which a task requires will directly affect the amount of information which will be gathered. While it would be ideal for a reconnaissance mission to gather all relevant information, this is not possible in every instance. Given sufficient time to conduct the mission and all the necessary manpower, an area reconnaissance of the entire area of interest would be the optimum solution. However, manpower is generally limited, as is the time in which to conduct the reconnaissance. These constraints will usually be noted in the reconnaissance order. Hence, the type of reconnaissance which will be used, while not stated directly in the mission statement, will be implied by the time available and the information requested.

A detailed analysis follows of the map-related tasks involved in conducting a reconnaissance mission. Completion of this task involves three major subtasks:

(1) Identify fastest routes to and from the objective (to be reconnoitered).
(2) Determine areas of likely enemy detection.
(3) Identify areas of adequate concealment.

As illustrated in Table 3-11, each of these subtasks can be further subdivided into its basic map use questions.

TABLE 3-11

OVERVIEW OF QUESTION-BASED
TASK ANALYSIS FOR
EXHIBIT E

USER: Cav Squadron

ECHELON: Battalion

TASK: Plan route for a reconnaissance mission of possible DTOC locations

SUBTASK:	MAP USE QUESTIONS:
E1 Identify fastest routes to reconnaissance sites	E1.1 *Which roads/trails can be used by reconnaissance vehicles?*
	E1.2 *Which bridges can be used by reconnaissance vehicles?*
E2 Determine areas of likely enemy detection	E2.1 *Where are areas of soil that will leave identifiable tracks if crossed by reconnaissance vehicles?*
	E2.2 *Where are the built-up areas?*
E3 Identify concealment potential of routes	E3.1 *Are there areas of concealment from enemy observation?*

3.10.2 Subtask D1: Identify Fastest Route to Reconnaissance Sites

Since repeated traveling over the same route increases the likelihood of detection, a general consideration of reconnaissance route planning is to avoid taking the same route in and out of the reconnaissance sites. Thus, the planner will be looking for alternate fast routes to and from the objectives. Prior to identifying routes to the objective sites, however, the analyst must ascertain the location and recent activities of the enemy. A review of intelligence reports and the current situation map is necessary to determine the likelihood of contact with the enemy during the mission. Once this information has been determined, the analyst will proceed to evaluate the possible routes.

Roads/Trails

Generally, existing roads and trails will be the fastest route available to the reconnaissance patrol. However, when used they increase the vulnerability of the recon party. Roads and trails classifications, widths and conditions are the primary concerns of the analysis. Portrayal of the widths of roads and trails, as well as their capability to support class 20 vehicles, will tell the analyst if his vehicles can travel on that road or trail. The standard topographic map does not provide direct information about road classification. Some information is, however, available on conventional maps about road widths. Certain maps provide road width information in terms of the number of lanes, while others provide general category widths (e.g., 4-6 meters, 6 meters or more). These maps, while helpful, do not provide the user with adequate specificity. Thus, the user is required to ascertain this information while conducting the patrol. Road condition, as affected by local weather on the other hand, is generally provided on the standard topographic map. Categories such as all-weather road and fair-weather road are usually provided. While this information is available about roads, it is not provided for trails. Thus, actual field observation is required to ascertain this information.

Bridges

When roads and trails within the area cross bridges, the analyst must be concerned with bridge load-bearing capacity. This type of information, however, is not available on the standard topographic map. Some standard topographic maps provide a bridge classification which is based upon the construction material of the bridge. While this type of information may provide an indication of the weight the bridge will support, it is not specific. Hence, an assessment based upon this type of classification could be misleading or in error; thus, the user might be required to ascertain this information while actually on the patrol.

3.10.3 Subtask D2: Determine Areas of Likely Enemy Detection

As previously discussed, the DTOC is the command, control and communication center of the division. This center is the primary target of the enemy, and as such its location must be unknown to him. Thus, while conducting reconnaissance of potential sites, it is important that the recon unit not be detected by the enemy. The reconnaissance route must be carefully planned to minimize detection by the enemy. In general, a reconnaissance route must avoid soil which will leave tracks, as well as avoid built-up areas.

Trackable Soil

One of the simplest ways a unit might be detected by the enemy is to travel over soil which leaves highly visible tracks. A vehicle traveling over plowed fields or soft soil would leave readily recognized tracks. The reconnaissance route must avoid these areas, but standard topographic maps provide little information about them. Conventional 1:50,000 scale maps do portray gardens and meadows, but more information is necessary for this task. Since the information required is not available prior to the reconnaissance, the user is forced to obtain the information during the actual execution of the recon mission.

Built-up Areas

When possible, a reconnaissance patrol should avoid traveling through a built-up area. Buildings can easily hide anti-tank weapons which could ambush and destroy the patrol. Thus, route planners must minimize the possibility of enemy ambush by avoiding built-up areas. Standard topographic maps provide the location of all built-up areas, and this level of detailed information portrayal seems quite adequate for the task.

3.10.4 Subtask D3: Identify Areas of Adequate Concealment

Adequate concealment will be of concern to the analyst if the route under consideration involves off-road movement. Generally, off-road travel is slower than on-road travel, and the chance of detection rises as movement slows. The final choice of routes will weigh the relative advantages of fast movement on available roads against the slower off-road concealed routes.

Concealment

Adequate concealment of a route offers the patrol protection from enemy observation. Vegetation greater than 3.7m in height will offer concealment for reconnaissance vehicles. However, the standard topographic map does not portray this information directly. The vegetation classifications provided on conventional maps (i.e., woods, scrub, vineyards, orchards) do offer a general indication of vegetation heights. These classifications could be misleading or erroneous, and thus appropriate concealment information must be determined by the patrol.

Various climatic conditions may also offer concealment for the patrol. Dense fog, for example, may provide adequate concealment for a moving unit. Conventional maps do not provide weather information, and the determination of historic, current and projected climatic conditions are generally provided by Air Force Weather.

3.10.5 Summary

Table 3-12 provides a summary of the information requirements for the task covered in Exhibit E.

TABLE 3-12

INFORMATION REQUIREMENTS FOR CAV SQUAD/BTN/RECONNAISSANCE ROUTE

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
E.1.1	Road/trails:		
	Classification	*All roads capable of supporting class 20 vehicles* (Fm 5-36).	Classification is required to determine which roads/trails are capable of supporting the recon vehicle movement.
	Width	*Specified in meters* (FM 5-36).	Generally, the method of portraying road width is to indicate the number of lanes. Some conventional maps do provide general width categories, such as 4-6 meters, and 6 meters wide or more. These methods of portrayal are too general and lacking in the specificity required to determine if the vehicle can "fit" on the road/trail.
	Condition	Weather impact on trafficability (IPB).	Classifications are provided for roads but not for trails on conventional maps. It would be useful to provide seasonal trafficability information about trails.

TABLE 3-12 (CONTINUED)

INFORMATION REQUIREMENTS FOR CAV SQUAD/BTN/RECONNAISSANCE ROUTE

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
E1.2	Bridges:		
	Load-bearing capacity	*All bridges capable of supporting class 20 vehicles* (FM 5-36).	Conventional maps contain classifications of bridges by their construction material. This information provides an indication about the weight which the bridge can support, but is not specific. Assessment requires the determination of bridges which are capable of supporting recon vehicle crossing.
E2.1	Trackable soil	*Locations of agricultural areas (plowed fields) and soft soil greater than .25 km in area* (FM 5-36).	Gardens and meadows are specified on 1:50,000 scale maps. However, these classifications are too limited to determine all areas of tracked soil which might lead to recon detection by enemy.
E2.2	Built-up areas	Location of all built-up areas (FM 5-36).	Sufficient detail is currently provided.
E3.1	Concealment	*Vegetation greater than 3.7 meters in height* (FM 23-3).	General classifications of vegetation may provide an indication of heights. However, precise assessment of heights cannot be made based on these classifications.

3.11 Exhibit F

USER: COMMANDER

ECHELON: COMPANY

TASK: PREPARE A COMPANY LEVEL DEFENSIVE FIRE PLAN AGAINST ENEMY ARMORED ATTACK

PROBLEM STATEMENT:

"I can't tell where to place my weapons so that they can be fired most effectively."

