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Graphic Portrayal of Battlefield Information: Executive Summary

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Battlefield Information Systems Technical Area
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U. S. Army

Research Institute for the Behavioral and Social Sciences

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Deputy Chief of Staff for Personnel

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Research findings from three part-contractual research effort regarding issues in military symbology are presented and integrated. Key findings from the three tasks--(1) compilation of automated symbol catalog; (2) user survey of needs for symbolized information; (3) discriminability technique for choosing among conflicting symbol alternatives--are described and incorporated into a plan for standardizing tactical symbols. The integration of these findings offers a succinct and useful summary of current progress toward the development of a standard set of tactical symbols, and a proposal (Continued)

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for the investigation of problems in developing ADP compatible (communication) symbology. A plan and discussion are offered to direct efforts to develop a standard symbol set (or sets) to meet modern battlefield needs.

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FOREWORD

The Battlefield Information Systems Technical Area of the Army Research Institute is concerned with the human resource demands of increasingly complex battlefield displays used to acquire, transmit, process, disseminate, and utilize information. Current research focuses on human performance problems related to the soldier system interface and is concerned with such areas as software development, the presentation of information on complex displays, user-oriented systems, decision making, systems integration, and utilization.

Of special interest are human factors problems related to developing and validating new ADP compatible symbology concepts for efficient display of tactically significant information. The current study is the summary document for a three-task symbology contract effort by Perceptronics, Inc., which provides an overview of significant findings relating to standardizing military symbology and how to proceed in the standardization process.

This research is responsive to general requirements of Army Project 2Q263739A793, and to special requirements of the U.S. Army Combined Arms Combat Development Activity (CACDA), as well as HRN 80-307 (Display of Battlefield Information).

EDGAR M. JOHNSON
Technical Director

EXECUTIVE SUMMARY

Requirement:

To summarize key issues and findings resulting from a three-task contract effort to investigate graphic (symbolic) portrayal of battlefield information, and thereby offer initiatives and recommended approach for standardizing current symbols and developing new symbols for tactical use.

Procedure and Results:

Key findings from the three tasks--(1) compilation of automated symbol catalog; (2) user survey of needs for symbolized information; (3) discriminability technique for choosing among conflicting symbol alternatives--are described and incorporated into a plan for standardizing tactical symbols. The integration of these findings offers a succinct and useful summary of current progress toward the development of a standard set of tactical symbols, and a proposal for the investigation of problems in developing ADP compatible (communication) symbology.

Utilization of Findings:

This document represents an important summary of ARI research efforts to date in the area of military tactical symbology and offers a plan to begin the development and testing of standard sets of symbols to meet future needs.

GRAPHIC PORTRAYAL OF BATTLEFIELD INFORMATION: EXECUTIVE SUMMARY

CONTENTS

LIST OF TABLES

LIST OF FIGURES

GRAPHIC PORTRAYAL OF BATTLEFIELD INFORMATION: EXECUTIVE SUMMARY

INTRODUCTION

Overview

Results of a three-year research and development program provide symbology developers with information for developing battlefield symbology to meet today's and tomorrow's user needs. The first-year effort focused on establishing a framework for the development of improved military symbology (Ciccone, Samet, & Channon, 1979), and on the demonstration of a task-based approach for determining map information requirements (Landee, Samet, & Foley, 1979). The second year of work was concerned with extending the symbology development framework by systematically enlarging and refining the related information requirements database (Landee, Samet, & Gellman, 1980), and by establishing and demonstrating an evaluation model and methodology for empirically testing new approaches to improving the symbolic representation of battlefield information (Samet, Geiselman, & Landee, 1980). The third year of the research effort focused on three tasks, namely: (1) the creation of an automated tactical symbology catalog containing a collection of existing symbologies from numerous sources (e.g., NATO, FM 21-30, etc.); (2) the survey of the user community to identify relevant tactical concepts that do not have a standard graphic portrayal method; and (3) the development of human-factor criteria to resolve redundancies and conflicts between existing and proposed symbols.

This document provides a summary of the findings of the third-year research. A detailed discussion of the survey portion of the research may be found in a separate document entitled "Military Symbology: A User Community Survey" (Landee, Geiselman, & Clark, 1981). A complete discussion of the development of human-factor criteria, Task 3 of the research effort, may be found in the document entitled "Perceptual Discriminability as a Basis for Selecting Military Symbols" (Geiselman, Landee, & Christen, 1981).

Statement of the Problem

The use of graphic displays to provide an overview of a battlefield situation can promote rapid comprehension of a vast quantity of information. The displayed information might not be understood as readily if presented in other forms, such as verbally. Generally, a battlefield situation is composed of a topographic map overlayed with tactical symbols (as represented in U.S. Army Field Manual 21-30, Military Symbols). The symbology of FM 21-30, and its related NATO version, provides a standard graphic language for the Army, as well as for the other services and Allied Nations. This graphic language provides one form of communication within and between the services and Allied Nations.

