Research Product 81-26

DESIGN GUIDELINES AND CRITERIA FOR USER/ OPERATOR TRANSACTIONS WITH BATTLEFIELD AUTOMATED SYSTEMS

VOLUME III-A:

HUMAN FACTORS ANALYSES OF USER/ OPERATOR TRANSACTIONS WITH TACFIRE - THE TACTICAL FIRE DIRECTION SYSTEM

HUMAN FACTORS TECHNICAL AREA

February 1981

ari

U.S. ARMY RESEARCH INSTITUTE for the BEHAVIORAL and SOCIAL SCIENCES

U. S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency under the Jurisdiction of the Deputy Chief of Staff for Personnel

JOSEPH ZEIDNER Technical Director	L. NEALE COSBY Colonel, IN Commander

Research accomplished under contract
to the Department of the Army

Synectics Corporation

DISCLAIMER NOTICE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Research Product 81-26

2. GOVT ACCESSION NO.: AD-A109 451

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): Design Guidelines and Criteria for User/Operator Transactions with Battlefield Automated Systems Volume III-A: Human Factors Analyses of User/Operator Transactions with TACFIRE-The Tactical Fire Direction System

5. TYPE OF REPORT & PERIOD COVERED: Interim: Oct 1979-Feb 1981 Final

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s):
Robert N. Parrish
Jesse L. Gates
Sarah J. Munger

8. CONTRACT OR GRANT NUMBER(s): MDA903-80-C-0094

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
Synectics Corporation
10400 Eaton Place
Fairfax, VA 22020

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 2Q263744A793

11. CONTROLLING OFFICE NAME AND ADDRESS:
U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Ave., Alexandria, VA 22333

12. REPORT DATE: February 1981

13. NUMBER OF PAGES: 60

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Dr. Raymond C. Sidorsky, of the Human Factors Technical Area, ARI, is the Contracting Officer's Representative (COR) for this project.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Battlefield automated systems
Design criteria
Design guidelines
Functional Standardization
Human-computer interaction
System analysis
Transaction Feature Analysis
User/operator transaction

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document is one of a series in the Final Report of Phase I in a project to develop design guidelines and criteria for user/operator transactions with battlefield automated systems. The report is organized in five volumes as follows:

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

375218

Item 20 (Cont'd)

I. Executive Summary (RR 1320)
II. Technical Report (TR 536)
III. In-Depth Analyses of Individual Systems
  A. Tactical Fire Direction System (TACFIRE) (this report)
  B. Tactical Computer Terminal (TCT) (RP 81-27)
  C. Admin/Log Automated Systems (RP 81-28)
  D. Intelligence Information Subsystem (IISS) (RP 81-29)
IV. Provisional Guidelines and Criteria (TR 537)
V. Background Literature (TR 538)

Volume I presents a succinct review of activities and products of the project's first phase. Volume II contains a technical discussion of the project's objectives, methodologies, results, conclusions, and implications for the design of user/operator transactions with battlefield automated systems. Volume III documents analyses of four unique battlefield automated systems selected to represent different stages of system development and different Army functional areas. Volume IV presents provisional guidelines and criteria for the design of transactions. Volume V provides a brief review of selected literature related to guidelines and criteria.

Research Product 81-26

DESIGN GUIDELINES AND CRITERIA FOR USER/ OPERATOR TRANSACTIONS WITH BATTLEFIELD AUTOMATED SYSTEMS

VOLUME III-A:

HUMAN FACTORS ANALYSES OF USER/ OPERATOR TRANSACTIONS WITH TACFIRE - THE TACTICAL FIRE DIRECTION SYSTEM

Robert N. Parrish, Jesse L. Gates, and Sarah J. Munger
SYNECTICS CORPORATION

Submitted by:
Stanley M. Halpin, Chief
HUMAN FACTORS TECHNICAL AREA

Approved by
Edgar M. Johnson, Director
SYSTEMS RESEARCH LABORATORY

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, Virginia 22333

Office, Deputy Chief of Staff for Personnel
Department of the Army

February 1981

Army Project Number 2Q263744A793

Human Performance Effectiveness and Simulation

FOREWORD

The Human Factors Technical Area of the Army Research Institute (ARI) is concerned with helping users and operators cope with the ever increasing complexity of the battlefield automated systems by which they acquire, transmit, process, disseminate, and utilize information. Increased system complexity increases demands imposed on the human interacting with the machine. ARI's efforts in this area focus on human performance problems related to interactions with command and control centers, and on issues of system design and development. Research is addressed to such areas as user-oriented systems, software development, information management, staff operations and procedures, decision support, and systems integration and utilization.

An area of special concern in user-oriented systems is the improvement of the user-machine interface. Lacking consistent design principles, current practice results in a fragmented and unsystematic approach to system design, especially where the user/operator-system interaction is concerned. Despite numerous design efforts and the development of extensive system user information over several decades, this information remains widely scattered and relatively undocumented except as it exists within and reflects a particular system. The current effort is dedicated to the development of a comprehensive set of Human Factors guidelines and evaluation criteria for the design of user/operator transactions with battlefield automated systems. These guidelines and criteria are intended to assist proponents and managers of battlefield automated systems at each phase of system development to select the design features and operating procedures of the human-computer interface which best match the requirements and capabilities of anticipated users/operators.

Research in the area of user-oriented systems is conducted as an in-house effort augmented through contracts with uniquely qualified organizations. The present effort was conducted in collaboration with personnel from Synectics Corporation under contract MDA903-80-C-0094. The effort is responsive to requirements of Army Project 2Q263744A793, Human Performance Effectiveness and Simulation, and to special requirements of the U.S. Army Combined Arms Combat Developments Activity (CACDA), Fort Leavenworth, Kansas.

JOSEPH ZEIDNER
Technical Director

DESIGN GUIDELINES AND CRITERIA FOR USER/OPERATOR TRANSACTIONS WITH BATTLEFIELD AUTOMATED SYSTEMS VOLUME III-A: HUMAN FACTORS ANALYSES OF USER/OPERATOR TRANSACTIONS WITH TACFIRE--THE TACTICAL FIRE DIRECTION SYSTEM

EXECUTIVE SUMMARY

Requirement:

To develop a comprehensive set of human factors guidelines and criteria for the design of user/operator transactions in battlefield automated systems for use by human factors specialists and system proponents, managers, and developers.

Procedure:

To provide data for a baseline function description of user/operator transactions in battlefield automated systems, user-computer interactions in TACFIRE were analyzed using a Transaction Feature Analysis technique. Data were collected during interviews with system experts and reviews of system documentation. The analysis focused on system design features that affect user/operator performance of transactional tasks.

Findings:

TACFIRE, one of the earliest Army battlefield automated systems, yielded abundant data for the project data base. Design deficiencies of greatest significance include: lack of a command language, limited use of menus, and inept design of function keys in control methods; inconsistent format and density of alphanumeric displays; variation in keyboard configurations at different work stations; and a plethora of message formats, data element names, abbreviations and codes whose sheer volume, inconsistent design, and use require ten volumes of user manuals. None of the material in these documents is available on-line. While most of these problems singularly, with the possible exception of the lack of an on-line glossary, would result in system degradation rather than system failure, the design problems in combination would result in system throughput deterioration and increased error rates, thereby severely curtailing system output and data base quality.

Utilization of Findings:

Findings from the analysis of individual systems may be useful to proponents in specifying user/operator requirements for future system evolution. In this project, the findings were incorporated in a data base on human factors requirements which provided the "real world" foundation for development of the provisional guidelines and criteria presented in volume IV of this report. The provisional guidelines and criteria will be utilized as the basis for development of the prototype handbook.

SUMMARY

This document reports a human factors-oriented analysis of user/operator transactions with the Tactical Fire Direction System (TACFIRE). Subject matter experts were interviewed and system documents were reviewed to learn about hardware, software, and procedural design features that affect those transactions. Observations were recorded with a Transaction Feature Analysis technique developed for this purpose. Transaction features analyzed with the technique were arranged by categories to facilitate presentation and discussion.

The analysis revealed only one deficiency that might be regarded as a major problem. TACFIRE employs over 200 different message formats, accounting for over 900 different data element names. Because of these numbers of formats and items, and because of ambiguities in data labels and codes, the system imposes memory requirements well beyond normal human limitations. To compensate for this burden, a user's manual is provided which runs to 10 volumes. Should part or all of this manual be lost or become unusable through damage, users/operators might literally become unable to operate TACFIRE effectively.

Minor deficiencies in the user-computer interface were common and pervasive. These deficiencies, individually unimportant or even trivial, nonetheless act in concert in many situations; thus cumulative effects could under operational conditions introduce serious errors into the system and reduce throughput rates. Particularly in stressful situations, they could adversely affect mission effectiveness. Improvements in the interface could reduce errors and increase throughput rates. Perhaps equally important, they would also make the system easier to use; by providing a simpler, "friendlier" user/computer software interface, they could reduce training requirements.

Recommendations for such improvements are summarized in Table 1. The table is organized by categories of design features as described in the report. Each recommendation is evaluated, according to the best judgment of the analysts, in terms of hardware changes, software reprogramming, or changes

in system operating procedures. Evaluations cannot be expressed in quantitative terms because appropriate data could not be collected. Therefore, the evaluation is expressed in terms of low (L), moderate (M) or high (H) impact on hardware, software, and performance, with a minus sign indicating negative impact (cost) and a plus sign indicating positive impact (benefit).

Table 1

Summary of Design Feature Recommendations and Their Impact on the System

CATEGORY	RECOMMENDATIONS	IMPACT* Hardware	Software	User/Operator Performance
1. CONTROL METHODS				
1.1 Command Language	N/A	N/A	N/A	N/A
1.2 Menus	• Use the same character to indicate menu selections in all messages containing menus.	None	L-	M+
	• Arrange format directory menus vertically.	None	L- to M-	M+
1.3 Function keys	• Make message segment deletion a two-switch action.	M-	M-	M+
	• Deactivate (or merely ignore) ACC SPA format selection matrix. Select formats from menus on RD Screen.	None to L-	M-	M+ to H+
1.4 Hybrid Methods	N/A	N/A	N/A	N/A
1.5 Prompts/HELPS	• Implement recommendation immediately above or redesign format selection matrix paper overlays.	None to L-	M-	M+ to H+
2. DISPLAY FORMAT				
2.1 Fixed Alphanumeric Displays	• Provide user/operator control of hardcopy output structure.	None	M-	M+
	• Provide a unique header for every hardcopy output message or report.	None	L-	L+ to M+
	• Provide message buffer on VFMED.	M-	L-	M+ to H+
	• Redesign message formats to achieve consistency of data element arrangement.	None	M+ to H+	H+
2.2 Variable-Length Alphanumeric Displays	N/A	N/A	N/A	N/A
2.3 Graphic Displays	• Provide overlay capability on graphics display device, or provide terrain features on display.	None to M-	M- to H-	L+ to M+
2.4 Highlighting	• Provide highlighting on VFMED and ACC displays.	M-	M-	M+ to H+
3. DATA ENTRY ASSISTANCE				
3.1 Information on Legal Entries	• Provide on-line checklists of legal values for data elements.	M-	M-	H+
3.2 Unburdening of Input	• Provide more convenient cursor movement capability.	None	L-	L+ to M+
	• Provide an alerting message in error message area to notify user/operator of urgent messages in queue.	None	M-	M+ to H+
	• Redesign cursor control to move cursor automatically to first data entry position when a new message format is displayed.	None	L-	L+ to M+
3.3 Interrupts and Work Recovery	N/A	N/A	N/A	N/A
4. MESSAGE COMPOSITION AIDS				
4.1 System Design Features	• Provide on-line checklists of requirements for multiple-message tasks.	None	M-	M+ to H+

*L = Low, M = Moderate, H = High impact; + = positive impact (benefit), - = negative impact (cost)

Table 1 (Continued)

CATEGORY	RECOMMENDATIONS	IMPACT* Hardware	Software	User/Operator Performance
	• Provide protection for data element names by skipping past them automatically.			
	• Provide unambiguous feedback to DMD operator about status of messages transmitted from DMD.	None	M-	M+ to H+
4.2 Format for Alphanumeric Messages	• Highlight data element names to help operator work through format.	M-	L-	M+ to H+
	• Redesign TACFIRE formats for easier use.	None	M-	M+ to H+
	• Redesign TACFIRE formats for consistency with formats of input sources.	None	M-	M+ to H+
4.3 Graphic Messages	N/A	N/A	N/A	N/A
5. DATA RETRIEVAL ASSISTANCE				
5.1 Query Method	• Provide capability to specify and delimit particular data categories for retrieval.	None	M-	M+
5.2 Query Structures	(Discussed in connection with other categories)			
6. GLOSSARIES				
6.1 Standard Terms	• Associate one unique element name with each unique data element and use in all messages containing that element.	None	M-	H+
	• Provide on-line definitions of data element names in error message area.	None	M-	H+
	• Give similar formats similar names at both division and battalion computers.			
6.2 Character Sets and Labels	N/A	N/A	N/A	N/A
6.3 Glossary Availability and Use	• Provide glossary information on-line.	None	M-	H+
6.4 Abbreviations and Coding	• Redesign abbreviations and codes IAW a consistent rule.	None	M-	H+
7. ERROR HANDLING				
7.1 Error Prevention	N/A	N/A	N/A	N/A
7.2 Error Detection	• Redesign TACFIRE to provide error checking after each data element is entered.	H-	M-	M+ to H+
7.3 Error Feedback	• Provide error feedback on-line.	None	M-	M+ to H+
	• Provide greater diagnostic information in error messages.	None	M-	H+

*L = Low, M = Moderate, H = High impact; + = positive impact (benefit), - = negative impact (cost)

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

INTRODUCTION

This document reports a human factors-oriented analysis of user/operator transactions with the Tactical Fire Direction System (TACFIRE). TACFIRE provides automated data processing to field artillery command and control. It is among the first of the Army's battlefield automated systems.