3.11.1 Background

The modern battlefield is characterized by fast-moving, highly lethal armored/mechanized/motorized weapons systems and vehicles. Thus, the task of preparing a company-level defensive fire plan against enemy armored attack represents one of the most critical of all planning tasks. It is this deliberate planning which is necessary to rapidly place the maximum fire on the enemy's main thrust and on its most lethal weapons systems.

Identification of the enemy's main thrust on the modern battlefield is the key to the successful defense. Effective, coordinate, understandable company-level fire plans depend upon the company commanders' and platoon leaders' ability to evaluate the terrain, understand the enemy's capability, determine the unit's capability and understand the mission.

The commander's assessment of the enemy's capability, his own unit's capability, and his understanding of the mission is a relatively simple matter by comparison to the evaluation of the terrain. It might be said that there is a direct relationship between the commander's ability to effectively evaluate the terrain and the amount of accurate data at his or her disposal.

Complete, usable, accurate terrain data is essential to this difficult, subjective analysis of the terrain. The level of detail needed and the degree of accuracy is greater at company level than at higher echelons.

At this critical level of tactical planning and execution the topographic map has habitually proven to be so inadequate that the small-unit leader has for decades resorted to field-expedient techniques to overcome these inadequacies. In preparing a fire plan, small-unit leaders have chosen to use sand tables, miniatures (mock ups), sketch maps, range cards and aerial photos (blown up). Just these few examples demonstrate the extremes to which a small-unit leader will go to obtain a more detailed picture for his or her planning. Unfortunately, most of these alternative representations lack grid coordinates, magnetic accuracy and standardization.

An in-depth analysis follows of the map-related procedures employed by a company commander when preparing a fire plan. The procedures involve two major subtasks:

(1) Conduct a map reconnaissance.
(2) Evaluate terrain information gathered from map reconnaissance.

As shown in Table 3-13, each subtask may be further subdivided into more basic map use questions.

3.11.2 Subtask F1: Conduct A Map Reconnaissance

A map reconnaissance is the procedure of studying a map to ascertain certain tactically-related features of the terrain. Of utmost concern in all aspects of conducting a map reconnaissance is the identification of likely armor approaches into the defensive unit's position, not only from the front, but from the flanks and the rear. A discussion concerning the task of identifying enemy avenues of approach has been presented earlier (Exhibit A). However,

TABLE 3-13

OVERVIEW OF QUESTION-BASED
TASK ANALYSIS OF
EXHIBIT F

USER: Commander

ECHELON: Company

TASK: Prepare a company level defensive fire plan against enemy armored attack

SUBTASK:	MAP USE QUESTIONS:
F1 Conduct a map reconnaissance	F1.1 *Where are the slopes which will pose an obstacle to enemy tracked vehicle movement?*
	F1.2 *Where are the ditches which enemy vehicles cannot cross?*
	F1.3 *Where are the vertical obstacles which enemy vehicles cannot climb?*
	F1.4 *Where are the fields of fire for friendly and enemy weapons?*
	F1.5 *Where are the areas of cover and concealment?*
*F2 Evaluate terrain information gathered from map reconnaissance	

*This subtask is not currently performed with a map, but is included for the sake of clarity and because it could be map-aided if an appropriate map product were made available.

identifying avenues of approach at the division level (see Exhibit A) has some key differences from the task at a company level. While the division G-2 may be concerned with the approach of a battalion or regiment, the company commander is primarily interested in single tank movement. Thus, the nature of the obstacles to movement, fields of fire and cover and concealment differ.

Obstacles to Enemy Armored Movement

One of the first obstacles to identify are slopes which enemy armor cannot ascend. Slopes in excess of 50% will be an obstacle to the Soviet T-62 tank. Slope information is not portrayed on the standard topographic map. The information required to calculate slope, namely contour intervals and elevation notations, is provided. Since the procedures necessary to calculate slope have been previously discussed (Exhibit A) further discussion of this procedure is omitted.

Additional obstacles to armored movement include wide ditches and vertical obstacles. Specifically, a ditch wider than 2.8 meters will be an obstacle to the Soviet T-62 and PT-76 tanks. Also, vertical obstacles in excess of 1.2 meters in height will stop the movement of Soviet T-62 and PT-76 tanks as well as BMP and BRDM personnel carriers. Identification of these obstacles is not possible on a standard topographic map. Though some 1:50,000 scale topographic maps note the location of ditches, there is no indication concerning the ditch width. Vertical obstacles are not indicated on conventional maps. Thus, the commander attempting to determine obstacles to enemy movement from a standard topographic map is restricted to determining slope obstacle information. Because of the inadequacy of the standard topographic map for the identification of other obstacles to movement, the commander must rely on other sources of information. For example, ground and aerial reconnaissance may provide the commander with the level of information detail required. The problem arises that these forms of reconnaissance require time and resources which may not always be available. Hence, if the commander must rely solely upon the standard topographic map to determine the obstacles to enemy movement, he will be able to identify slope obstacles only.

Friendly and Enemy Fields of Fire

Fields of fire are the areas a weapon (or group of weapons) can effectively cover from a given position. To determine fields of fire the minimum level of detail required is vegetation heights in .3 meter increments over distances up to 3000 meters. This type of detail, not available on the standard topographic map, would allow the assessment of potential crew served, ground mounted weapons firing positions. Some conventional maps do, however, offer general classification of vegetation: woods-brushwood, scrub, orchards and vineyards. While this classification scheme offers an indication of vegetation heights it is not of sufficient detail to specify fields of fire. Thus, an accurate determination of fields of fire from a standard topographic map is not possible. Again, the commander must utilize aerial or ground reconnaissance, if available, to locate the information required for the task.

Areas of Cover and Concealment

Areas of cover and concealment offer protection from the effects of fire as well as protection from observation. A depression deeper than 2.4 meters will conceal a Soviet T-62, while a depth of 1.8 meters will conceal the BRDM personnel carrier. Vegetation can also provide concealment. For example, vegetation a foot in height may conceal an infantryman in a prone firing position. The minimum level of detail required to portray cover and concealment would necessitate contour intervals of one meter and vegetation heights in one-foot increments. This level of information detail is not available on conventional maps. The problems inherent to the portrayal of 1 meter contour intervals has been previously discussed (Exhibit A). To briefly summarize the difficulties, legibility of 1 meter contour intervals would require a map scale of 1:10,000, and this would in turn require a vast quantity of maps to portray the modern battlefield. Thus, the problems which are likely to be involved in providing the necessary vegetation level of detail will have to be investigated by map makers.

3.11.3 Subtask F2: Conduct A Terrain Evaluation

The conduct of a terrain evaluation is essential to the sequential process of preparing a fire plan. While it is now rarely, if ever, a map-related task it could be if the maps provide the detail necessary for terrain evaluation. Sufficient detail would be defined as that information and level of detail discussed in the map reconnaissance subtask.

The conduct of a terrain evaluation is the subjective assessment of the advantages and disadvantages the terrain offers to the attacker as well as the defender. The commander's ability to conduct a complete and sound terrain evaluation is greatly dependent upon his assembled knowledge of the terrain. If his level of detail and/or accuracy is incomplete or erroneous then the utility of his terrain evaluation will suffer.

Assuming he has adequate information from his reconnaissance he will then subjectively evaluate the terrain from both the friendly and enemy point of view. The results of his terrain evaluation will enable the commander to determine the best positions for his organic weapons systems as well as the division of responsibilities for his subordinate maneuver units. He must make maximum use of the terrain in concert with his organic and supporting fires to prepare a tactically sound fire plan which complements his scheme of maneuver.

3.11.4 Summary

Table 3-14 provides a summary of the information requirements for the task covered in Exhibit F.