The conventional symbology (FM 21-30) is used for identifying unit types and sizes, as well as designations, principal weapon systems, and locations. One user has described conventional military symbology as having

been "designed for an era of more time and less information."[1] FM 21-30 has not been updated since 1970; thus numerous newer weapons, equipment, and units do not have standard symbols. In the absence of formal standards, informal standards evolve among those groups of users dealing with the new information (Landee, Samet, & Gellman, 1980). A proliferation of personalized symbols has evolved in an attempt to represent such concepts as availability and status. Undoubtedly, personalized methods serve a necessary function for the users. However, the loss of standards, through personalization, is likely to reduce the communicative value of the display and may result in misunderstandings, confusion, errors, or time delays.

While introduction of automated battlefield systems into the tactical environment provides command staffs with increased graphic capabilities, the symbology of FM 21-30 could be augmented to better exploit emerging systems. For example, FM 21-30 lists the use of four colors for coding purposes. New graphic systems, however, may have color capability that exceeds four colors, and could support increased requirements. Numerous systems are scheduled for fielding within the next few years, and many of these systems will have graphic capabilities. With limited standards to follow, displays may evolve independently, possibly on a system-by-system basis, producing little agreement across systems about how to portray a given concept.

The goal of the present program of research is to provide requirements developers with recommended guidelines for updates in symbology to meet today's and tomorrow's needs. Toward accomplishing this goal three parallel lines of research and development were undertaken.

Technical Approach

Task 1: Tactical Symbology Catalog. Task 1 of the research effort produced an automated tactical symbology (TACSYM) catalog[2] that combined symbol sets from a variety of sources.[3] The symbols contained in the catalog were organized in a comparative manner based upon the concept a symbol represented. In other words, aviation symbols were contained in one section; within that section all helicopter symbols were grouped together. This type of organization permits a rapid identification of the symbols available to portray specific concepts.

Task 2: User Community Survey. The primary purpose of Task 2 concerned the identification of important military concepts that currently do not have a standard method of graphic portrayal in FM 21-30. A secondary purpose was to examine the nonstandard (personalized) methods that are being used at

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[1] "A Command Post Is Not a Place," Concept Paper by General Paul Gorman.

[2] System design, development, and implementation by Steve Johnston and Pat Peck, Perceptronics, Inc., Washington, D.C.

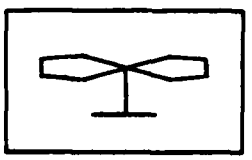
[3] Sources included in the catalog: FM 21-30; NATO D-49, 1980; BETA Test Bed; TOS; PLRS; VIDS, CDEC; Combat Power Symbology; DIVRAS; Marine Systems--MIFASS, TCO, TAOC-85, TACC, ITAOC; Air Force--AFR 55-25, E3A PPI, 407L/485L TACS.

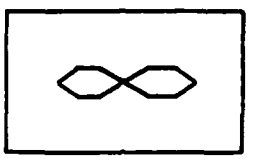
present in graphic displays. The approach taken was to survey experienced Army personnel in the context of a tactical task scenario.

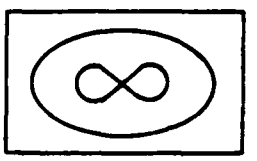
Task 3: Human-Factor Criteria for Resolving Symbol Conflicts. The purpose of Task 3 concerned the development of human-factor criteria that could serve as a basis for selecting new symbols for use in tactical displays. An easy-to-use discriminability-index formula was developed that could be employed to derive a figure of merit for alternative new symbols in terms of their discriminability from a set of FM 21-30 symbols.

FINDINGS

The TACSYM catalog highlights the fact that there is a vast quantity of unique symbols in existence. These unique symbols represent distinctions between equipment and weapons. Also, the automated catalog provides evidence that system-by-system graphic development is occurring. Consider the portrayal of attack helicopter units--a concept not appearing in FM 21-30. When a system requires an attack helicopter symbol, one is simply developed. For example, each of the following represents an attack helicopter unit:


TOS


BETA Test Bed


TCO

Thus, the catalog offers justification for the concern that in the absence of standards, system-by-system development is a likely consequence.

The user community survey revealed numerous tactical concepts that are relevant to users. It was found that many of these concepts appear regularly on tactical displays, but the concepts are missing from FM 21-30. Although the major concepts identified by the users are not addressed by FM 21-30, the possibility exists that other symbologies have developed a portrayal method for them. The TACSYM catalog provides an easy-to-use reference for such an application by enabling a user to look up any concept. The major concepts identified from the survey include status, capability, availability, threat, and logistics. Additional concepts that were frequently displayed include activities (related to enemy intentions and indications), civilian affairs, communications, enemy formations, range fans, and the enemy's 2nd echelon. All of these concepts have been displayed by various users with nonstandard techniques. In Table 1 the major concepts from the survey are listed, as well as the findings of the TACSYM catalog search. One must conclude that the important concepts missing from FM 21-30 are not currently available elsewhere.