As indicated above, the analysis focused on user/operator transactions. It therefore did not examine such traditional human engineering features as stroke width of characters, force-displacement characteristics of keys, color- or shape-coding of knobs and levers, control-display ratios, or arrangements of workplaces. Indeed, the analysis addressed both hardware and software only insofar as they affect user/operator transactions. Throughout the effort, the emphasis remained on transaction features such as command methods, display formats, data entry and handling, message composition, data retrieval, glossaries, error handling, and user/operator configurations.

This analysis of TACFIRE, and those of other systems listed in the Preface, served to validate information gathered during an earlier survey of Army battlefield automated systems. It also provides additional information for a data base on user/operator transactions initially developed from the earlier survey. This data base identifies and classifies problems and deficiencies in the human-computer software interface of battlefield automated systems. It will provide the foundation for developing guidelines and criteria for the design of user/operator transactions with future systems.

No attempt is made here to integrate the analysis of TACFIRE with those of other systems. Such an integration clearly is required to permit the comparisons among systems that will reveal problems and deficiencies common to battlefield automated systems in general, and those unique to a particular system. The integration of separate analyses, comparisons among systems, description of problems and deficiencies, and conclusions and implications drawn from results are reported in Volume II of the final report of this project's first phase.

Because the analyses are oriented toward validating and enlarging a data base of problems and deficiencies in battlefield automated systems in general, recommendations for changes to TACFIRE or any other particular system are not a major purpose of the effort. However, the analytical technique described later leads naturally to recommendations for resolving problems and deficiencies described by the technique, and these recommendations are reproduced in the Appendix to this report. This issue is discussed more fully later in the report.

OVERVIEW OF THE SYSTEM

PURPOSE AND MAJOR FUNCTIONS

TACFIRE is "...an electronically integrated command control information system."[1] Its major functions are to provide:

1. Efficient communication in the operational elements of field artillery units.

2. Tactical fire control (i.e., target evaluation, and selection of cannon units for fire missions, munitions to be fired, and number of rounds to be fired by each gun).[2]

3. Technical fire control (i.e., computation of firing data for each fire mission).

4. Development of artillery target intelligence (ATI).

5. Fire planning.

6. Solution of survey schemes and data storage.

7. Support of the division artillery fire support element.

In addition, TACFIRE will integrate other field artillery subsystems currently under development including target acquisition radars, a battery computer system, an automated meteorological station, and a forward observer laser.

RELEVANT HARDWARE ELEMENTS

According to the document cited in Footnote 1, "TACFIRE provides central computers and terminal equipment to the field artillery command and control team. Central computers are provided to the corps FA section, HHB FA group, division artillery and cannon artillery battalions. Terminal equipment is

---

1/*Tacfire The Tactical Fire Direction System.* Reference Note, FT-CA RN. U.S. Army Field Artillery School, Department of Combat Development, Fort Sill, Oklahoma, April 79, p. 1-1.

2/*TACFIRE Tactical Fire Direction System.* TC 6-1. Headquarters, Department of the Army, 15 July 1977.

provided to forward observers, fire support officers, the firing batteries, the operation centers at both division artillery and battalion, and the divarty FSE." (p. 6-1). Typical deployment configurations of TACFIRE's central computers are illustrated in Figures 1 and 2.

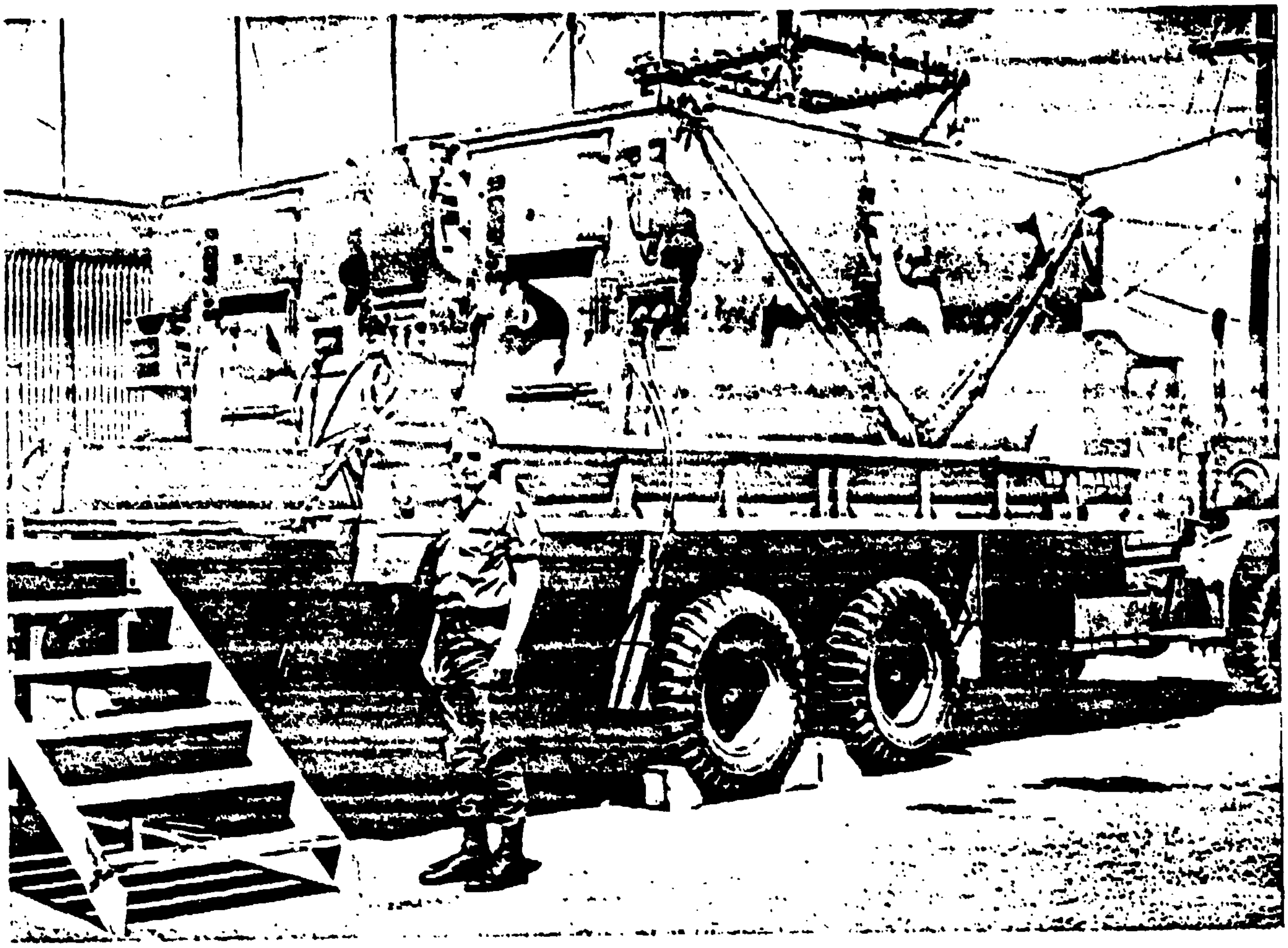

Figure 1. A typical configuration for a TACFIRE central computer facility.

The system's central computers at battalion, division, and corps are linked together by a communications net so that they can pass data among themselves. Additionally, terminal equipment can, when necessary, use one central computer to relay messages to and from another.

The system's functions are accomplished through a combination of hardware and software. Communication among the various elements, users, and operators is provided by a Communication Control Unit (CCU), a kind of programmable switchboard used to assemble, control, and service the necessary communication

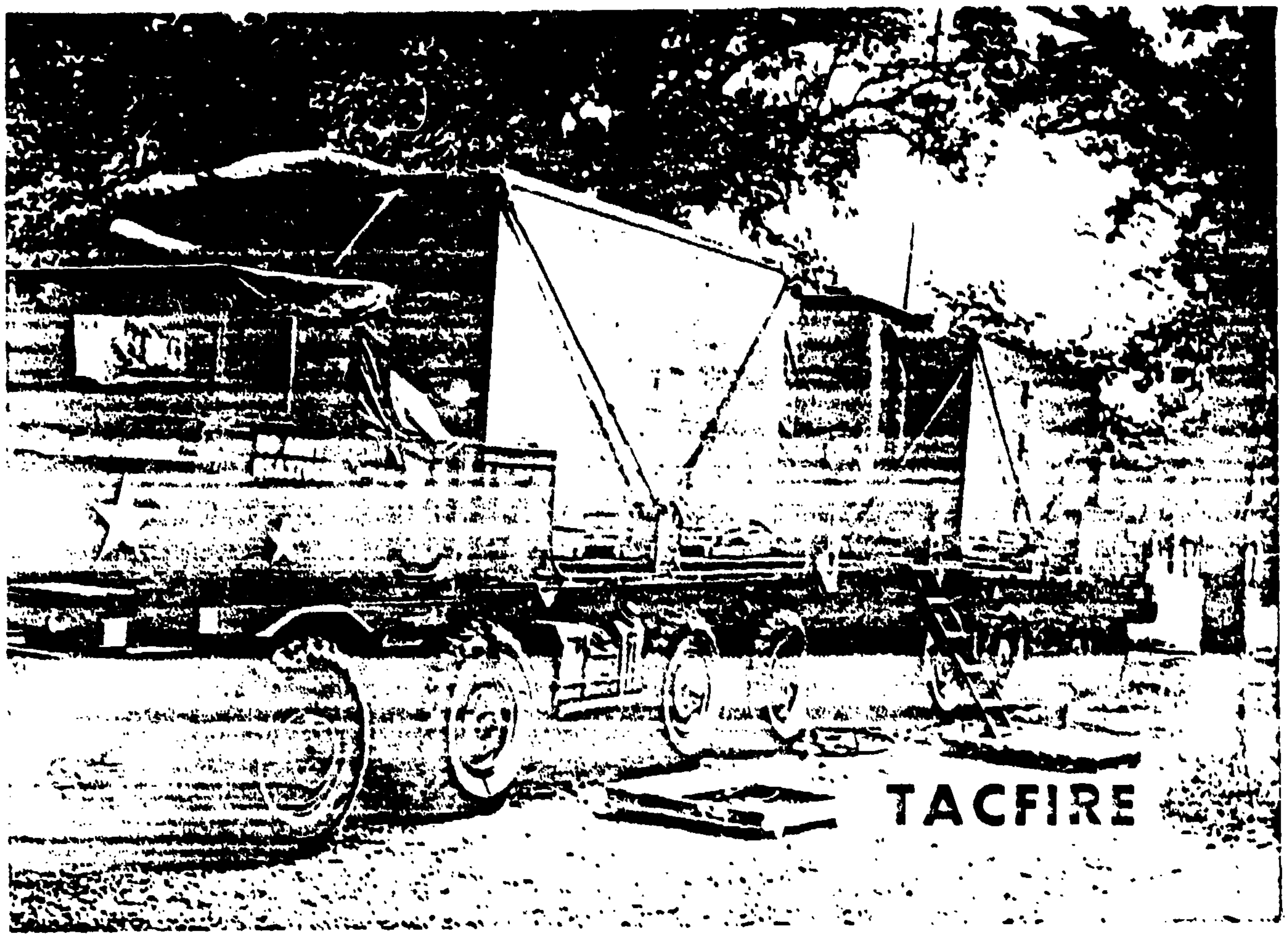

Figure 2. An Alternative Configuration for a TACFIRE Control Computer Facility.

nets. Electronic interface devices convert incoming frequency shift keying (FSK) signals to digital signals, and outgoing digital signals to FSK signals. Similar devices on remote terminal devices perform the same functions for these devices.

The elements of most concern to this project are those by which users/operators communicate with the system. These elements consist of the Artillery Control Console (ACC), the Variable Format Message Entry Device (VFMED), and the Digital Message Device (DMD). Other equipment at the central computer that relates to users/operators includes the electronic line printer (ELP) for hard-copy records of incoming and outgoing messages; the digital plotter map (DPM) for displaying incoming target intelligence, fire requests, and data recalled from the computer; and the electronic tactical display (ETD) used at corps FA section, division artillery, and FA brigade to display tactical information. The Battery Display Unit (BDU) includes a remote data terminal and a hard-copy device used to provide fire commands to firing batteries. However, it is a receive-only device, and is not considered further in this report. The configuration of computers and user/operator interface devices is shown in Figure 3.

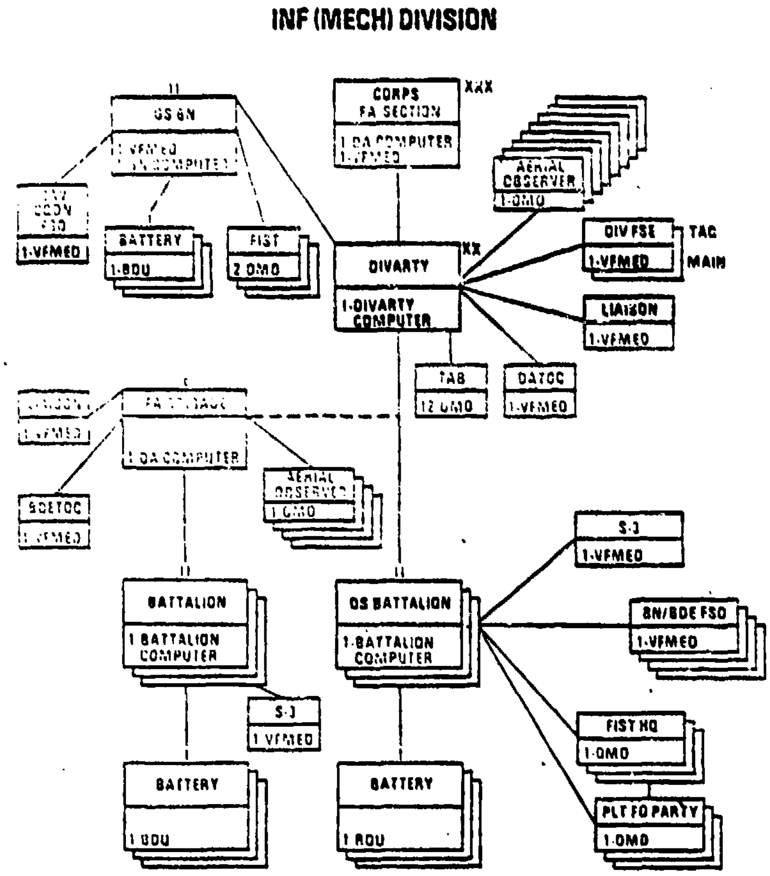

Figure 3. The TACFIRE Configuration for a Mechanized Infantry Division. (Extracted from *TACFIRE Tactical Fire Direction System*, TC 6-1, Headquarters, Department of the Army, 15 July, 1977.)