TABLE 3-14

INFORMATION REQUIREMENTS FOR COMMANDER/CO/DEFENSIVE FIRE PLAN

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
F1.1	Slopes which enemy vehicles cannot climb.	*Slopes in excess of 50%* (FM 23-3).	The elements necessary for calculating slope, namely contour intervals and elevation notations, are provided.
F1.2	Ditches enemy vehicles cannot cross.	*Ditches wider than 2.8 meters* (FM 23-3).	While ditch locations are generally provided, the widths of the ditches are not. Hence, the determination of a ditch as an obstacle to movement is not possible from standard maps.
F1.3	Vertical obstacles too high for enemy vehicles to climb.	*Vertical obstacles higher than .9 meters* (FM 23-3).	The determination of vertical obstacles to movement requires sources other than the map to be consulted.
F1.4	Fields of fire.	*Vegetation heights in .3 meter increments* (FM 100-5, FM 23-3).	Conventional maps contain general classification of vegetation (e.g., woods, scrub, etc.). While this categorization provides an indication of vegetation heights, it lacks the specificity required for the assessment of fields of fire.

TABLE 3-14 (CONTINUED)

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
F1.5	Cover and concealment	*Contour intervals of 1 meter* (FM 100-5, FM 23-3).	1:50,000 scale maps contain 10 meter contour intervals with supplementary intervals of 5 meters. 1:250,000 scale maps provide 50 meter intervals with 25 meter supplementary intervals. Neither of these scales satisfies the minimum level of detail, which in fact could not be legibly portrayed on a 1:50,000 scale map. While a 1:10,000 scale map might allow legibility, it would require numerous additional maps at the upper echelons. An alternative strategy might be to store this detailed information in a TOS terrain file so that it may be assessed when needed.
		Vegetation heights in .3 meter increments (Fm 100-5, FM 23-3).	General classifications of vegetation are provided on conventional maps. While this method may provide an indication of height, it lacks the detail necessary to assess concealment potential for fire plan.

3.12 Exhibit G

USER: G-1

ECHELON: CORPS

TASK: SELECT PRISONER OF WAR COLLECTION SITES

PROBLEM STATEMENT:

> *"I don't know enough about buildings to know if I can safeguard prisoners in there."*

3.12.1 Background

The task of selecting prisoner of war (POW) collection sites is significantly different from all the others discussed here in the fact that it is primarily concerned with the avoidance of combat, contact with enemy fire, and the pursuit of direct and decisive victory on the battlefield. Instead, it is concerned with the basic premises of care and disposition of enemy POWs and suspected prisoners of war. At all times the security and safety of POWs is the responsibility of the G-1, as the POWs can no longer defend themselves. It should be kept in mind that before the G-1 can accomplish this task he must: (1) understand the mission of the unit (in this case, corps); (2) obtain POW numerical estimate data; and (3) know the location of higher headquarters' collection point(s).

An analysis and discussion follows of the procedures and considerations involved in the selection of the POW collection sites within a corps defensive sector. The major subtasks in the selection of such collection points are:

(1) Identify lines of communication within the area of interest.
(2) Evaluate the possible collection points within the corps sector.

As illustrated in Table 3-15, each of these subtasks can be further subdivided into still more funuamental map use questions.

3.12.2 Subtask G1: Identify Lines of Communication Within the Area of Interest

This subtask involves the consideration of the existing roads over which prisoners can be transported in organic or locally available transportation. In the demand for, and level of, detail necessary to select the proper evacuation routes, this subtask is very similar to that of selecting a corps main supply route. The difference is that the POW evacuation route should not compete with the logistician for the same roads or trails, lest both functions suffer. Thus, the G-1 will eliminate roads dedicated to supply movement from the routes he will evaluate.

Road Networks

The primary requirement of the route selected is that it be able to support the heaviest vehicle which will use the road. Hence, the road classification required for this task should be capable of supporting class 50 vehicles, which would probably be the heaviest vehicle expected to use the route. Since this type of information is not available on the standard topographic map, the G-1 must take his "best guess" at the road classification if time and resources are not available for reconnaissance.

Since the movement along the selected route will be two-directional, road widths must be considered. Standard topographic maps provide road width indirectly by noting the number of lanes; other conventional maps, however, indicate road width categories (e.g., 4-6 meters, more than 6 meters). While these categorization schemes may be useful, they lack the specific information required for the task. A specification of road widths in precise number of meters is the preferred level of information required by this task.

TABLE 3-15

OVERVIEW OF QUESTION-BASED
TASK ANALYSIS FOR
EXHIBIT G

USER: G-1

ECHELON: Corps

TASK: Select POW collection sites

SUBTASK:	MAP USE QUESTIONS:
G1 Identify lines of communication	G1.1 *Which roads can be used to transport POWs?*
	G1.2 *Which bridges can be crossed during POW transport?*
	G1.3 *Where are the unbridged rivers/streams which are obstacles to crossing?*
G2 Evaluate possible collection sites	G2.1 *Which buildings can safely house POWs?*
	G2.2 *Where are the areas providing concealment?*

The final consideration necessary for route selection involves road trafficability. Road conditions (i.e., weather-related trafficability) is portrayed on standard topographic maps and the available classifications, such as fair-weather and all-weather roads, are generally sufficient for performing the task.

Bridges

Frequently the road networks under consideration contain bridges, thus necessitating an evaluation of these bridges. Three categories of bridge information must be considered: (1) load-bearing capacity; (2) width; and (3) overhead clearance. The load-bearing capacity relates to the ability of the bridge support capability, and for this task a bridge must be capable of supporting class 50 vehicles. Although bridge load-bearing capacity is not portrayed directly on conventional maps, an indication of the weight a bridge can support might be obtained from the basic construction type classification (e.g., wood, concrete) portrayed on the map. This information could, however, be inaccurate, but in the absence of a reconnaissance of the bridge, it is the only information available to the G-1.

Information concerning bridge widths and overhead clearances are unavailable on the standard topographic map. Whether the vehicles carrying the POWs can "fit" through the bridge cannot, therefore, be determined from a conventional map. Once more, in the absence of reconnaissance data for the area, this information will be unavailable to the G-1.

Rivers/Streams

If a route being considered involves a river or stream crossing, specific information about the area must be determined. Specifically, river depth, the speed of the current, and the slope of approach must be known. Generally, trucks will be used to transport POWs, thus, the fording capabilities of the truck must also be considered. A truck can ford a river depth of up to .75 meters, and a maximum slope of approach of 33%. Since the speed of the current will also affect trafficability, it should be included in the analysis. Standard topographic maps limit river/stream information to location and direction of current flow, but this level of information detail is insufficient to make an assessment of potential truck fording sites. Thus, without supplementary sources of information, the G-1 will not be able to adequately complete the assessment.

3.12.3 Subtask G2: Evaluate The Possible Collection Sites

As previously stated, the responsibility for the safety and protection of POWs rests with the captor. Some of the characteristics required for POW sites are the same as those for command posts, medical aid stations and maintenance areas. Considerations of cover and concealment are similar for all the sites. POW collection sites require, in addition, facilities which allow for the segregation, search and security of prisoners, as well as factors such as adequate sanitary facilities. Thus, existing buildings are most likely to meet the requirements of POW collection sites.

Existing Buildings

When evaluating buildings which could be used as POW collection sites, the G-1 needs to know certain types of information. Specifically, building size and type (i.e., can a building safely house prisoners?) is the minimum level of information required, but determining this information from a standard topographic map is not possible. On the conventional 1:50,000 scale map, most buildings are portrayed as black rectangles. Hence, in the absence of other sources of information about the buildings, the G-1 has no information upon which to base his evaluation.

Cover and Concealment

Since it's the G-1's responsibility to provide protection for unarmed prisoners, the cover and concealment of the area is an important consideration. In terms of cover and concealment, the buildings selected should be of masonry, and one story, since this type of building is likely to provide protection for the prisoners. Although the determination of building height and construction type is not possible from standard maps, certain types of buildings may be noted like churches, subway stations and public buildings. The heights and construction types of such buildings are not given, but some conjectures can be made. Whatever the case, for precise information the G-1 must consult other sources, if available.

Additional information required to evaluate potential POW collection sites involves the vegetation in the area. Vegetation heights in excess of 3.7 meters around the buildings would provide concealment of site activity. This level of detailed information is not directly available on conventional maps. However, the general classifications portrayed on the standard topographic map (e.g., woods, scrub, etc.) will provide an indication of possible heights.