In contrast to the above-mentioned lack of existing symbol representations, inspection of the TACSYM catalog reveals a number of instances where more than one symbol is available to portray a given military concept. The discriminability-index (DI) formula provided one viable basis for resolving

these symbol conflicts; that is, for selecting one symbol over another. Sample applications of the formula are presented in Figure 1. The top panel shows two symbols from the TACSYM catalog that are alternative graphics for the same concept, namely a support unit. In this case, symbol (a) would be selected on the basis of its predicted discriminability from FM 21-30 symbols in general use. The DI formula can also be applied readily to symbols intended to represent concepts which currently do not appear in the TACSYM catalog. The bottom panel shows two symbols designed to portray a FROG unit (no symbol appears in the catalog to portray this concept). In this case, symbol (b) would be selected. Although the DI formula is easy to apply and easy to interpret, perceptual discriminability is only one important criterion to be considered in selecting symbols. How well the symbol portrays its referent (i.e., its meaningfulness) is another factor that should be taken into account.

Table 1

Sample TACSYM Search

Key symbology needs	TACSYM catalog entry
Status--current state of affairs or situation	Not listed.
Capability--potential of an entity (whether an Army or weapon)	Not listed; however, the area below a symbol (according to FM 21-30) may be used for additional identifying information. This is not a technique used by many of the users surveyed to portray capability.
Availability--the presence and readiness of an entity (whether ammunition or fire support).	Not listed.
Threat--composed of various types of information, including status, doctrine, capability, among others.	Not listed; however, an experimental symbology entitled Combat Power Symbology (CPS) was developed as a threat symbology. In this symbology the level of threat is assigned based on the type of unit (i.e., the most threatening unit is armor). Thus, the concept of threat per se is not symbolized.
Logistics--fuel, ammunition, spare parts, etc.	While depots, installations, and logistics units are symbols found in FM 21-30 and NATO D-49, the user required information is at a level of information detail not found in the catalog.

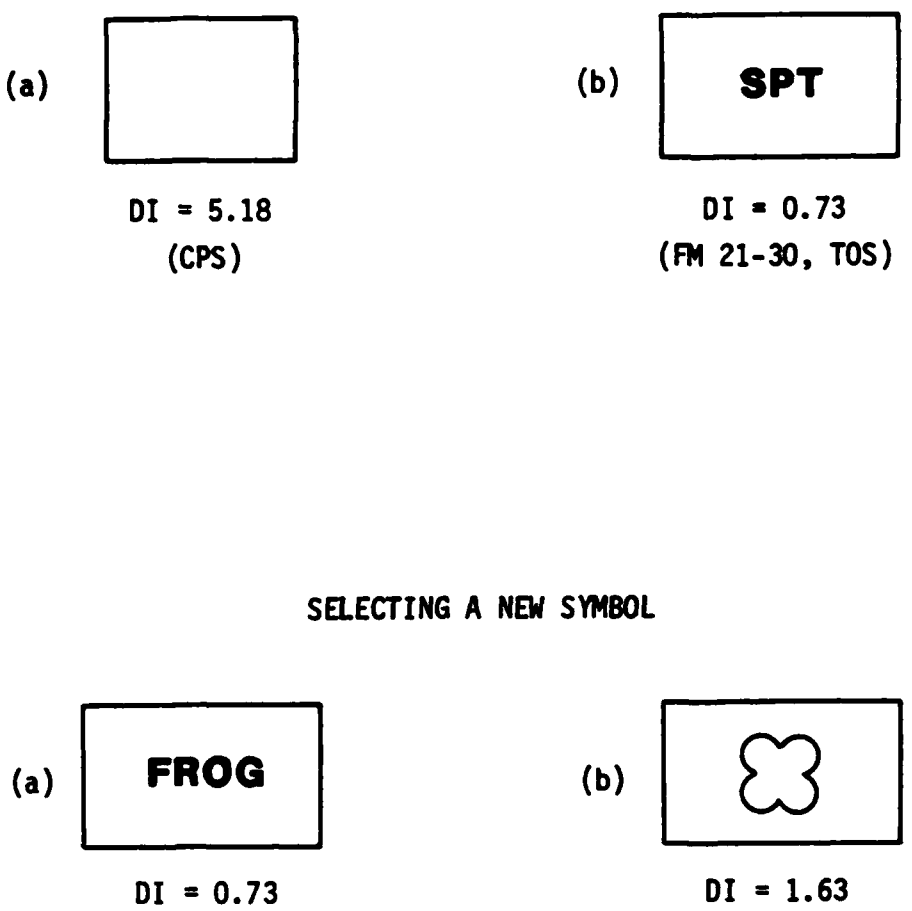


Figure 1. Application of the discriminability index.