The Artillery Control Console (ACC)

The ACC is an integral component of the central computer. Thus, one is located at each cannon battalion, division artillery, FA group, and corps FA section. The ACC is operated by the fire control sergeant, under the supervision of the counterfire officer, at division artillery, FA group, and corps FA section. At cannon battalions, it is operated by the fire direction sergeant under the supervision of the fire direction officer. Using the ACC, the operator can control all computer operations.

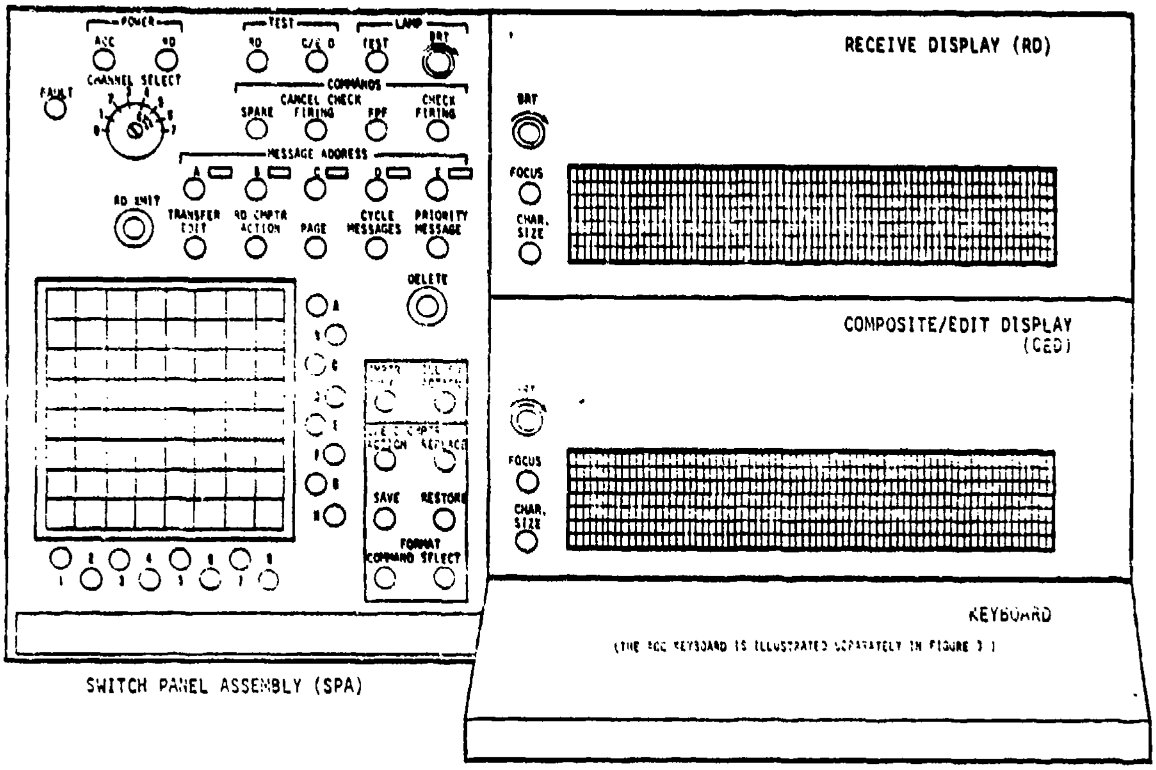

Figure 4. Configuration of the Artillery Control Console.

The configuration of the ACC is shown in Figure 4. The ACC consists of two CRT's called display editors (DEs), a standard alphanumeric keyboard augmented by additional keys and switches, and a switch panel assembly (SPA).

<u>The display editors (DEs)</u>. The upper DE is the receive display (RD), which is used for all incoming messages and computer outputs. When a message is received on the RD, the ACC operator (ACCO) reviews it for completeness and processing requirements. If the message is informational only, the ACCO merely notes the information and then deletes the message. If it requires processing and is acceptable, the message is transmitted to the computer. Otherwise, the ACCO moves it to the lower DE, which is the compose/edit display (C/ED or CED). The keyboard is then used to type in required additions, deletions, or corrections before transmitting the message to the computer for processing. The CED is also used to compose messages originating at the central computer site. These messages can then be transmitted to a remote display, to the computer for processing, or to another computer. All messages processed by the computer result in an output message, which is displayed on the RD. After the output message is reviewed, it can be deleted, moved to the CED for editing, or transmitted to the appropriate destination.

The Keyboard. The ACC keyboard contains the standard (QWERTY) four rows of keys, plus supplementary keys (such as "ACK" for acknowledge and "EOT" for end of transmission), controls (such as cursor reset, print, transmit, clear), and switches (power on/off, compose mode, auxiliary input/output). As noted above, the keyboard is used in conjunction with the CED. The configuration of the ACC keyboard is shown in Figure 5.

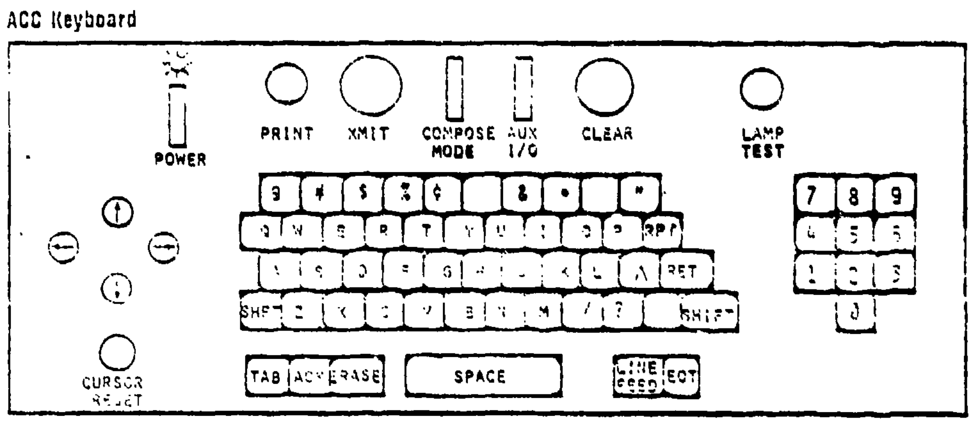

Figure 5. ACC Keyboard Configuration

The switch panel assembly (SPA). The SPA provides manual control of the computer. TACFIRE's commands are executed by means of switches on the SPA. In addition, the panel allows the ACCO to call up a maximum of 64 of the system's message formats via an 8x8 selection matrix. To call up a particular format, the ACCO presses the row and column switches corresponding to the matrix intersection containing the format identifier, and then presses the FORMAT COMMAND switch. These actions bring the desired format to the CED, where the ACCO performs the necessary operations on it from the keyboard. The configuration of the SPA is shown in Figure 4.

The Digital Message Device (DMD)

TACFIRE includes several different remote displays. The digital message device (DMD) shown in Figures 6 and 7 is a two-way device used by forward observers (FO's), air observers, sound and flash observers, and sound and flash centrals. The DMD is a portable device consisting of a display panel, a numeric keypad, a non-standard alpha-symbolic keyboard, and a set of operating controls. The DMD has the capability to relay through central computers

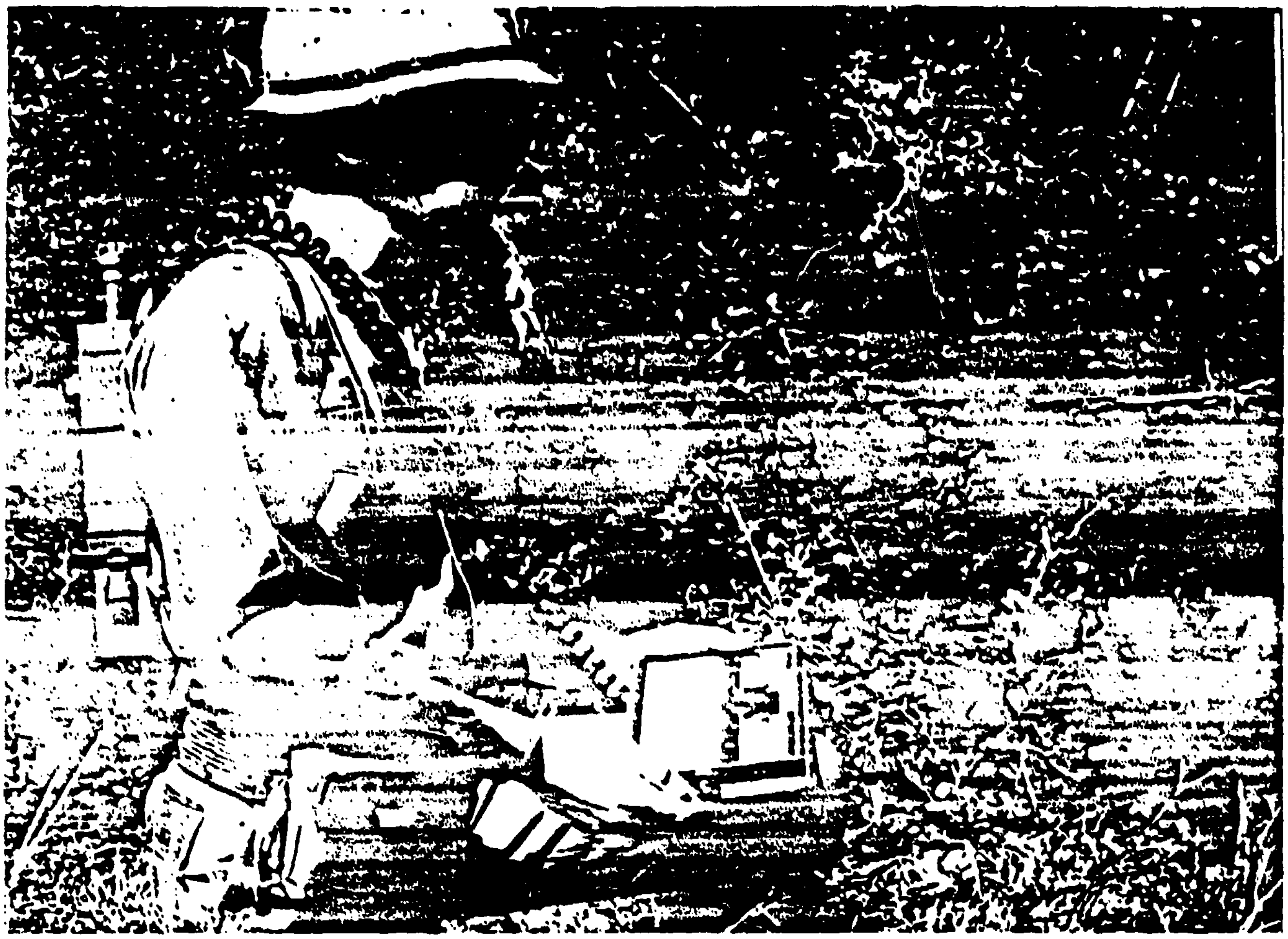

Figure 6. The digital message device (DMD) in use in the field.

to other remote devices. In addition, if another remote device is on the same frequency, the DMD can communicate directly with that device. However, these capabilities are used only in emergencies. The DMD normally communicates only with the central computer at the FA battalion's Fire Direction Center (FDC). The DMD is used primarily to transmit fire requests and artillery target information (ATI), and to receive the message to observer (MTO).