3.12.4 Summary

Table 3-16 provides a summary of the information requirements for the task covered in Exhibit G.

TABLE 3-16

INFORMATION REQUIREMENTS FOR G-1/CORPS/POW COLLECTION SITES

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
G1.1	Road networks:		
	Classification	*All roads capable of supporting class 50 vehicles* (FM 5-36).	Road classification, while not portrayed on conventional maps, is required to determine roads which will support the movements of vehicles carrying POW's.
	Width	*Specified in meters* (FM 5-36).	Currently, conventional maps portray road widths by either of two methods; one provides the number of lanes, while the other provides categories of widths (e.g., 4-6 meters, more than 6 meters). Neither method provides the specific width information necessary to determine if vehicles will "fit" on the road.
	Condition	Weather impact on road trafficability (IPB).	
G1.2	Bridges:		
	Load/bearing capacity	*All bridges capable of supporting class 50 vehicles* (FM 5-36).	An indication of bridge strength is provided by the construction type of the bridge (e.g., wood, concrete). This classification does not allow an accurate determination of bridges which can support the crossing of class 50 vehicles.

TABLE 3-16 (CONTINUED)

INFORMATION REQUIREMENTS FOR G-1/CORPS/POW COLLECTION SITES

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
G1.2	Bridges:		
	Width	*Specified in meters* (FM 5-36).	The determination of bridge widths and clearances which will allow vehicle crossing cannot be made from conventional maps.
	Overhead clearance	*Specified in meters* (FM 5-36).	
G1.3	Rivers/streams:		
	Depth	*Depths in excess of .75 meters* (FM 5-36).	Conventional maps provide river and stream locations as well as the direction of the current flow. Some maps even provide the location of potential fording sites, but these are not specified as to the type of vehicle the information is reflecting. However, this task requires a determination of areas where transport vehicles will not be able to cross. Since the fording capabilities of various vehicles differ, this information must be specified.
	Current speed	*Specified in meters-per-second* (FM 5-36).	
	Slope of approach	*Slopes greater than 33%* (FM 5-36).	

TABLE 3-16 (CONTINUED)

INFORMATION REQUIREMENTS FOR G-1/CORPS/POW COLLECTION SITES

QUESTION REFERENCE NUMBER	CATEGORY	MINIMUM LEVEL OF DETAIL	COMMENTS
G2.1	Existing buildings:		
	Size	*Specified in maximum occupancy* (FM 7-11, FM 7-20).	1:50,000 scale maps portray most buildings as black rectangles. Certain buildings, such as churches, public buildings and subway stations are specified. However, since size, height and type of construction are not given, an evaluation of buildings which are capable of housing the prisoners and providing cover for them is not possible from standard maps.
	Height	*Specified in number of stories* (FM 7-11, FM 7-20).	
	Construction type	*Specified as wood, masonry, etc.* (FM 7-11, FM 7-20).	
G2.2	Concealment	*Vegetation heights in excess of 3.7 meters* (FM 7-11, FM 7-20).	General vegetation classifications (e.g., woods, scrub, etc) provide an indication of heights. However, to evaluation the concealment provided by an area for POW protection requires specific vegetation height information.

4. IMPLICATIONS FOR MILITARY MAP DEVELOPMENT

4.1 Introduction

Information in the physical environment may be viewed as a continuum of information categories and details. Not all information about the environment can be portrayed on a map nor is all the information required by the map user. Thus, the question becomes one of how much information detail from the real world should be portrayed on a map. The user of a map generally wants a lot of information about the environment, but the information will be of little practical value if it is not portrayed at the level of detail he requires. Thus, a trade-off between information categories and levels of information detail must be made.

For example, if the environment to be represented on a map contains a forest, there are a number of ways to portray it. One method would be to present each tree as an individual element, showing each tree height, trunk diameter, foliage spread, seasonality, as well as the spacing between trees. On the other extreme, the forest area could merely be represented (e.g., shaded green) to indicate the presence of vegetation. If the map maker wishes to include numerous other categories of information on the map, he is unlikely to use the first method, since it could create too much clutter; instead, he might use the shading technique and simply note the area as a forest. However, if the user of the map were trying to determine if he could drive a tank through the forest, the information provided by the shading technique would be insufficient. An alternative strategy might be to portray the forest in greater detail at the expense of other information categories that would necessarily be eliminated (i.e., to create a simplified map). One would then, however, have to determine if the deleted categories create information gaps for users other than tank-movement planners. Perhaps the answer to the problem would be to produce a special purpose map for the tank driver, but then the issue of cost-effectiveness is raised. And so on.

It is evident, therefore, that the creation of a map which will meet user needs requires an explicit previous accounting of user information requirements. This accounting is necessary, whether one general map for everyone or a separate map for each user is being developed. Such an analysis of user information requirements can be provided by the task-based methodology demonstrated in the previous chapter. A summary of the results from a task-based analysis highlights the following:

(1) Identification of categories of information required by single users and groups of users. For example, for the tasks sampled in this effort, the graphic portrayal of the location of built-up areas was required by G-1, G-2, and cav squadron users, but this information was not needed by the G-4.

(2) Within an information category, specification may be made of the classification of the minimum level of detail required for portrayal by each user. For example, for the tasks analyzed, the location of built-up areas is sufficient detail for G-2 and cav squadron users, however, the G-1 may need to know the heights and construction types of buildings.

In the context of the present discussion, examples of information categories would be road width, road condition, vegetation obstacles; within a category, say, vegetation obstacles, examples of information detail classifications would be tree trunk diameters in meters, tree spacing less than six meters, etc. By contrasting information requirements across tasks and related tactical questions, guidelines can be derived for the development and evaluation of improved military maps. Such guidelines, which include consideration of alternative methods of information portrayal, can be further extended by the sampling and analysis of a greater range of map user tasks.

4.2 Cross-Task Analyses of Information Requirements

The following sections will discuss three major categories of information which are traditionally portrayed on standard topographic maps and which are typically required by various users. The discussions will focus on the portrayal of vegetation (4.2.1), road networks (4.2.2), and built-up areas (4.2.3). Included in each section is a cross-task comparison table. These tables are offered as an example of how the results of the task-based analysis can be used to develop map content guidelines. Each table is organized in a "task by information category" manner. Within the body of the table the minimum level of information detail, as specified by the task, is presented. The findings presented in these sections should be viewed as an illustration of the types of implication which can be drawn by utilizing a task-based methodology. The discussions and tables in the following sections are not intended to be specific recommendations for information portrayal on military maps; rather, an attempt was made to demonstrate the potential of the task-based methodology developed by this research effort.

4.2.1 Vegetation

In all tasks sampled by this research effort, vegetation was observed to be a critical information item. The required information about vegetation depends, however, upon the attribute of vegetation being assessed. For example, vegetation may be assessed to determine any of the following:

(1) Vegetation as an obstacle.
(2) Vegetation providing concealment.
(3) Vegetation affecting fields of fire.
(4) Vegetation providing canopy closure.

Furthermore, the level of detailed information required for each of these categories depends somewhat upon the task being considered. For example, the level of detail required to assess vegetation obstacles to tank movement differs from that required to identify obstacles to helicopter landing zones.

Currently, the classification of vegetation information differs among various scales of topographic maps. Specifically, the conventional 1:250,000 scale maps portray one classification of vegetation, namely, woods, brushwood and plantation (with no distinction made between them). On the other hand, some 1:50,000 scale topographic maps provide portrayal enabling the distinction of the following forms of vegetation:

(1) Deciduous forest.
(2) Coniferous forest.
(3) Mixed forest.
(4) Trees and shrubbery.
(5) Park.
(6) Vineyard.
(7) Hop-garden.
(8) Meadow, pasture.
(9) Heath.
(10) Swamp, bog.
(11) Peat cutting.
(12) Garden.
(13) Orchard.
(14) Nursery (trees).

However, referring to the cross-task comparison of information requirements (Table 4-1), the reader will note that the conventional method of categorizing vegetation does not fulfill the required level of detail.