FUTURE DIRECTIONS

The three parallel research efforts conducted during the third year of work have led to the identification of a number of major issues concerning tactical symbology:

- In terms of quantity, there does not appear to be a shortage of tactical symbols, i.e., these include redundant symbols as well as individual symbols representing fine distinctions between concepts.
- There are a number of user-required battlefield concepts not addressed by any of the symbologies contained in the TACSYM catalog--many of these are being displayed with personalized techniques.
- With system-by-system symbol development and the widespread use of personalized techniques, symbol standardization is not the rule of the day.

- There is no simple quick fix solution for selecting an optimal set of symbols to please all users for all tasks.

We propose two general approaches to deal with these issues, each of which draws upon the knowledge gained from work to date. One approach concerns an updating of the FM 21-30 symbology, and the other concerns the development of a symbology resource, designed specifically to communicate graphic information from one user to another.

FM 21-30 Update

It is apparent from the TACSYM catalog that a large number of symbols exist which make fine distinctions among many battlefield entities. Conversely, it is apparent from the user community survey that there are new entities, as well as important dynamic concepts, that are not contained in FM 21-30. As a consequence of a lack of standards, many concepts are being portrayed with personalized methods and new entities have been represented by a variety of symbols developed on a system-by-system basis. Thus, an updating of FM 21-30 appears crucial. This updating should lead to (a) a reduction in the number of redundant or obsolete symbols now contained in FM 21-30, hopefully resulting in a more manageable symbol set, (b) standardization of new symbols for portraying dynamic aspects of the battlefield such that the symbology would more accurately reflect the user's needs, and (c) standardization of new symbols to portray modern entities such as important new equipment and weapons.

The most expedient methodology for reducing the number of redundant or obsolete symbols would be to conduct a second survey of the user community using the TACSYM catalog as a guide. Special attention would necessarily be given to the needs of users at different echelons operating under different roles.

Guidance for representing the missing but important dynamic concepts identified by the first user survey can be drawn from the personalized methods already being employed by display users. Experiments to choose among the alternative methods are needed. In general, however, there are no simple guidelines currently available for selecting or developing symbols. Support work toward such guidelines might include the identification of global constraints in symbol design based on standard conventions (e.g., from FM 21-30--rectangle represents unit, circle represents installation), the improvement of the discriminability instrument developed during the third year of work and determination of the formula's generalizability, and the development of a parallel methodology for maximizing associability of concepts to be portrayed with symbol forms. These tools would provide military symbol developers with necessary guidance in the design and selection of new and alternative symbols to enable them to more effectively carry out the proposed updating of FM 21-30.

Communication Symbology

A basic conflict, as indicated by the survey results, exists between the users' need to "see" their information versus the consequence of a lack

of standardization. On one side of the conflict, there exists a body of information not addressed by FM 21-30, such as status, capability, availability, and threat, which is being portrayed in a nonstandard manner. On the other side of the conflict, nonstandard methods may seriously jeopardize the communicative value of the graphics. A related conflict is evident in system-by-system symbol development, as seen in the TACSYM catalog. If there is no symbol in a given symbology to portray a concept, a symbol is made up. Hence, the communicative value of graphics may be diminished between systems, as well as between the users who are personalizing their graphics.

Given the objective of both serving the user's needs and having standardization, there are a few approaches that might be taken. First, a symbology resource, such as the TACSYM catalog, could be incorporated into advanced tactical systems and this resource could be used as a symbology translator between systems. The TACSYM catalog could be updated routinely with each system's latest symbols and modifications so that translation into the necessary symbology of a given system would be current. This symbology translator only would be of benefit between automated systems, however, with the aid of automation.

The proposed symbology translator essentially would eliminate standardization concerns, at least in the automation arena. If standardization is of concern, an alternative solution might be to focus only upon the most potentially troublesome area of graphics, namely, at the point where graphics are communicated. An approach such as this could permit users graphic flexibility while hopefully eliminating most misunderstandings between both users and systems. There are very positive features to such an approach. For one, a relatively small communication language would not require large-scale retrofitting of existing graphic systems. The second feature, and perhaps the most important, is the likelihood of user acceptance.

From this year's research effort, we must conclude that FM 21-30 in its present form cannot provide the guidance for the future graphic needs of users as well as for advanced automated systems. From a cost-effective perspective, the symbology problem must be addressed in the near future, before the only viable solution is to "retrofit" battlefield graphic systems.

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