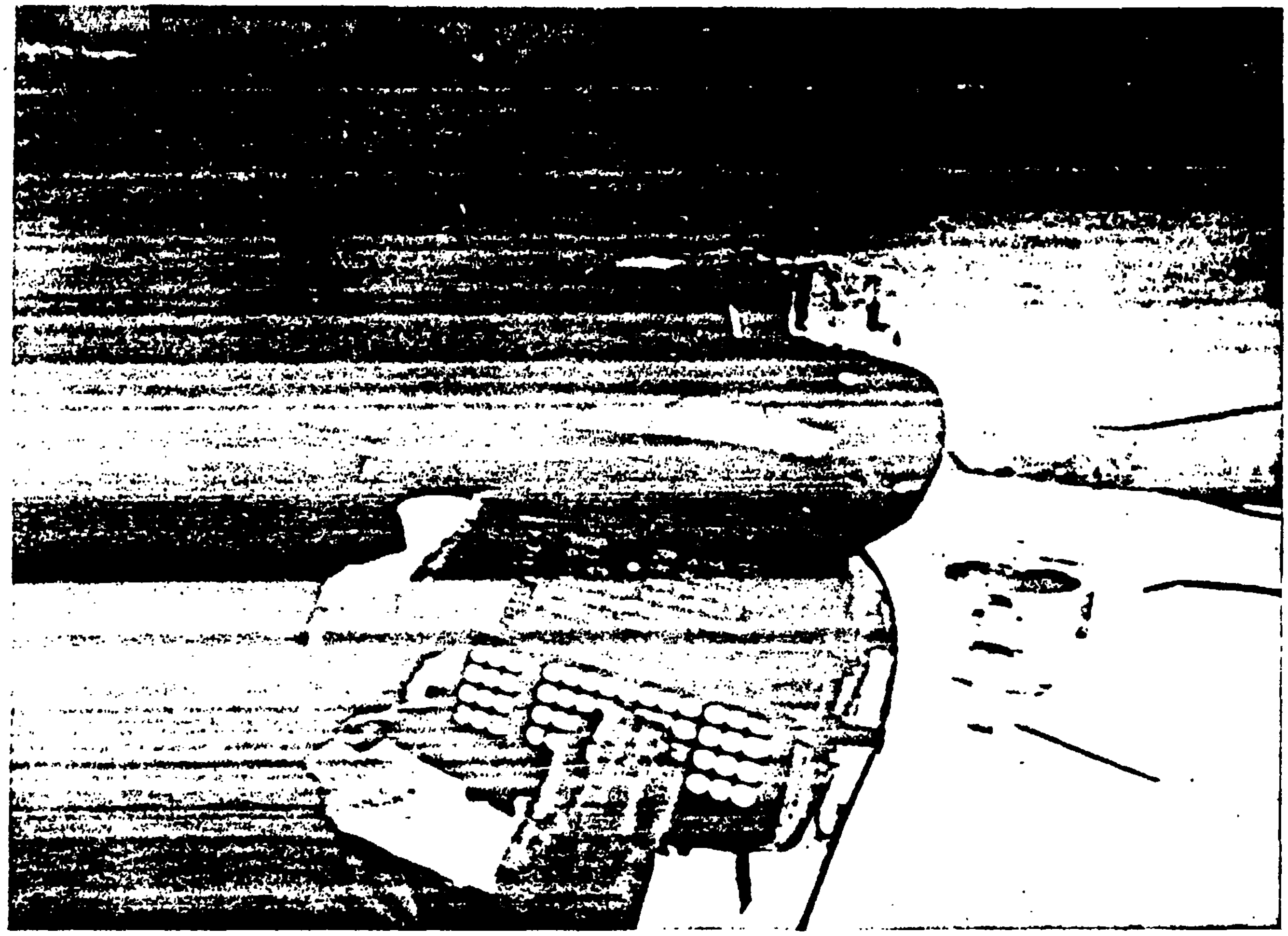

Figure 7. The DMD in Use.

The Variable Format Message Entry Device (VFMED)

The variable format message entry device (VFMED) shown in Figures 8 and 9 is a larger device than the DMD, with greater capabilities. It is a two-way device for encryption, transmission, receipt, and decryption of messages. The VFMED includes a standard QWERTY keyboard, a single display scope, and an ELP for message printing. The device is used by fire support officers (FSO's) at field artillery-support unit fire support elements (FSE's), by the operations and intelligence sections, and by counterfire personnel. It permits direct communication with central computer to provide data processing for remote locations.

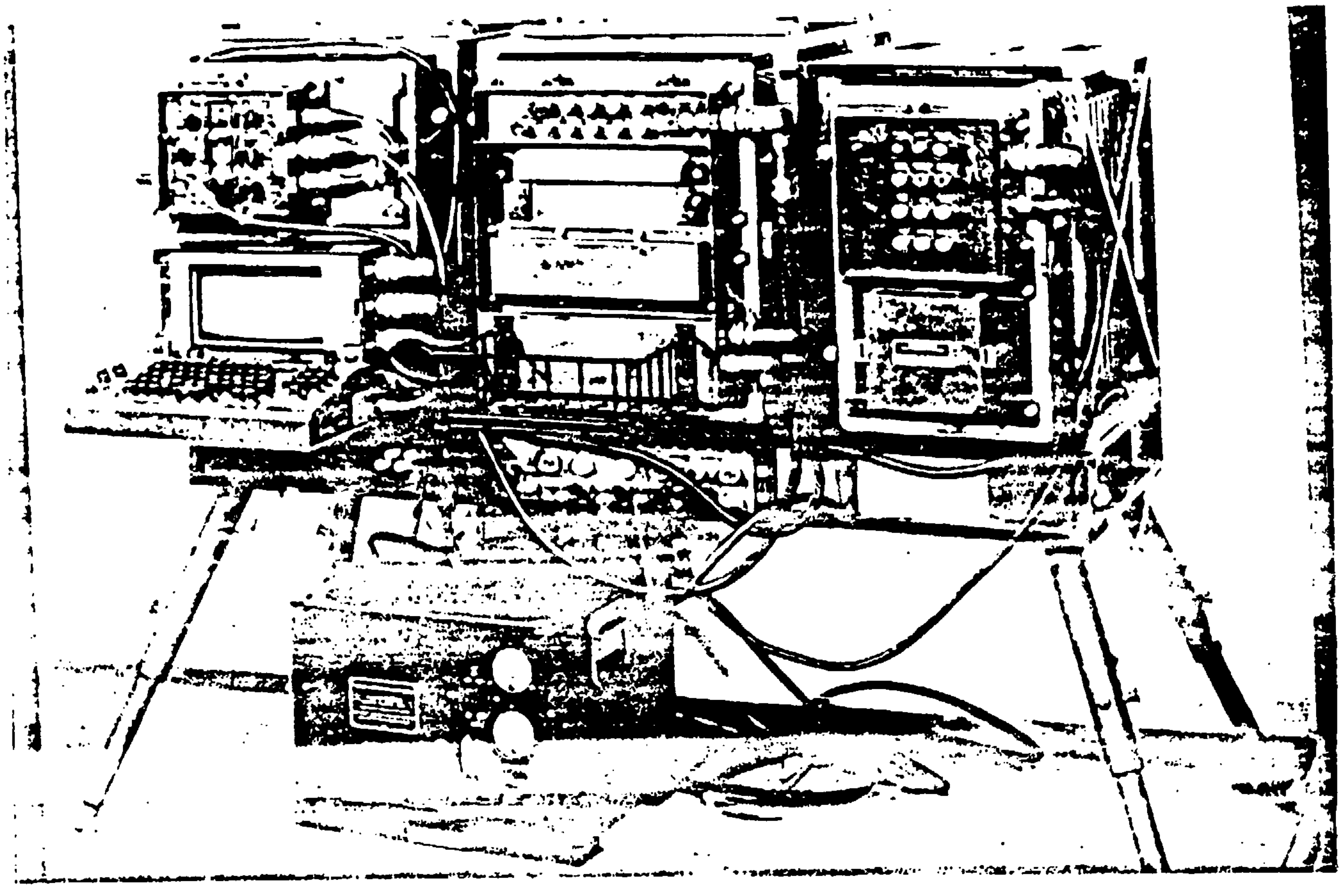

Figure 8. Configuration of the VFMED.

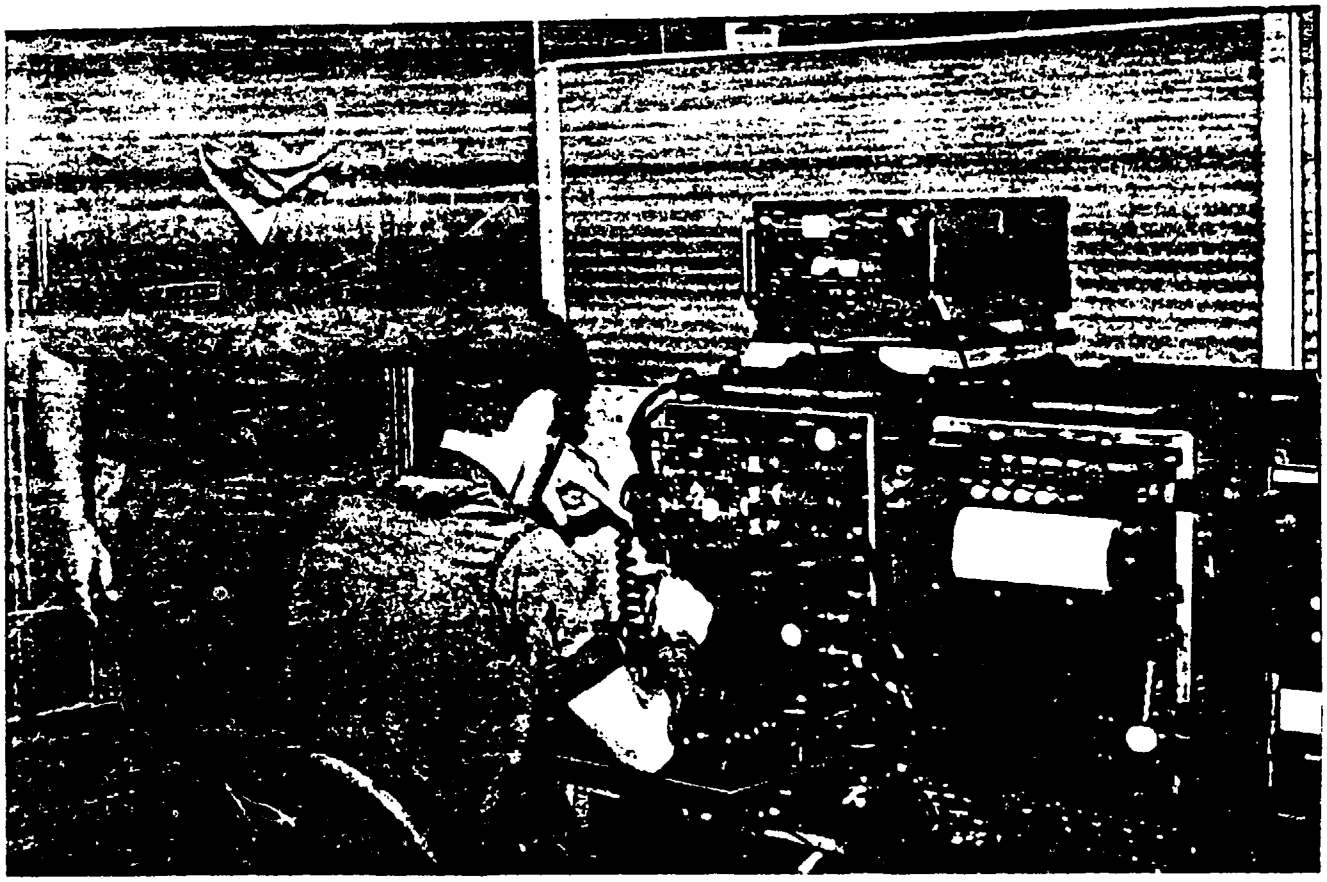

Figure 9. The VFMED in Use.

RELEVANT SOFTWARE ELEMENTS

TACFIRE software operations are initiated, controlled, and terminated by two primary methods. One method, function keys on the various terminal devices, is discussed in detail later in this report. The other method is a set of formatted messages, which are called up individually and then completed using a "fill in the blanks" approach. Though available documentation is not specific, subject matter experts report between 220 and 230 separate message formats. These formats are divided among ten program types and general message categories, as shown in Table 2.

Each formatted message is presented in a 7-line, 72-character area of the displays on the ACC at the division artillery or FA battalion computer, or on the VFMED at varous remote locations (an additional two lines are available for error messages). On the DMD, messages are constructed in a unique format. When DMD messages are received for processing by the computer, the machine converts them to the ACC/VFMED format. Figure 10 illustrates the latter format.

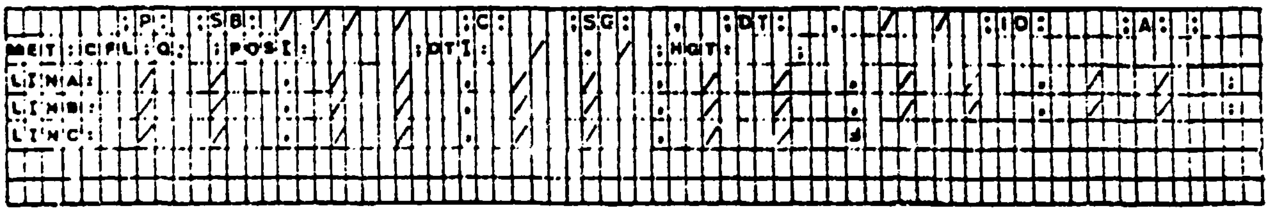

Figure 10. Sample TACFIRE Formatted Message.

Each ACC/VFMED message is composed of four basic components: (1) a message header, which has the same format for all TACFIRE messages, and is always presented on line 1 (Figure 10); (2) a message identifier, which is always the first eight to ten characters on line 2 ("MET;CFL;" in Figure 10); (3) one or more "data elements;" and (4) an end-of-message symbol.

A data element consists of two parts: (1) an "element name," which identifies the data to be entered into the element; and (2) an "element field," which provides space for the actual entry of data. An element name is always followed by a colon, and an element field is always followed by a semi-colon.

An element field may be divided into "subfields". Note, for example, the element name "SB:" in the header line of Figure 10. The element field

Table 2

TACFIRE Application Program Areas and General Message Types

PROGRAM AREA AND MESSAGE TYPE	MNEMONIC IDENTIFIER	PURPOSE PURPOSE/FUNCTION
System	SYS	Control the scheduling of processing, determination of priorities, input and output of data, scheduling of operations, establishment and maintenance of the COMSEC function, and the establishment of system subscribers.
Support	SPRT	Determine locations of units, targets, and battlefield geometry; control the display of units, targets, and battlefield geometry; maintain data on the weapon systems within the Army inventory.
Ammunition and Fire Unit Status	AFU	Control the initial entry and subsequent update of fire units and their ammunition.
Tactical and Technical Fire Control	FM	Process fire missions and determine the best unit/shell/fuze combination to use to defeat a target. Compute the actual ballistic solutions to requests for fire.
Artillery Target Intelligence	ATI	Process intelligence reports, target buildup; generate fire missions automatically.
Meteorological	MET	Update weather data for ballistic computations.
Survey	SURV	Compute control point locations to define boundaries and the location of battlefield geometry; perform survey calculations.
Non-Nuclear Fire Planning	NNFP	Prepare fire plans using non-nuclear munitions.
Fire Support Element	FSE	Provide the capability to conduct preliminary target analysis, nuclear target analysis, chemical target analysis, fallout prediction, and nuclear fire planning.
Command	COMD	Permit initiation or cancellation of check firing; permit final protective fire.

is divided into three single-character subfields, a two-character subfield, and a three-character subfield. Notice that adjacent subfields are separated by a virgule (/).