TABLE 4-1. CROSS-TASK COMPARISONS FOR VEGETATION

VEGETATION INFORMATION CATEGORY	TASK						
	G-2 DETERMINE ENEMY AVENUES OF APPROACH	G-4 DETERMINE MAIN SUPPLY ROUTE	S-3 AIR SELECT HELICOPTER LANDING ZONES	G-3 DETERMINE POSSIBLE DTOC LOCATIONS	CAV SQUADRON PLAN RECONNAISSANCE ROUTE	COMMANDER PREPARE DEFENSIVE FIRE PLAN	G-1 SELECT POW COLLECTION SITES
Vegetation: as obstacle	1) Trunk diameters greater than .22 m 2) Tree spacing less than 6.1m		1) Vegetation heights in 1m increments 2) Specific type of vegetation (or vegetation categorized on the basis of clearability)				
as fields of fire						Heights in .3m increments	
as canopy closure				1) Tree spacing of less than 6.1m 2) Tree heights in meters 3) Seasonality			
as concealment	Heights greater than 3.7m	Heights greater than 3.7m			Heights in .3m increments		Heights greater than 3.7m

An alternative approach might be to provide functionally-oriented vegetation classifications. A functional classification scheme would permit the user to answer critical battlefield questions directly from a map. The following categories and questions provide an example of the structure for such a scheme.

(1) Specific vegetation type and height: *Can I clear the vegetation for a landing site?*

(2) Tree spacing of less than 6.1m, tree trunk diameters greater than .2m: *Will the vegetation stop friendly/enemy tanks?*

(3) Vegetation heights in .3m increments: *Does the vegetation offer concealment, fields of fire, canopy closure or present an obstacle to helicopter landings?*

The last classification (i.e., vegetation heights in .3m increments) might require numerous subclassifications; yet at the same time, this classification reflects a large range of critical information. The exact number of subclassifications might be reduced by employing ranges of heights as opposed to separate .3m increments. The utility of such a procedure for representing vegetation heights requires further task sampling and analysis. In addition, further investigation is required to determine the extent of need for other vegetation classifications such as tree spacing and clearability to be portrayed on the same map.

From the tasks sampled in this effort, vegetation clearability was required only for the selection of helicopter landing zones; however, it is possible that this same consideration might be found necessary for other tasks. Thus, additional sampling and validation would assist map makers in the determination of the number of vegetation types for portrayal within each information category. Though it may not be feasible to greatly reduce the number of vegetation categories currently portrayed on the standard topographic map, it is possible that their respective classifications could be made more functional for the map users.

4.2.2 Road Networks

Road networks are obviously a key category of information which requires representation on a map. The question which arises is how should road networks be portrayed so that the user is provided with the most effective information? One approach might be to employ a functional description of road networks designed to answer user questions. The following represent several features of roads and associated user questions which they could address.

(1) Military load classification: *Is the road capable of supporting my vehicle(s)?*

(2) Road widths: *Is the road wide enough to allow my vehicle(s) to travel in one or two directions?*

(3) Condition (weather related trafficability): *During which general weather conditions can I travel the road?*

(4) Gradients: *Are there sections of the road where I will have to slow down?*

(5) Amount of curves: *Are there sections of the road where I will have to slow down?*

(6) Amount of road narrowing: *Are there sections of the road where I will have to slow down?*

(7) Amount and type of vegetation along road networks: *Will I be concealed while traveling the road? Are there likely enemy ambush sites along the road?*

(8) Road lengths: *How far can I travel on the road?*

The information attributes or categories themselves may be further decomposed. For example, road widths may be expressed in number of lanes, in meters, or in categories of meters. On the other hand, some of the classifications can reflect a composite of detailed information. For example, the military load classification system represents a load capability rating system which takes into account vehicle weight, type and its effect on roads.

Since the map maker must consider the fact that a map will contain other information besides road networks, all possible road network information cannot be portrayed. At this stage, it is useful to turn to the standard topographic map. Generally, the following road information may be found on a conventional 1:50,000 scale map:

(1) Dual highways.
(2) Dual motor-road.
(3) Federal main road, all weather, two lanes wide or more.
(4) Main road, all weather, two lanes wide.
(5) Secondary road, all weather, two lanes wide or less.
(6) Road, light surface.
(7) Road, fair surface.
(8) Farm and forest road, fair weather.
(9) Foot paths.

Each of these nine categories is portrayed separately on conventional maps. While the categories represent an abundance of information, only one battlefield related question among those analyzed could be directly answered *(During which general weather conditions can I travel the road?)*.

The tasks sampled by this research effort identified three attributes common to users of road information, as noted in Table 4-2. The condition, width and military load classification were the common attributes identified. Road condition is currently provided adequately on the standard topographic map. On the other hand, road width as presently portrayed (i.e., number of lanes; categories of 4-6 meters in width and of 6 meters or more) do not allow all users to determine whether or not their vehicle(s) will fit on the road. It would most likely be unnecessary for each road width to be noted; appropriate categories of width would probably suffice. However, such width categories should reflect the discriminations which must be made by the user; for example, the G-4, when selecting the MSR,

TABLE 4-2. CROSS-TASK COMPARISONS FOR ROAD NETWORKS

ROAD-NETWORK INFORMATION CATEGORY	TASK		
	G-4 DETERMINE MAIN SUPPLY ROUTE	CAV SQUADRON PLAN RECONNAISSANCE ROUTE	G-1 SELECT POW COLLECTION SITES
Classification	Class 60 Vehicles	Class 20 Vehicles	Class 50 Vehicles
Width	In meters	In meters	In meters
Condition	Weather impact on trafficability	Weather impact on trafficability	Weather impact on trafficability
Gradients	Greater than 7%		
Curves	Radii less than 30 meters		
Narrowing of Roads	Widths less than 8 meters		

needs to identify road widths in excess of 8 meters. Thus, the categories of widths must allow for such a discrimination. The third road network attribute identified was military load classification. From the tasks sampled, roads capable of supporting class 20, 50 and 60 vehicles were required. These should not be viewed as the definitive categories required for map portrayal, since sampling of other tasks might uncover additional categories. For example, a task requiring the identification of roads capable of supporting a division size tank maneuver might necessitate the location of roads which could support class 80 vehicles.

The task-based approach uncovered both overlapping information requirements among users as well as unique requirements for specific users of road network information. The three tasks sampled required detailed road information about load classification, widths and conditions. As noted by Table 4-2, the G-4 requires additional information when performing an MSR analysis. The information requirements of this task, however, would be considered excessive for the other users.

4.2.3 Built-up Areas

Traditionally, built-up areas are portrayed on standard topographic maps. Generally, 1:250,000 scale maps portray the following:

(1) Cities with populations in excess of 25,000.
(2) Cities with populations of less than 25,000.
(3) Scattered settlements and isolated farms.

On the other hand, 1:50,000 topographic maps provide greater detail of built-up areas. Some maps provide not only the location of all built-up areas, but also feature locations such as the following:

(1) House.
(2) Hut.
(3) Railway station.
(4) Youth hostel.
(5) Hospital.
(6) Rest center.
(7) Barn, shed, stable.
(8) Castle.
(9) Military training area.
(10) Inn.

The primary reason for the portrayal of these details appears to be due to their recognizability as landmarks. Most buildings other than those mentioned above, however, are portrayed only as black rectangles.

As noted in Table 4-3, the task-based analysis illuminated a primary requirement for the map portrayal of built-up area locations. While two tasks require the location of all built-up areas (cav squadron, plan reconnaissance route and G-1, select POW collection sites) one task requires the locations of only those built-up areas which exceed a specific size (G-2, determine enemy avenues of approach). Thus, two of the tasks could be easily accomplished with a conventional 1:50,000 scale topographic map. The standard 1:50,000 scale map did, however, provide more information than necessary for one task (i.e., G-2, determine enemy avenues of approach).