Subfields may be "iterated". Notice line 3 of Figure 10, for example. The data element name is "LINA:", and the element field extends to column 70, with the terminating semi-colon in column 71. Notice that the first subfield in the element field is two characters in length. This subfield is followed by a virgule, a three-character subfield, a second virgule, and a second three-character subfield. Notice also that a comma follows the second three-character subfield. The comma signals the user/operator to expect iteration of the subfields that precede the comma. And, inspection of line 3 in Figure 10 shows that the subfields following the comma are identical in format to those preceding the comma; that is, the subfields preceding the comma are reiterated following the comma. In this manner, TACFIRE permits data that are identical in format (though different in specific values) to be entered without wasting space with repetitive element names.

However, notice line 4 of the illustration. The data element labeled "LINB:" is identical in format to "LINA:". This feature illustrates a restriction on TACFIRE message formats. A data element must appear in its entirety on a single line; no portion of the element may continue to a subsequent line. This restriction also explains the blank space at the end of line 2 in Figure 10, following the data element labeled "HGT:"; the line had sufficient space remaining for only one set of two-character/three-character/three-character subfields. The format designer evidently elected to leave this space blank and begin subsequent data entry on line 3.

The final component of an ACC/VFMED message format is the end-of-message symbol. This symbol is shown as an upside-down "F" in all illustrations of TACFIRE formats. It always replaces the semi-colon in the last element field of a message. The features described above are summaried in Table 3.

Table 3

Field Delimiting Symbols Used in ACC/VFMED Formatted Messages

Symbol	Definition
:	Follows the element name of a data element (and precedes the element field).
;	Follows the element field (and precedes the next element name if another data element appears on on the same line).
/	Separates an element field into subfields.
,	Denotes iteration of subfields.
[illegible]	Indicates end of message.

ANALYSIS OF TRANSACTION FEATURES

As with other analyses in this series, TACFIRE was analyzed by means of two primary methods: document reviews and interviews with subject matter experts. In both methods, personnel recorded their observations using a Transaction Feature Analysis technique developed by Synectics for this purpose. Table 4 illustrates the observation recording form used with the technique, and explains each of the forms' sections.

The Transaction Feature Analysis technique is useful in helping the analyst detect and describe desirable as well as undesirable design features affecting user/operator transactions. In the case of desirable features, the technique can capture lessons learned from one system that will be relevant to other, perhaps future, systems. In this way, the technique can help to overcome the problem of information transfer among systems. Of course, when describing a desirable feature, the analyst enters a uniform notation for Recommended Resolution: "None required."

Table 4

Description of the Transaction Feature Analysis Technique

Transaction Feature. The analyst describes the type of transactions being analyzed.
Description. The analyst describes how the feature works in system operations. The description includes a specific example of the feature in straightforward, operational terms.
Behavioral Implication. The analyst describes the feature's impact on the user's/operator's performance. The description includes what the individual must do--and must not do--in using the feature. It also includes requirements imposed upon the user/operator in terms of memory burden, error liklihood, skill requirements, and/or other performance-related issues.
Transactional Implication. The analyst describes the feature's effect on the system's processing operations. The description includes issues such as the system's ability to detect errors, its error handling procedures, and/or the time required to complete transactions.
Consequences. The analyst describes the feature's impact on overall system performance. Here, the analyst predicts the answers to questions such as the following. What effect does the feature have on the accuracy and timeliness of the data base? What effect does the feature have on the quantity and quality of output? Will the commander's picture of the battlefield be enhanced or distorted? Will targets be fired more quickly, or lost?
Recommended Resolution. The analyst describes specific, detailed remedial action. These recommendations include changes to hardware, software, or procedures that will improve system performance.

Transaction features analyzed with the technique are organized according to the categories shown in Table 5. Results of the analyses are discussed in the same order; the individual analyses are presented in the Appendix.

1.0 CONTROL METHODS

Control methods are the methods by which the user/operator controls the sequence of execution of system functions. Using control methods, the user/operator instructs the computer which functions to perform, and in what order.

1.1 Command Language

For purpose of this effort, project personnel define command language as the syntax and vocabulary of system control instructions that are entered

Table 5

Categories of Design Features Affecting User/Operator Transactions with Battlefield Atuomated Systems

1. CONTROL METHODS
   - 1.1 Command Languages
   - 1.2 Menus
   - 1.3 Function Keys
   - 1.4 Hybrid Methods
   - 1.5 Prompts/HELPS
2. DISPLAY FORMAT
   - 2.1 Fixed Alphanumeric Displays
   - 2.2 Variable-Length Alphanumeric Displays
   - 2.3 Graphic Displays
   - 2.4 Highlighting
3. DATA ENTRY AND HANDLING
   - 3.1 Information on Legal Entries
   - 3.2 Unburdening of Input
   - 3.3 Interrupts and Work Recovery
   - 3.4 Manipulating Stored Data
4. MESSAGE COMPOSITION AIDS
   - 4.1 System Design Features
   - 4.2 Format for Alphanumeric Messages
   - 4.3 Graphic Messages
5. DATA RETRIEVAL ASSISTANCE
   - 5.1 Query Method
   - 5.2 Query Structure
6. GLOSSARIES
   - 6.1 Standard Terms
   - 6.2 Character Sets and Labels
   - 6.3 Glossary Availability and Use
   - 6.4 Abbreviation and Coding
7. ERROR HANDLING
   - 7.1 Prevention
   - 7.2 Detection
   - 7.3 Feedback
   - 7.4 Correction/Recovery
8. USER/OPERATOR CONFIGURATION
   - 8.1 Operator(s) Only
   - 8.2 Operator(s) and User(s)
   - 8.3 Combined User/Operator
   - 8.4 User and Operator Chains

into the computer as statements composed of words, abbreviations, or codes (commands) and appropriate parameters. Most typically, such statements are entered by typing at a keyboard. Under this definition, TACFIRE does not incorporate a command language. System control instructions are entered into the computer via menus and function keys.

1.2 Menus

TACFIRE makes limited use of menus, but uses them in two principal ways. Some messages have embedded menus to provide options for editing and other functions. Also, a format directory message is provided for each program area/message type. Problems in menus center around the use of different input characters to indicate menu selections in various messages, and the horizontal arrangement of menu options.

1.3 Function Keys

The majority of TACFIRE function keys are contained on the ACC SPA (Table 6); function keys on the VFMED and DMD are more limited in number, but those available perform functions similar to their counterparts on the ACC. The DELETE switch on the ACC provides the capability to delete an entire sequence of messages inadvertently. However, the major problem in the function key arena is the 8 x 8 message format selection matrix, which imposes on the user/operator a requirement for careful eye/hand coordination.

1.4 Hybrid Methods

Project personnel did not observe any hybrid control methods in TACFIRE, such as, for example, using a function key to indicate a selection from a menu displayed on a CRT.

1.5 Prompts/HELPS

Prompts are plentiful in TACFIRE. That is, the 8 x 8 format selection matrix and the individual format directory menus provide prompts regarding message format identifiers (e.g., FM;RFAF). Also, each message format contains data element names to prompt the user/operator to enter data in the element fields. Many of these prompts are highly meaningful (e.g., "COORD" for

Table 6

Fixed Function Keys on the TACFIRE ACC SPA

Function Key	Function
Channel Select Switch	Designates the adjacent DEC addresses to which the ACC is assigned for data exchange with the computer.
Message Addresses Switches (5 of them labeled: A, B, C, D, & E)	Each switch, when activated, causes the ACC to address the subscriber(s) associated with that switch via the SYS;ADDR format. If no message address switch(es) specified, the ACC addresses all battalions and Battalion ACC DivArty addresses. The message address switches can be used in conjunction with RD XMIT, COMMAND, or the Keyboard XMIT switch.
SPARE	One of 4 COMMAND switches. When pressed and then RD CMPTR ACTION switch is pressed (when message is on RD), operator can override misidentified, misauthenticated, or misserialized messages, or can initiate automatic resync procedures.
CANCEL CHECK FIRING	One of 4 COMMAND switches. Generates and transmits a special command to conceal firing to those addresses designated by the MESSAGE ADDRESS switch(es).
FPF	One of 4 COMMAND switches. Generates and transmits a special command for final protective fire to those addresses designated by the MESSAGE ADDRESS switch(es).
CHECK FIRING	One of 4 COMMAND switches. Generates and transmits a special command to begin check firing to those addresses designated by the MESSAGE ADDRESS switch(es).
RD XMIT	Causes message displayed on RD and all segments to be transmitted to indicated addresses and removed from receive queue and status line. Next message in queue is displayed; status line is updated. If pressed following non-acknowledge message, message is retransmitted. If pressed while SUBSCRIBER OFF warning is displayed, entire subscriber file is processed for transmission. If receive queue is empty when RD EMIT is pressed, ILL SW ACTION indicator lights.
TRANSFER TO EDIT	Transfers message on RD to CED. RD is cleared and either next message segment or next message in the queue is displayed. During the transfer-to-edit process, CED is cleared before transferring information from RD.
RD CMPTR ACTION	Clears RD and displays the next message in the queue; status line is updated. Message appearing on RD before activation of RD CMPTR ACTION switch is activated becomes input to computer when switch is pressed. Computed solution, if any, is added to the receive queue with status line updated.
PAGE	Clears RD and displays next message segment with status line updated. Subsequent activation displays remaining message segments.

Table 6. (Continued)

CYCLE MESSAGE	Clears RD and displays next message in queue with status line updated. Each activation displays next message. When lowest-priority message has been displayed, next activation of switch displays highest priority message.
PRIORITY MESSAGE	Lights when message with higher priority than message currently being displayed is added to the queue. When pressed, RD is cleared and highest priority message is displayed with status line updated. Indicator goes off.
DELETE	Clears RD and next message in queue is displayed. If segment of message is deleted, next message segment is displayed. If segment deleted was first segment of segmented message, entire message is deleted. Message cleared from RD is removed from the queue and status line is updated. If receive queue empty when DELETE is pressed, ILL SW ACTION indicator lights.
ILL SW ACTION	Indicator lights when illegal switch operation has taken place. Additional switch actions are not accepted until ILL SW ACTION is pressed. Indicator goes off, status lines are updated, and display of or removal of comm line or message displayed on the RD occurs.
C/ED CMPTR ACTION	Causes transmission of message to computer for processing. Processed solution may be added to receive queue and status line as received message.
REPLACE	Causes message on CED to be returned to its original place in receive queue; CED is cleared. Is used when editing multiple-segment received messages. Only one segment at a time is transferred to CED; each edited segment must be returned to its original place in the receive queue.
SAVE	Clears the CED and message is transferred to CED buffer for temporary storage. Action is illegal on a message transferred to the CED from the RD by means of the TRANSFER TO EDIT switch. (This action activates the ILL SW ACTION switch.)
RESTORE	Clears the CED and causes the SAVE indicator to activate and the saved message is removed from the CED buffer and transferred to the CED. (Activation of this switch when the SAVE indicator is not lighted activates the ILL SW ACTION switch.)
Format/command matrix switch-indicators A through H; 1 through 8.	Row and column switches designate cell in format/command matrix. Cell defines message format skeleton, message format directory, or operating system program command. Subsequent activation of FORMAT COMMAND switch displays selected skeleton or directory on CED, or executes command.
FORMAT COMMAND	Clears the CED and displays format skeleton selected using the format/command matrix or message format directory displayed on the CED. Or, other commands are processed.
FORMAT SELECT	When message format directory is displayed on the CED, desired format is selected by placing cursor just before and under first letter of the appropriate message skeleton name and pressing the FORMAT SELECT switch. The CED is cleared and the selected message format skeleton is displayed.

coordinates and "FUZE" for fuses) and aid the user/operator to decide what data are required in the element field. However, TACFIRE is inconsistent in regard to prompts, in two ways. First, many prompts cannot easily be associated with a data type (e.g., "D" does not associate with subscriber index number). Second, the same prompt is often associated with more than one data type (e.g., "D" refers to subscriber index number in the SYS; ADDR message, and to command post location and closing time in the AFU;SR message).

HELPS are software routines which allow the user/operator to break out of the normal procedure for a transaction, obtain assistance regarding definitions of terms or values of legal entries, and then return to the point at which the normal procedure was interrupted. Project personnel did not observe any HELPS in TACFIRE. This is a deficiency of the system, because it forces the user/operator to resort to offline job aids for assistance at virtually any point of difficulty.

2.0 DISPLAY FORMAT

2.1 Fixed Alphanumeric Displays

TACFIRE displays are severely limited in regard to space. Each display on the ACC and VFMED is fixed at 7 lines and 72 columns. As a result, displays tend to be densely packed with information, making difficult any attempt to scan a message to find a selected data item or to review a completed message for accuracy and completeness. In addition, the VFMED is a "dumb" terminal, providing no display buffer. The user/operator must take overt action to clear the screen before an incoming message arrives; otherwise, the incominb message simply overprints whatever is already on the display screen, with a high probability that portions of the resulting display will be garbled.

Output reports also present problems. Some output reports have headings or identifiers (e.g., SYS;1201), while others don't. On the latter, the information is merely printed out, and the user/operator must recognize the report by its content. Also, some reports have the same identifier, but different contents. For example, a SYS;1201 report can contain a list of all message types for input, a list of legal message types for auto relay, and a list of message addresses. The various segments just described can also be printed separately; each such segment will be identified as SYS;1201. There is great potential for confusion between various segmented and complete reports as users/operators search for specific items of information.

2.2 Variable-length Alphanumeric Displays

All TACFIRE message formats are fixed in length. Output reports vary in length primarily as a function of amount of information reported. Project personnel found no features regarding variable-length alphanumeric displays that required Transaction Feature Analysis.