While the standard topographic map provides considerable detail of built-up area locations, these locations are not the only important dimension of built-up areas; in fact, location information is not sufficient for the completion of one of the tasks which was sampled. Specifically, a G-1 attempting to locate possible POW collection sites requires much more detail than is provided by a 1:50,000 standard topographic map. This task

TABLE 4-3. CROSS-TASK COMPARISONS FOR BUILT-UP AREAS

BUILT-UP AREA INFORMATION CATEGORY	TASK		
	G-2 DETERMINE ENEMY AVENUES OF APPROACH	CAV SQUADRON PLAN RECONNAISSANCE ROUTE	G-1 SELECT POW COLLECTION SITES
Location	1) *Greater than* 1 sq km in area or 2) 2 or more areas less than 1 km apart	All built-up areas	All built-up areas
Buildings			All
Size			Maximum occupancy
Height			In stories
Construction			Type (masonry, wood, etc.)

requires not only the location of all buildings but also, the maximum occupancy, height in stories and the building construction type. Furthermore, the G-1 is somewhat unique in that the manpower or resources available to this map user for conducting reconnaissance are limited. Although the tasks of the G-1 are vital, this user must rely solely on a map which, in fact, does not currently contain the required information detail; thus the G-1 might, for example, have to choose POW sites on the basis of a "best guess." While the detail requirements of the G-1 do not overlap with the requirements of any of the other user-task combinations sampled, this special need should nevertheless be considered.

4.3 Map Development Implications

The task-based methodology is generally applicable to the development of any military map, be it special purpose or general purpose. For this reason the following discussion will focus on the development of maps, whether they be designed for general or specific use. Figure 4-1 provides an overview of the development of guidelines for user-oriented map products as it evolves from the task-based approach.

In brief, task-based map information requirements can be employed to compare data which is required for tactical task performance with data that is currently available on standard maps. From this comparison, three important identifications about map information can be made:

(1) Information categories which are required by the user and are portrayed at an appropriate level of detail on conventional maps;
(2) Information categories and/or levels of detail which are required by the user but are not available on conventional maps;

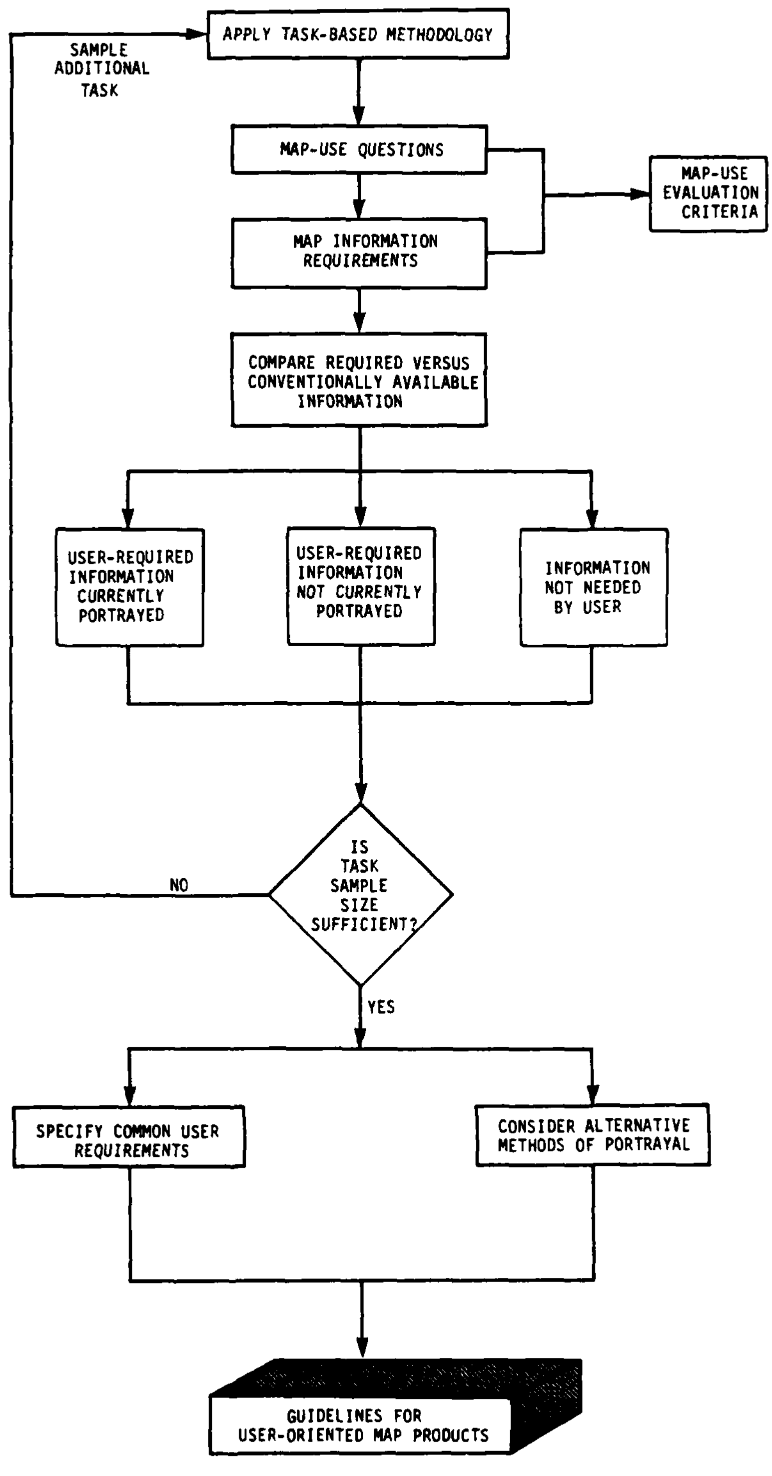

FIGURE 4-1.
TASK-BASED GUIDELINE DEVELOPMENT OF USER-ORIENTED MAP PRODUCTS.

(3) Information categories and/or levels of detail which are not needed by map users.

By focussing in on these map-related information distinctions, suggestions can be offered concerning the adequacy of conventional maps and the design of future maps which might meet user requirements as precisely as possible. These suggestions are primarily guided by an accounting of common user requirements and consideration of alternative methods of graphic portrayal. In addition to the generation of guidelines for user-oriented military maps, the map-use questions and specific map information requirements derived from the application of the task-based approach can also provide explicit criteria for evaluating the impact of map variables on human performance.

4.3.1 Common User Requirements

One of the most important advantages of a task-based approach is the opportunity it offers the map maker to accommodate the specialized requirements of different map user groups. Once a representative sample of task requirements has been established, as illustrated in Chapter 3, cross-task comparisons can begin to identify the common as well as the unique categories of information required by different military users. Those tasks which overlap considerably in their information requirements could be grouped together and a single map developed to meet their common information needs. In this case, however, a "lowest common denominator" rule would need to be applied to insure that minimum level of detail requirements were satisfied for each user. At issue here is a compromise between user needs on the one hand, and development cost-effectiveness on the other.

A cost-effective map product is one which can be used successfully by a large segment of the military population without any undue strain resulting from unnecessary and/or irrelevant information detail. The task-based approach can help to develop such products by providing map makers with a detailed inventory of competing task-based requirements. The problem for map development, in this context, is to identify those subtasks which hold many or even most of their information requirements in common.

Information Categories

One method for assessing common information requirements across users was demonstrated via the frequency tabulations applied to Tables 4-1, 4-2, and 4-3, which resulted from the task-based analyses. Such a tabulation of information requirements can be used to determine map content for general purpose as well as special purpose maps. In the same manner, information categories not generally needed for the performance of common tactical tasks could, in the interest of map simplification and clutter reduction, be systematically eliminated from new map products. Thus, for example, if a general purpose map is being developed for tactical planning tasks, the map maker can look across the relevant tasks analyzed to identify the common information requirements of users. Finding that most of the potential users would probably require road network information, the map maker can then compare the projected use of the information categories (e.g., military load classification, width, conditions, gradients, etc.) toward deciding on a user-oriented portrayal of road networks. If it were observed, as in the case of the tasks sampled here, that military load classification, width and condition were much more frequently required than the other attributes, only these categories might therefore be included on the intended map.