2.3 Graphic Displays

TACFIRE provides graphic display capability only with the DIVARTY computer. The major problem noted in connection with the graphic display device is that it presents information essentially in "free space." That is, the device has no capability to use map overlays or underlays, and it does not display identifying terrain features. Thus, graphic symbols appear on the display without contextual information, necessitating frequent references to a separate map.

2.4 Highlighting

The only instance of highlighting in TACFIRE occurs on the DMD, where the element name flashes to identify the data element currently being completed. The ACC and VFMED apparently have no highlighting capability to draw the user's/operator's attention to particularly important portions of the display.

3.0 DATA ENTRY ASSISTANCE

3.1 Information on Legal Entries

The TACFIRE computer provides no information on legal data entries. All legal entry information is contained in off-line manuals.

3.2 Unburdening of Input

TACFIRE has few provisions for unburdening the user's/operator's input tasks. For example, if the same coordinates are required in two separate messages, the user/operator must enter each coordinate twice, once for each message. The computer has no capability to fill in such redundant information automatically, nor to permit the user/operator to order it filled in. Also, TACFIRE provides no automatic cursor placement. That is, the computer does not have the cursor automatically when a new message format is called up. There is no capability to position the cursor automatically to the element field in which an error has been detected. There is also no capability to skip over element field names automatically during data entry. For all such operations, the user/operator must space the cursor manually, using cursor control keys. Additionally, the only capability the user/operator has to examine the contents of the message queue is to page through the queue, one message at a time. There is no capability to query the computer regarding the presence in the queue of time-sensitive messages.

3.3 Interrupts and Work Recovery

Information available to project personnel revealed nothing about this topic, beyond the capability to save the message currently on the screen in a temporary buffer and to recall that message later. Project personnel observed no features in this category requiring Transaction Feature Analysis.

4.0 MESSAGE COMPOSITION AIDS

4.1 System Design Features

A potentially serious problem arises in the design of keyboards used at TACFIRE workstations. Figure 11 compares the configurations of the DMD and ACC keyboards. Notice that both the alphabetic key groups and the numeric keypads are arranged in radically different ways. The differences in these two designs will be troublesome to users/operators who transfer from one workstation to the other. Having learned to use one terminal, they will have to unlearn those skills while also learning the other terminal. This will be a highly error-prone situation, particularly for experienced personnel.

At least two other TACFIRE system design features may cause problems for users/operators. One is the lack of protected fields; data element names can be overprinted because the cursor does not skip automatically past these names. Thus, either inadvertently or deliberately, a user/operator can change data

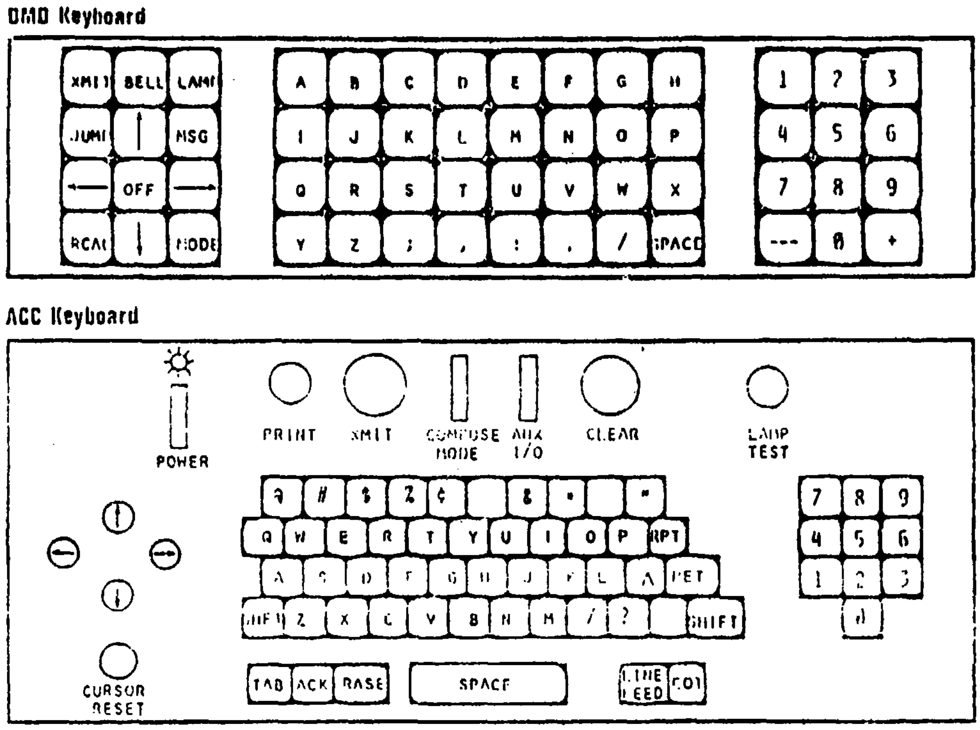

Figure 11. Two Keyboard Configurations Used in TACFIRE.

element names by overprinting, thereby incurring errors or entering erroneous data into the data base. Indeed, a user/operator could call up an authorized format and then type in, character by character, an entirely different authorized message--or even an unauthorized message. In this way, the possibility exists that unauthorized personnel could change critical data such as commander's criteria and no-fire areas.

Another problem occurs in the technique for DMD message transmission. DMD digital messages are "piggybacked" onto voice channels. Because the communications network is designed to give precedence to voice traffic, voice transmissions can easily override parts or all of DMD messages, delaying fire requests and other important information.

4.2 Format for Alphanumeric Messages

Because of the small sizes of display screens, TACFIRE formatted messages are densely packed with data element names and element fields. This density requires the user/operator to monitor cursor position closely, impedes efforts to review completed messages for accuracy and completeness, and impedes efforts to locate fields in which errors have occurred. Also, subject matter experts report that many of the formats of input messages do not correspond to the formats of data sources such as printed data recording forms or voice messages. Thus, users/operators frequently are observed to skip around in the displayed format as they enter data. In addition to causing excessive cursor movement with consequent waste of time, such skipping literally encourages errors of omission.

4.3 Graphic Messages

Project personnel had no opportunity to observe graphic messages in TACFIRE. Therefore, no opportunity arose for Transaction Feature Analyses in this category.

5.0 DATA RETRIEVAL ASSISTANCE

5.1 Query Methods

The user/operator queries the TACFIRE data base through query messages similar in format to other messages. The only problem observed in this category relates to queries for similar data types from multiple files. Each file requires a separate query message, even if the desired type of data does not change. This requirement imposes an administrative burden upon the user/operator, and consumes time that could otherwise be spent on other transactions.

5.2 Query Structures

The structures of query messages in TACFIRE do not differ significantly from these of other input messages. Therefore, Transaction Feature Analyses of messages reported elsewhere in this report apply equally to query messages.

6.0 GLOSSARIES

Glossaries are perhaps the greatest single source of trouble for the TACFIRE user/operator. Undesirable transaction features were found in each of this major category's four minor categories, as described below.

6.1 Standard Terms

TACFIRE uses approximately 225 different message formats. These formats include in excess of 900 data element names; project personnel had no opportunity to count the number of legal entries required to complete the element fields for all these data elements. However, at least 10 manuals[3] are required to describe procedures for using the available message formats and to describe the data elements, their element names, and the legal entries for their names. User's manuals by definition are job aids; the sheer volume of these aids testifies to the unwieldy procedures and memory burden imposed upon TACFIRE users/operators.

Even astronauts, who were selected with excruciating care and given extensive training, were not required to memorize so many data codes. Thus, TACFIRE users/operators (who are not asked to memorize the system's glossary) must rely heavily on off-line documentation, particularly since the computer provides no on-line glossary assistance. This slows down the performance of transactions and reduces system efficiency. In addition, should these documents be lost or become unusable through damage, the consequences to mission effectiveness could be severe.

Some data element names have different meanings in different messages. For example, the code "D" refers to a subscriber index number in the "SYS;ADDR" message, and to both a command post location and its closing time in the "AFU;-SR" message. At the same time, different names are often used in separate messages to refer to the same data element. Thus, "CORD," "CORD1," "COORD," and "COORD1" all are codes for "coordinates." Such inconsistencies in data elements may actually encourage users/operators to commit errors.

In another vein, message format designators may add to the user's/operator's confusion. For example, to update ammunition inventories at DIVARTY, the user/operator calls up the "AFU;BAMOUP" message. Meanwhile, at the FA battalion, the user/operator performs the same function using a format that differs from the "AFU;BAMOUP" only in details, but is labeled "AFU;AMOUPD." A user/operator who transfers from DIVARTY to FA battalion--or vice versa--surely will experience confusion over such anomalies, at least initially. During fast-moving tactical operations or under other forms of stress, the user/operator may

---

[3]/TM 11-7400-240-10, volumes 1 through 10.

"regress" and try to call up a message format by its "old" designator. Ironically, the more experienced the individual, the more likely errors will occur.

In addition, TACFIRE codes sometimes conflict with doctrinal terminology. Figure 12 compares nine versions of codes used in TACFIRE with their doctrinal counterparts in FM6-20. Conflicts such as these are an unnecessary source of confusion to users/operators, since they force the individual to remember two different codes for a single concept.

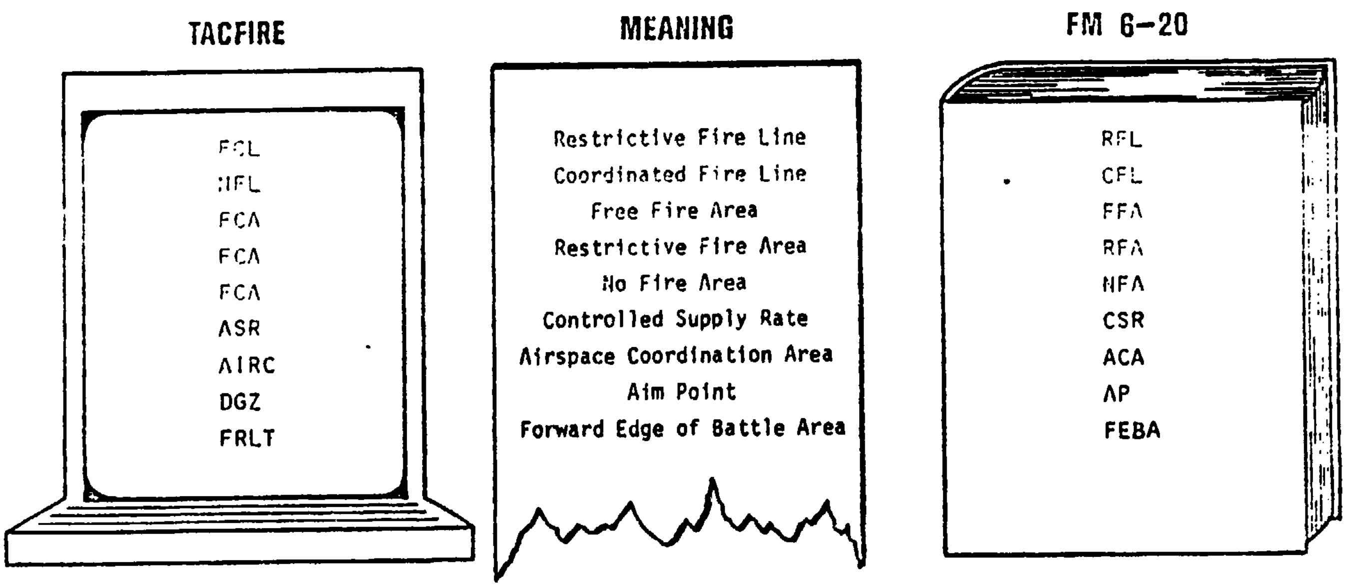

Figure 12. Comparison of TACFIRE codes with standard codes from FM6-20.

6.2 Character Sets and Labels

TACFIRE uses the 26 characters of the alphabet and the digits 0 through 9 for data entry. Special symbols (Table 2) appear to be used only as delimiters, as described earlier. The graphics display at DIVARTY uses other symbols; however, subject matter experts report that the device is seldom used because it does not display terrain features. Project personnel observed no features in TACFIRE character sets and labels that required Transaction Feature Analysis (data element labels are treated in other portions of this section).

6.3 Glossary Availability and Use

In other categories of transaction features, project personnel observed no problems where one could say, "This problem would make the system fail." However, in the case of glossary availability, one can imagine such a situation arising. TACFIRE glossaries are contained exclusively in off-line documentation; the computer provides no on-line definitions of data element names and no on-line dictionaries of legal terms. As noted above, there are so many such names and terms that no user/operator could reasonably be expected to memorize more than a relatively few of them. In a fluid tactical situation, if the off-line documents should be lost, one could easily imagine that a situation might arise in which users/operators would need to enter messages beyond their normal (and presumably well-learned) repertoire. Deprived of their primary job aids--the documents--users/operators could only guess at element name definitions and at legal entries. In this event, the system very well might fail to perform its mission.

6.4 Abbreviations and Coding

The TACFIRE glossary contains a mixture of full words (e.g., "SPHERE," "FUZE") abbreviations (e.g., "COORD," "FZE"), mnemonics (e.g., "GZ," "DTG"), and codes (e.g., "D," "LINA"). No consistent rule for formulating these element names has been discovered. This lack of consistency complicates the user's/operator's attempts to decode element names and forces even greater reliance on off-line job aids.

7.0 ERROR HANDLING

7.1 Error Prevention

TACFIRE appears to incorporate only one on-line error-prevention technique: data element names. However, as noted repeatedly above, the numbers, redundancies and inconsistencies in these element names appear to degrade rather than enhance user/operator performance.

7.2 Error Detection

TACFIRE performs no error checking until a message is completed and entered for processing. Then, it checks the message one field at a time. If an error is detected, an error message is displayed (however, see Section 7.3:

Error Feedback) and processing of the message stops. The user/operator corrects the erroneous entry (see Section 7.4: Error Correction/Recovery), and error checking continues. The machine provides no indication of multiple errors, detecting the next error only after the previous error has been corrected. This procedure is a needless annoyance to the user/operator, and delays the completion of transactions.