The task-based approach can also be used to help identify unique or non-overlapping information requirements. For example, consider the map information item of contour intervals. From the tasks sampled, it was observed that users are generally concerned with areas where vehicles can and cannot travel; in other words, the user is primarily interested in the slope of the area. By extending the task-user-echelon sample, other uses of contour intervals may be defined. If further sampling revealed that contour lines are used primarily for slope determination, various methods of portraying slope information directly might be considered. ETL (1973), for example, in their experimental terrain graphic (A.O.G. IIc) portrays slope directly by using various colors keyed to categories of slopes, thus relieving the user of the need to calculate slope from contour intervals. We are not advocating the removal of contour intervals from maps and portraying slope directly; rather, this is an attempt to illustrate the very basic issues in map making which may arise from an application of a task-based analysis.

Level of Information Detail

In order to provide a map product which would be useful to a wide range of users, the level of information detail portrayed must satisfy their needs. One approach to this problem is to identify the lowest common denominator of detail across user requirements. For example, tactical map users must frequently assess concealment, canopy closure and fields of fire on the battlefield. The common denominator for these information categories is vegetation height. Thus by portraying appropriate categories of vegetation heights on a multi-purpose map, the needs of all those interested in concealment, canopy closure and fields of fire could be served.

In contrast, ETL (1973) using an operations-based rather than task-based approach, created a map (A.O.G. IIc) that directly portrays varying amounts of concealment, canopy closure and fields of fire which are graded specifically in support of armor-related information requirements. Users needing to assess concealment, canopy closure and fields of fire for other purposes might have difficulty using this map because vegetation providing concealment, for example, for a tank (see Exhibits A and B) differs from the concealment needed for, say, the selection of a POW collection site (see Exhibit G). Hence, the portrayal of the lowest common denominator of information detail can represent a cost-effective approach to map development in that a wide range of users may be satisfied with a minimum number of graphics.

Summary

Each role-play of another map use task will add user-specified requirements to the map content database, and the corresponding information requirements and levels of detail common among users will require reassessment. Creating a comprehensive map content database will, of course, require an expanded task sampling and hence the present research effort represents only a starting point. However, the establishment of such a database can serve as an important foundation from which user-oriented map products may be developed.

4.3.2 Information Portrayal Alternatives

Within the framework for map development, an important step is the consideration of alternative methods of portrayal. Clearly, the information portrayal technique and the task-based use for the information impact upon each other. For example, in terms of how information is portrayed, road information would be more useful for tactical planning tasks if the roads were distinguished by functional categories, such as military load classification and condition. On the other hand, these functional categories may not be very helpful in ground navigation tasks, where a descriptive categorization scheme such as specification of the number of road lanes would be preferable. Whether categorization systems can be devised which combine functional as well as descriptive attributes will require further investigation.

Traditionally, military maps have provided the user with a flat, overhead perspective of the environment, using contour lines, color coding, and symbols to indicate the natural and man-made features. For many map users, however, it seems possible that there may exist more effective ways of representing the map information content. As pointed out in Section 2.3.2, ETL (1973), for example, has for several years been experimenting with new portrayal techniques. Recently a guide to innovative design has been prepared (Weltman, 1979) which provides 151 different examples of useful ways of displaying geographic and environmental information. Several examples from the guide are described in Table 4-4. They have been selected because they: (1) are relevant to the map-related tactical tasks analyzed in the present report; (2) promise an improvement over a conventional display technique; and (3) are theoretically amenable to modern forms of graphic display. Each example includes a brief description of the portrayal technique and its application potential for military tasks.

Most of the examples presented in Table 4-4 were drawn from "thematic map" representations in the sense that they focus on the display of individual variations of a single phenomenon or the relationship between phenomena. The rationale, therefore, for studying these creative maps has been provided by Robinson and Petchenik (1976):

TABLE 4-4

INNOVATIVE EXAMPLES WITH IMPLICATIONS FOR ALTERNATIVE MILITARY INFORMATION PORTRAYAL

(The number in parentheses following each map title refers to its identification in the Weltman (1979) report.)

EXAMPLE 1: COMPUTER GENERATED TOPOGRAPHY AND CONCEALMENT MAP (1.1)

DESCRIPTION: Provides three-dimensional representations of surface configuration; Allows easy visualization of gross surface features and areas of concealment potential.

APPLICATION: May prove useful to tactical planners concerned with the availability of natural concealment (see Exhibits E and F); As an insert to a standard topographic map, may provide users with a quick, easy-to-recognize view of an area.

EXAMPLE 2: SEQUENTIAL SECTIONS (1.4)

DESCRIPTION: Shows the cross-section of topography for one axis only, thus providing a sense of travel conditions over the land in the same direction as the contour lines.

APPLICATION: Might be useful to tactical route-planners (see Exhibits A and E).

EXAMPLE 3: AIR LANDING GRAPHIC (1.5)

DESCRIPTION: Aerial photograph with color overlayed to indicate ground cover and potential helicopter landing sites; Detailed photos and site descriptions provided on reverse side.

APPLICATION: Could provide direct information needed for selecting landing sites (see Exhibit C).

TABLE 4-4 (CONTINUED)

INNOVATIVE EXAMPLES WITH IMPLICATIONS FOR ALTERNATIVE MILITARY INFORMATION PORTRAYAL

EXAMPLE 4: GROUND TACTICAL DATA (1.11)

DESCRIPTION: Soil type is noted by color, and vegetation classifications are represented by texture; Various patterns of dotted and dashed lines represent stream widths and depths.

APPLICATION: Provides valuable information for the assessment of trafficability (see Exhibit A).

EXAMPLE 5: ORIENTEERING MAP (1.15)

DESCRIPTION: A topographical map of an area refined to include terrain details such as cliffs, boulders, ruins, fences, small foot paths, etc., designed for on-foot navigation.

APPLICATION: Might be useful to ground forces involved in non-vehicular movement.

EXAMPLE 6: FISH EYE AERIAL PHOTO (2.3)

DESCRIPTION: Provides a wide field of view by means of distortion; Information is clearest in the center of the photograph; Surrounding information, while visible, recedes rapidly into impressionistic information.

APPLICATION: May be helpful to users requiring information about buildings (see Exhibit 6); Although slightly distorted, the wide field of vision provides a sense of context within a built-up area.

TABLE 4-4 (CONTINUED)

INNOVATIVE EXAMPLES WITH IMPLICATIONS FOR ALTERNATIVE MILITARY INFORMATION PORTRAYAL

EXAMPLE 7: 360^{o} PANORAMIC PERSPECTIVE (2.5)

DESCRIPTION: Provides a four-directional view of an urban area from the top of a specified landmark; Diagonal intersections of the four perspectives create discontinuous street patterns; Avoids the distortion problems of the "fish-eye" view, which also offers a panorama perspective.

APPLICATION: Might prove helpful to users concerned with building heights (see Exhibit 6); Might aid in self-orientation and self-localization since mimetic representations of the environment are utilized.

EXAMPLE 8: BAR MAP (4.9)

DESCRIPTION: A variation of the bar graph; For example, bar segment lengths may be proportional to the percentage of time that winds of varying velocities occur in specific directions averaged over a period of time.

APPLICATION: Could offer a valuable overview of seasonal aspects of battlefield weather, such as rainfall estimation (see Exhibits A and D); Might be applied to the seasonal variation of river depths, vegetation (in terms of concealment afforded), as well as soil trafficability; Might provide an alternative to tabularized seasonal information portrayed on some graphics (e.g., A.O.G. IIb, ETL, 1973).

TABLE 4-4 (CONTINUED)

INNOVATIVE EXAMPLES WITH IMPLICATIONS FOR ALTERNATIVE MILITARY INFORMATION PORTRAYAL

EXAMPLE 9: TIME-DISTANCE MAP (5.10)

DESCRIPTION: Warped in such a way as to indicate travel time rather than distance from a specified location; Concentric circle bands represent time frames for locations of the various points, and a point which takes a long time to reach will appear relatively far away.

APPLICATION: Could be adapted to reflect travel time for tracked or wheeled vehicular movement; Might be of assistance to tactical route-planners (see Exhibits A, B, E and G).