7.3 Error Feedback

Some TACFIRE error messages are reasonably clear and specific. For example, if a user/operator attempts to enter 39 as the day of the month in the SYS;INIT message, the error indication "DAY TOO LARGE FOR MONTH" probably will make the nature of the error clear (although appending "IN DATE FIELD" would be even more explicit). However, most error messages examined by project personnel appeared far more cryptic. "AA/AAA ILLEGAL MESSAGE CATEGORY," for example, does not tell the user/operator clearly that he or she entered a message category that does not match any of the message categories currently stored in the PCLD table. Also, the message does not tell the user/operator the location of the error in the input message.

On-line error messages contain little or no diagnostic information. When an error occurs, the user/operator typically reads an error code from a panel on the main computer, according to subject matter experts. This code is displayed as a set of binary lights, which the user/operator converts to octal code (a conversion which easily can be done incorrectly). He or she then looks up the octal code in an off-line manual. The process is unwieldy, distracts attention from the primary transactional task, and may contribute to additional errors.

7.4 Error Correction/Recovery

As noted above, error correction begins only after the entire message is completed and entered for processing. For each error, the user/operator must first diagnose the error as described above, and retrieve the correct entry from memory or off-line manuals. He or she then must visually locate the data element containing the error and position the cursor to the element field using the cursor control keys. In the event of multiple errors, this procedure must be repeated for each error. The procedure is unwieldy and unnecessarily complicates the user's/operator's task.

In some cases at least, a single error may require reentry of several data element fields. For example, to orient the DPM, the user/operator enters into the SPRT;MAP message the coordinates of each of the four corners of the map. However, an error at any point in this procedure requires the user/operator to reenter all four corners again, even if three of the four are correct. This is an unnecessary source of frustration, imposes unnecessary effort, and requires excessive time to correct errors.

3.0 USER/OPERATOR CONFIGURATIONS

In principle, possible user/operator configurations in TACFIRE are extremely varied. For example, virtually any user or operator can transmit an ATI message to the computer, from which it may go to the intelligence section or to one of the support unit FSEs.

Perhaps the most common user/operator configuration is exemplified by the following series of transactions. (See Figure 13.) The FO (a user) provides information and instructions to the RTO (an operator). The RTO transmits a fire request on the DMD. The request is received on the ACC RD at the

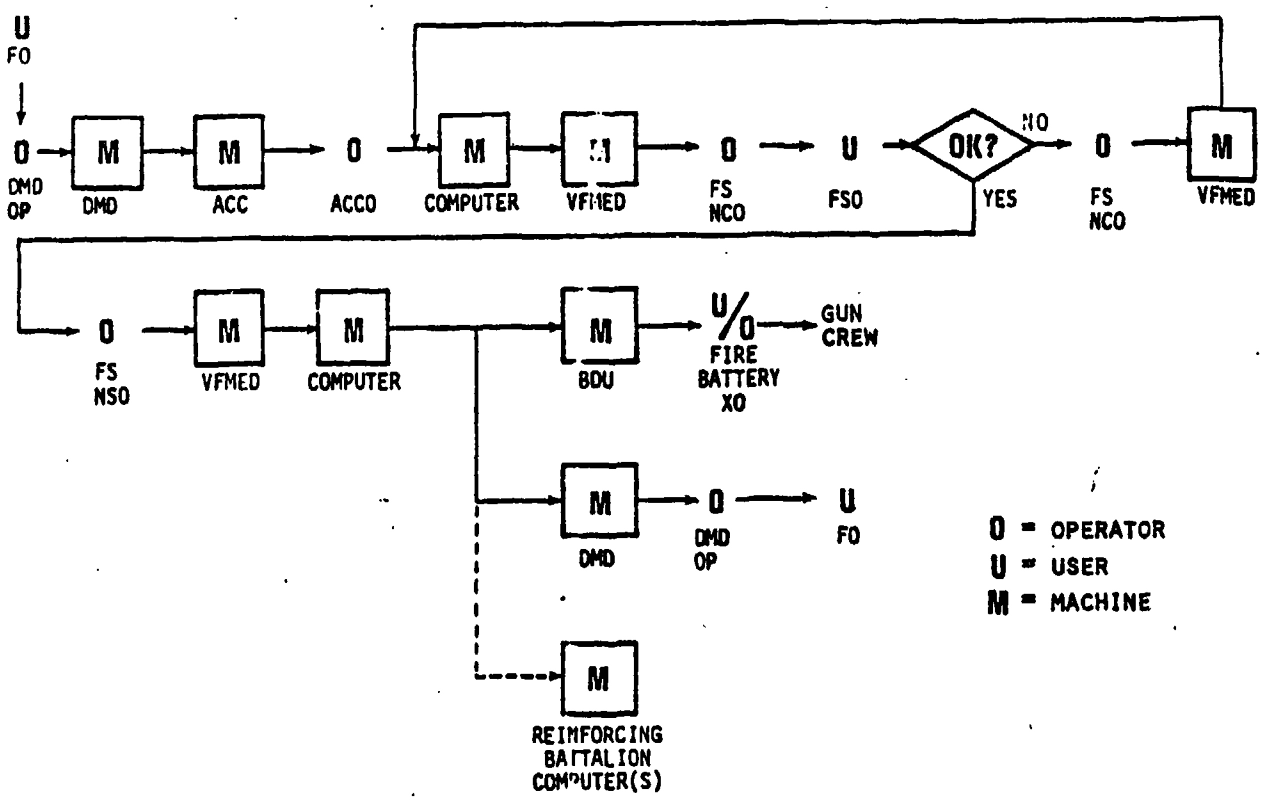

Figure 13. User/Operator Configuration for a Typical Series of TACFIRE Transactions.

cannon battalion where the ACCO (an operator) transmits it to the computer. After processing, the computer displays battery firing data, any error and warning messages, and if the selected batteries cannot provide sufficient fire, request for additional fire (RFAF) messages directed to other cannon battalions or to the FA brigade. These messages are transmitted automatically to the VFMED (operated by the fire support NCO) at the support unit's FSE, where they are reviewed by the FSO (a user). The FSO can cancel the fire mission, approve it as computed, or modify any or all parts of the mission. If the mission is modified, new firing data are computed and presented on the VFMED for review. When the FSO approves the mission, either as originally computed or as modified, the fire support sergeant presses a transmit switch. The firing data are then transmitted automatically to the appropriate battery BDU's, where the battery executive officer (XO--a user/operator) relays them to gun crews. RFAF messages are transmitted automatically to the appropriate cannon battalion computers, and a message to observer (MTO) is transmitted automatically to the RTO who relays the information to the FO.

CONCLUSION

This analysis of TACFIRE yielded abundant information about user/operator requirements in a software interface that controls transactions with the computer. As shown in the above summary of the Transaction Feature Analyses, data were extracted for nearly all the transaction features listed in Table 4. These data, when consolidated with similar findings from other systems currently being analyzed, will provide the broad foundation required for further development of design guidelines and evaluation criteria.

TACFIRE, of course, was among the first of the Army's efforts to bring automation to the battlefield. As such, it was developed largely without benefit of an extensive background of experience in battlefield automated system development. Nonetheless, results of this analysis lend at least partial support to an underlying theme of this project, and to one of its major justifications: t[illegible], there is no adequate, readily-accessible human factors technology to guide the development of user/operator transactions with battlefield automated systems. If similar results are obtained from other analyses currently being completed, this conclusion will be strengthened considerably.

RECOMMENDATIONS

Recommendations for changes to TACFIRE or any other specific system are not a major purpose of this project. However, the Transaction Feature Analysis technique, by its design, leads to a recommendation to resolve each deficiency discovered with it. Thus, the reader will find a recommended resolution for each of the TACFIRE deficiencies described in the Appendix. These recommendations, it should be noted, do not take into account any hardware or programming constraints that may exist in the current configuration of TACFIRE. Project personnel are confident that many of these recommendations could be implemented in the current version of the system. Providing consistent data element names from one format to another, for example, would require no changes to TACFIRE equipment. Nor would this improvement require any additional space; indeed, since it would eliminate redundant versions of data element names, the modification doubtless would require less space while reducing the user's/operator's memory burden.

Completely redesigning message formats for consistency of layout, while feasible technically, might not be practically feasible because of the cost of extensive reprogramming that might be involved. On the other hand, actually eliminating the 8 x 8 format selection matrix in the current TACFIRE undoubtedly is not feasible because it would lead to hardware changes that would be prohibitively expensive (however, it could simply be ignored and its functions implemented in menus).

Project personnel generally did not attempt to make such judgements regarding recommended resolutions. They reasoned that TACFIRE proponents and developers know the system far better than do project personnel on the basis of this analysis. Thus, the TACFIRE design team clearly is in the best position to determine whether a particular problem resolution should be implemented on the current system, or deferred to a later generation (or, in those cases of tradeoffs that inevitably arise, disregarded). For these reasons, recommendations are offered without reference in most cases to the particular configuration of the system.

APPENDIX

Transaction Feature Analyses of TACFIRE

1. CONTROL METHODS

1.1 Command Languages

TACFIRE does not incorporate a command language *per se*. System commands are executed with menu selections and/or function keys, as described below.

1.2 Menus

- *Transaction Feature*. Indicating menu selections to system.

  Description. Some message formats (e.g., SYS:SBT, SYS:LBSB; see Figure A-1) incorporate menus to allow the user/operator options to perform text editing and other functions (e.g., PRINT, DELETE,

```
        ; P :  ; S B :  /  /  /    /       ; C : U N    ;
S Y S ; S B T ; E D I T :  ; P R I N T :   ; D E L E T E :    ;
I 1 :    ; L 1 :  /  /  /    /       ;  P 1 :     ; D 1 :     ;
I 2 :    ; L 2 :  /  /  /    /       ;  P 2 :     ; D 2 :     ;
I 3 :    ; L 3 :  /  /  /    /       ;  P 3 :     ; D 3 :     ;
I 4 :    ; L 4 :  /  /  /    /       ;  P 4 :     ; D 4 :     ;
I 5 :    ; L 5 :  /  /  /    /       ;  P 5 :     ; D 5 :     ;
```

Figure A-1. TACFIRE SYS:SBT Message, Showing Edit, Print, and Delete Menu.

  EDIT, RELAY). To select an option, the user/operator positions the cursor to the element field of the data element. Depending on the particular message and option, the user/operator then enters an "X," an "A," a "Y," an "S," or some other character. Some of these data elements permit more than one legal entry (such as "A" for "all" and other characters for other options). For most, however, only one character is legal. The legal character differs from one data element field to another. One element field requires an "X," another requires an "A," and so on. The system provides no on-line assistance indicating which letter is required for a given element field.

  Behavioral Implications. The user/operator must know which letter will satisfy the requirement of each menu data element. This necessity imposes an excessive memory burden on the user/operator and creates a highly error-prone situation for no defensible purpose.

  Transactional Implications. User/operator menu selections errors will occur more frequently than necessary, thereby delaying completion of transactions. Inadequate error feedback (see section 7: ERROR HANDLING, below) will cause additional delay during user/operator efforts to diagnose and correct errors.

Consequences of the Problem. Unnecessary delays in transactions concerned with target intelligence (e.g., ATI;BDR) could result in lost targets. Unnecessary delays in transactions concerned with fire missions (e.g., FM;RFAF) could result in fires delivered to locations no longer occupied by targets. At a minimum, such delays will reduce the rate of processing artillery information. In a fast-moving tactical situation, overall field artillery effectiveness will be reduced, adversely affecting the mission.

Recommended Resolution. Revise TACFIRE software for consistency of item selection from menus embedded in message formats. Regardless of the message being entered, or the data element, use the same character to indicate a menu selection. "X" would be a logical choice, because people typically associate that letter with selecting operations. Where necessary, restructure "compound" data elements. For example, in a DELETE element, "S" might mean "DELETE SEGMENT" and "A" might mean "DELETE ALL." Restructure the element to form two separate elements (e.g., a DELETE SEGMENT data element and a separate DELETE ALL element). The user/operator could then select the appropriate element with the standard "X."

- *Transaction Feature.* Format directory menu structure.

Description. TACFIRE directory menus (e.g., SYS;DIR) are arranged in a horizontal format, with successive menu options listed one following another along a line.

Behavioral Implications. The user/operator must move the cursor vertically to the appropriate line, and then horizontally to the element field of the desired menu option before indicating a selection. This imposes a trivial, but time-consuming, task on the user/operator.

Transactional Implications. Transactions require more time than necessary to complete as the user/operator repeatedly presses cursor control keys to skip across unwanted options.

Consequences of the Problem. Artillery information processing is delayed unnecessarily. In a fast-moving tactical situation, targets may be lost or fires directed to locations no longer occupied by targets. Overall field artillery effectiveness is reduced.

Recommended Resolution. See following Transaction Feature Analysis.

- *Transaction Feature.* Format directory menu structure.

Description. As noted in preceding Transaction Feature Analysis, items in format directory menus are arranged horizontally.

Behavioral Implications. In addition to behavioral implications already described, the horizontal arrangement of menu items makes more difficult the user's/operator's attempt to scan the menu quickly to locate the desired option.

Transactional Implications. The user/operator needs more time than should be necessary to locate the desired menu item.

Consequences of the Problem. Same as for preceding Transaction Feature Analysis.

Recommended Resolution. Revise TACFIRE software to arrange format directory menus vertically. Number the items sequentially. Provide the capability to select the desired item by typing in the appropriate item number. The vertical arrangement will aid the user/operator in scanning the menu. The selection procedure will eliminate excessive cursor movement. (Also see "SPA message format selection matrix" in section 1.3.)

1.3 Function Keys

- *Transaction Feature*. DELETE switch on the SPA.