EXAMPLE 10: PROBABILITY OF AERIAL DETECTION, HORIZONTAL VISIBILITY AND FIELDS OF FIRE (6.16)

DESCRIPTION: Color and value express degree of concealment from aerial observation; Superimposed numbers provide maximum horizontal visibility in meters; Colored dot patterns and numbers indicate restricted field of fire and their depth in meters.

APPLICATION: Could provide tactical planners with valuable information (see Exhibits D and F).

EXAMPLE 11: COMPUTER SIMULATION (8.3)

DESCRIPTION: A mathematical construction generated via a computer system; Offers a realistic three-dimensional and/or dynamic representation.

APPLICATION: Might prove useful to tactical planners requiring an overview of the surface configuration of an area (see Exhibits C, D and G); Could indicate slopes (though not in the precision available on standard topographic maps), natural concealment and potential movement corridors; Might be useful as a navigational training aid.

TABLE 4-4 (CONTINUED)

INNOVATIVE EXAMPLES WITH IMPLICATIONS FOR ALTERNATIVE MILITARY INFORMATION PORTRAYAL

EXAMPLE 12: COMPUTER REPRESENTATIONS OF AIRPLANE LANDINGS (8.4)

DESCRIPTION: Computer generated sequence of pictures simulating landings.

APPLICATION: Provides a useful training or planning device since sequence allows one to move through the important steps prior to actual execution; Might be useful for small areas of operation, such as inner-city navigation (possibly for commando-type operations).

"One of the most elegant things about thematic mapping, in fact, is that it makes it possible for us to achieve a total view of phenomena when that view is not possible in any other way. There may well be a preferred scale for each phenomenon being mapped thematically, as asserted by Miller and Voskuil (1964), who argue that we search for this "correct" scale in any thematic mapping activity." (p. 122)

In light of the preceding remarks, it is interesting to note that some of these creative maps violate the principles of standard cartographic design. For example, Robinson, Scale, and Morrison (1978) list balance as a desirable element of map design. They define the terms as follows:

"Balance in graphic design is the positioning of the various visual components in such a way that their relationship appears logical or, in other words, so that it does not unconsciously or consciously disturb the viewer. In a well balanced design nothing is too light or too dark, too long or too short, in the wrong place, too close to the edge, or too small or too large. Layout is the process of arriving at proper balance." (p. 286)

Nevertheless, some of the innovative map portrayal techniques referred to above clearly violate the principle of balance. A case in point is the 360° Panoramic Perspective (Example 7); yet this display method may be very effective and useful in providing a necessary view in certain situations. Consequently, map developers will have to properly integrate possibly conflicting graphic portrayal guidelines derived from varied sources.

4.3.3 Map Evaluation Issues

The task-based approach to map database development has important implications for map evaluation as well. The decomposition of superordinate map-use tasks, first into subtasks and finally into tactical questions, serves to specify a set of explicit criteria for judging map product effectiveness. For example, determining an enemy avenue of approach involves intermediate subtask components (e.g., identify obstacles to movement, identify areas sufficient for enemy movement; etc.) and these in turn involve several concrete map-use questions (e.g., *Are there any slopes enemy vehicles cannot climb?; Where are the areas providing cover for enemy tracked vehicles?; etc.*). Each question, in effect, reflects a potential requirement for effective map use performance. The relative ease with which a particular map enables the user to answer each question can be taken as a measure of that product's content adequacy.

The task-based approach to map evaluation may also prove valuable in diagnosing the effects of multiple independent variables. For example, as new map products are developed they are likely to portray numerous categories of geographical and tactical information. Thus, emerging products may portray some categories in a new way while leaving others in their traditional form. A major problem for research, therefore, will be to pinpoint the relative effectiveness of multiple map factors. Potash (1977) gives the following example:

> *"If one wants to test the effect of using layer tints for evaluation as contrasted with contours by themselves than one is automatically excluding the use of layer tints for vegetation. If ability to extract information about vegetation from the map is also of interest, it is legitimate to contrast a map with contour lines plus layer tints for vegetation with a map using contour lines and layer tints for elevation plus iconic figure coding for veletation."*

Thus, by offering a set of multiple performance criteria corresponding to basic subtask requirements, the use of a question-based approach to map evaluation should make it easier to interpret the effects of complex map variables. It would, for example, permit a more detailed analysis of map effectiveness by specifying which subtask skills were improved and which were not. In addition, a profile of subtask performance might be developed to reflect the composite input of numerous independent map variables. Ideally, such a profile should allow one to match a set of map parameters with a corresponding set of task-based skill requirements. The result could perhaps lead to guidelines for the design of maps specially tailored to enhance performance over a well-defined range of tactical rquirements.

In the evaluation of alternative map products, simple research strategies should be sought. A straight-forward methodology might be to present test subjects, who have been exposed to various map products, with a sample set of task-oriented questions in order to assess the accuracy and the timeliness of their responses. This technique seems to offer a cost-effective compromise between empirical field testing and subjective rating-scale procedures. The former methodology cannot be used routinely because of its prohibitive cost, while the latter has not always proved to be sufficiently reliable (Farrell, 1977). Thus, the use of paper and pencil question-based techniques to objectively evaluate performance with maps such as demonstrated by Wheaton, Zavala, and Van Cott (1967), should be further explored and developed.

4.4 Summary and Conclusions

The application of an in-depth analysis of information requirements for specific map-use tasks appears to be a valuable technique for supporting the development of improved military map products. While this effort examined only a few representative tasks, the analyses showed that by drawing comparisons of information needs across different tasks, specific requirements can be identified which are relatively common among tasks or somewhat unique to particular tasks. The integrated analysis of such commonalities and differences, as they relate to various task objectives, can provide a basis for enabling map developers to make sensible trade-offs in considering the production of new user-oriented maps. From an analysis of such information, it was illustrated that development guidelines, for either general purpose or special purpose maps, can be systematically derived. In order to generate more comprehensive map-development guidelines, it will be necessary to sample a wider range of battlefield users and tasks and to analyze their specific, detailed information requirements.

From the analyses performed here, it appears that, overall, the content of standard topographic maps do not as yet satisfy many user requirements for terrain information. As one example, consider vegetation portrayal. Although vegetation classifications are provided on a standard map, the level of detail does not enable distinction between vegetation as an obstacle to movement from vegetation which provides concealment; and such a functional distinction appears to be required for the successful accomplishment of certain tactical tasks. In addition, the research results indicate that deficiencies with standard maps do not seem to favor particular groups of users. That is, for the tasks sampled, the information detail requirements of one user-echelon (e.g., Corps G-4) do not appear to be met by the standard topographic map any more readily than the requirements of a different user-echelon (e.g., Company Commander).

Maps, whether special purpose or standard topographic, play a vital and integral part in battlefield decision making, and their context must reflect the information needs of the user. The present research effort focused upon the development and demonstration of a methodology designed to systematically specify such information needs at a detailed, functional level. The emphasis of the technical approach applied can perhaps be adequately summarized by the following eloquent quote from Robinson and Petchnik (1976):

> *"...a map is constructed fundamentally to accomplish one or more informative purposes; like any utilitarian article, it must be designed with primary attention to its functioning. Recent developments in cartography have been phenomenal. This is especially true of the technical aspects: as new methods and products of cartographic ingenuity are developed and applied, we can look forward to a continuous and exciting transformation of the field. But the real basis for evaluating such things as manual landform representation, or systems of computer hill shading, or methods of generalization, or the orthophoto map, lies not in the reduction of cost, the lessening of the lag time between the beginning and the completion of a map, or in the map's popular appeal, but is to be found in the character of the precepts the map marks actually induce. The worth of all research in cartography, whether the investigation be evaluative or innovative, technical or philosophical, must ultimately be judged on functional, perceptual-cognitive grounds." (pp. 108-109)*

Within the context of research in cartography, therefore, the present work began with the precept that military maps are primarily intended to serve users in the performance of functional tasks. By capitalizing on the task-based approach, progress was made in the direction of improving techniques for identifying map-related information requirements. However, such progress can be considered only as an initial step in the study of the mapping process, which must eventually lead to the improvement of cartographic portrayal techniques and to the evaluation of task performance based on resultant, innovative map products.

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