  Description. Pressing the DELETE switch on the SPA clears the RD and displays the next message. The message is automatically cleared and removed from the receive queue when the DELETE switch is pressed. If a segment of a message is being displayed, only that segment of the message is deleted. However, if the segment that is deleted happens to be the first segment of the message, the entire message is deleted, i.e., removed from the RD and also removed from the message queue.

  Behavioral Implications. There is no protection feature for priority messages. The operator could inadvertently delete an important message by accidentally pressing the delete switch or by not recognizing that deleting the first message segment will delete the entire message.

  Transactional Implications. Unintentional deletion of the first segment will delete the entire segmented message. Thus, important messages could be lost inadvertently.

  Consequences of the Problem. Critical information could be lost. Critical fire support could be overlooked until voice traffic corrected for lost messages--after a possibly critical delay. The mission could be adversely affected.

  Recommended Resolution. Modify the equipment in the next generation TACFIRE to make deletion of a message or a message segment a double action requiring two switches so that messages cannot be inadvertently deleted from the RD and the message input queue.

• *Transaction Feature*. SPA message format selection matrix.

Description. When a message format is required for entering data, the format must be called up from storage. Format message name codes are displayed on the ACC SPA. Codes are composed of abbreviations; they are printed on a paper overlay that is attached to an 8 x 8 selection matrix on the SPA. To select a message format, the user/operator first locates the proper code on the matrix, then pushes a button below the column in which the code is located, and finally, pushes another button to the right of of the row in which the code is located.

Behavioral Implications. The user/operator must locate the intersection containing the desired message format code. Then, the user/operator must track both horizontally and vertically to locate the buttons required to identify the proper intersection. The procedure requires careful eye-hand coordination to avoid errors.

Transactional Implications. Failure to coordinate hand and eye correctly will call up the wrong message format. If it is sufficiently different from the proper format so that the user/operator recognizes the error, time will be lost while the screen is cleared and the call-up/procedure is repeated again. If the wrong format is similar to the proper format, the user/operator may go ahead and enter data.

Consequences of the Problem. At best, the overall rate of artillery information processing will be reduced, delaying computation of fire missions or other functions and consequently losing targets. At worst, fire missions and other functions may be processed on the basis of erroneous data, causing misdirected (and wasted) fires and increasing the burden on maneuver units.

Recommended Resolution. Eliminate the ACC SPA message format selection matrix. The matrix need not be physically removed; it could simply be ignored. Develop a capability to select message formats using the ACC receive display and screen. An initial menu could list format categories (e.g., SYSTEM, ARTILLERY TARGET INTELLIGENCE, FIRE MISSION), and a second menu could list message types within the desired category (e.g., QUERY, AIR CORRIDOR, REQUEST FOR ADDITIONAL FIRES). If options were numbered within each menu, the user/operator could call up the desired format with a minimum of keystrokes, greatly reducing the probability of error. (Also see "Format Directory Menu Structure" in Section 1.2.)

1.4 Hybrid Methods

No hybrid control methods were observed in TACFIRE. For example, function keys are not used to select menu items.

1.5 Prompts/HELPS

- *Transaction Feature*. SPA message format selection matrix.

  Description. Each TACFIRE computer uses an 8 x 8 matrix on the ACC SPA for selecting message formats used in command and data entry. The matrices at division and battalion have 47 format name codes in common. Of these, 19 are placed in the same location on the matrices at both division and battalion (the codes enclosed in boxes in Figure A-2). The remaining 28 common codes are at different locations on the two matrices (the codes in circles in Figure A-1).

  Behavioral Implications. Users/operators who transfer from battalion to division or vice-versa will confuse locations on their "old" matrix with those on their "new" matrix. This confusion, which will be greatest for the user/operators with the greatest experience, will greatly increase the probability of errors.

  Transactional Implications. Errors in selecting message formats will be significant, perhaps unacceptably high, particularly when the user/operator is under stress. Completion of transactions will be delayed during error diagnosis and correction procedures.

  Consequences of the Problem. The overall rate of artillery information processing will be reduced. Processing of fire missions and other functions will be delayed, possibly losing important targets.

  Recommended Resolution. See recommended resolution for "SPA Message Format Selection Matrix" in Section 1.3. Alternatively, redesign SPA message format matrices, placing all common format name codes in the same locations at both division and battalion (see Figure A-3). This design will greatly reduce the memory burden on users/operators transferring from one echelon to the other, and will thereby reduce error rates.

2. DISPLAY FORMAT

2.1 Fixed Alphanumeric Displays

- *Transaction Feature*. Output message structure.

  Description. The output message structure is fixed. The user/operator has no control over the message structure, even to the identification of categories of information to be provided or eliminated from the output.

DIVISION

SYS FCM	SYS INIT		SPRT MAP	AFU UPDATE	NNFP COMFP	ATI TRY	ATI COR
SYS PDS	SYS MISC		SPRT DPM	AFU AMOUPD	NNFP INST	ATI COMB	ATI AZR
SYS PCLD	SYS MDS		SPRT GEOM	AFU AMOL	NNFP RESFU	ATI SPLIT	ATI TGR
SYS SBT	SYS RD	MET CM	SPRT ZNE	AFU ASR	NNFP F2TU	ATI QUERY	ATI SHR
SYS LGSB	SYS CED	MET CFL	SPRT AIRCOR	AFU BUILD	NNFP FPA	ATI SRI	FM RFAF
SYS COMSEC	SYS NORM	MET CW	SPRT DISPL	AFU LAUNCH	NNFP NUSCD	ATI PREFP	FM FMCAP
SYS ADDR	SURV DIR	MET COMD	SPRT COMD	AFU COMD	NNFP COMD	ATI CMD	FM COMD
SYS DIR	FSE DIR	MET DIR	SPRT DIR	AFU DIR	NNFP DIR	ATI DIR	FM DIR

BATTALION

SYS FCM	SYS INIT	AFU UPDATE	AFU AMOL	NNFP COMFP	ATI COR	FM INTM	FM RFAF
SYS PDS	SYS MISC	AFU [illegible]	SPRT MAP	NNFP INST	ATI AZR	FM NUKE	FM SUBS
SYS PCLD	SYS MDS	AFU ASR	SPRT DPM	NNFP RESFU	ATI SHR	FM FUSEL	FM OF
SYS SBT	SYS RD	AFU MASK	SPRT GEOM	NNFP F2TU	ATI MFR	FM XCLUDE	FM MOD
SYS LSGB	SYS CCD	AFU MV	SPRT ZNE	NNFP FPA	ATI QUERY		FM ATTACK
SYS COMSEC	SYS NORM	AFU BUILD	SPRT AIRCOR	NNFP EXECFP	ATI SRI	MET CM	FM OBCO
SYS ADDR	SYS FSO	AFU COMD	SPRT COMD	NNFP COMD		MET COMD	FM COMD
SYS DIR	SURV DIR	AFU DIR	SPRT DIR	NNFP DIR	ATI DIR	MET DIR	FM DIR

Figure A-2. TACFIRE SPA Message Format Selection Matrices for Division and Battalion Computers.

SYS FMC	SYS INIT	AFU UPDATE	SPRT MAP	NNFP COMFP	ATI CDR	FM DIR	MET DIR
SYS POS	SYS MISC	AFU BAMOUP AFU AMOUPD	SPRT DMP	NNFP INST	ATI AZR	FM COMD	MET COMD
SYS PCLD	SYS MDS	AFU AMOL	SPRT GEOM	NNFP RESFU	ATI SHR	FM RFAF	MET CM
SYS SBT	SYS RD	AFU ASR	SPRT ZNE	NNFP FPTU	ATI QUERY	FM FUSEL FM FMCAP	MET CW
SYS LSGB	SYS CED	AFU COMD	SPRT AIRCOR	NNFP FPA	ATI SRI	FM XCLUDE ATI TRY	FM MCD MET CFL
SYS COMSEC	SYS NORM	AFU DIR	SPRT COMD	NNFP COMD	ATI DIR	FM OF ATI COMB	FM NUKE
SYS ADDR	SYS FSO FSE DIR	AFU BUILD	SPRT DIR	NNFP DIR	ATI MFR ATI TGR	FM ATTACK ATI CMD	FM SUBS
SYS DIR	SURV DIR	AFU MASK AFU LAUNCH	AFU MV SPRT DISPL	NNFP EXECFP NNFP NUSCD	ATI SPLIT	FM INTM ATI PREFP	FM UBCO

Figure A-3. Redesigned TACFIRE Message Format Selection Matrix. All Codes Common to Division and Battalion are in the Same Location.

Behavioral Implications. The user/operator may receive more information than needed or wanted.

Transactional Implications. The presentation of information in excess of that required may distract the user/operator, and provide unnecessary opportunities for the user/operator to pick up data from an inappropriate data field.

Consequences of the Problem. The user/operator expends extra time searching for the desired information. The user/operator may commit errors in the extraction of data from the message format.

Recommended Resolution. Permit the user/operator to control the structure of the output. In particular, provide a unique identifying header for every output message or report. Also, provide software capability to suppress unwanted sections of reports.

Transaction Feature. Alphanumeric displays on the VFMED.

Description. The VFMED is a "dumb" terminal; it contains no storage, processing capability, or message buffer. Thus, after transmitting a request to the computer for a message, or after transmitting a completed message, the display screen must be cleared before the next message arrives. If the screen is not cleared before the new message arrives, the new message simply overprints whatever is on the screen at that moment.

Behavioral Implications. The VFMED user/operator must take overt action to clear the display screen before an incoming message arrives. In a busy situation, such as an exercise or tactical operation, the user/operator may forget to perform this procedure.

Transactional Implications. An arriving message, overprinting the screen's existing contents, may be uninterpretable. The transaction will be delayed while the user/operator requests transmission of a new "copy" of the required format. Alternatively, the user/operator may elect to attempt reconstruction of the "garbled" message by typing in the overprinted portions. This procedure would require the user/operator to type in data element names--in precisely the correct character positions--as well as the data that he/she normally enters in element fields. This is a time-consuming and error-prone procedure.

Consequences of the Problem. At a minimum, time to complete transactions will be increased, resulting in a reduction in the rate of artillery information processing. Additionally, errors may be introduced into the data base. Overall field artillery effectiveness may be reduced, and the mission may be affected adversely.

Recommended Resolution. In the next generation of TACFIRE, provide a buffer on the VFMED, large enough to hold at least one message format. A "MESSAGE WAITING" indicator will also be required.

Meanwhile, before transmitting the actual message or message format to a VFMED, first transmit a "dummy format" consisting of a blank screen. This procedure will clear the screen before the actual message format arrives, thereby preventing overprinting of existing display contents.

- *Transaction Feature*. Data field arrangement.

Description. Data fields common to two or more message formats often appear in different places from one field to the next. For example, the codes "FRLT," "NFL," "FCL," "DSA" appear in two message formats used to input battlefield geometry data (SPRT; GEOM and SPRT;BUILD). The codes appear on different lines in the two formats, in different orders within the lines, and in different column groups.

Behavioral Implications. Users/operators must exercise care in switching from one message format to the other not to confuse the sequence of codes. This requirement imposes an unnecessary burden on the user/operator in terms of memory load and attention to detail.

Transactional Implications. Transactions will be delayed by conscientious users/operators who maintain close, cautious attention to the message format in their attempts to ensure accurate data entry. The probability is increased that erroneous data will be entered by inexperienced users/operators, or by experienced personnel working under stressful conditions.

Consequences of the Problem. At a minimum, overall artillery command and control information processing rates will be reduced, with a possible consequent loss of targets. Also, erroneous entries may result in confusion of data regarding, for example, the front line trace and the no-fire area. This type of confusion could prevent fires on enemy targets, or result in fires directed toward friendly forces.

Recommended Resolution. Redesign message formats to ensure that common data fields appear in the same locations and sequences in all message formats in which they appear.

2.2 Variable-Length Alphanumeric Displays

Except for hard-copy reports (which may vary in length though not in structure), no variable-length alphanumeric displays were observed in TACFIRE.

2.3 Graphic Displays

- *Transaction Feature*. TACFIRE graphic display device.

  Description. TACFIRE provides a graphic display with division computers. The display provides graphic information essentially in "free space," because it does not display identifying terrain features and includes no capability to use map overlays or underlays.

  Behavioral Implications. The user/operator must correlate graphic information on the display with terrain features and other location information on a separate map. Subject matter experts report that this procedure requires frequent attention switches from the display to the map and back.

  Transactional Implications. In general, graphic displays are more-or-less final outputs rather than transactional steps, according to a subject matter expert. Therefore, this situation has no apparent transactional implications.

  Consequences of the Problem. Time is lost in planning and decision-making activities while graphic display information is correlated with map information. Errors in correlation between the display and the map are encouraged by the necessity to alternate attention.

  Recommended Resolution. Provide an overlay capability on the graphics display device, with a software capability to register the map and to adjust display scale to match map scale. Alternatively, provide sufficient terrain features in graphics displays to assure positive recognition of the locations of units, targets, and other information represented by graphic symbols.

2.4 Highlighting

- *Transaction Feature*. DMD highlighting.

  Description. On the DMD, messages are built up on the display one data field at a time. The field into which data are to be entered is highlighted by causing the associated element name to flash.

  Behavioral Implications. The user/operator is able to locate quickly the field into which data are to be entered.

  Transactional Implications. Time required to locate data entry points is eliminated. Transactions are completed expeditiously.

  Consequences of the Problem. User/operator performance is enhanced.

Recommended Resolution. None required; however, such highlighting should be extended to other terminals in the next generation of TACFIRE.

3. DATA ENTRY ASSISTANCE

3.1 Information on Legal Entries

- *Transaction Feature*. Information on legal entries.

  Description. TACFIRE provides no on-line information on legal data entries.

  Behavioral Implications. The user/operator must extract data entry information from memory or from off-line user's manuals.

  Transactional Implications. There is potential for error in depending on memory for data entry information. There is also potential for transcription error in extraction of codes from off-line manuals and reduced system efficiency due to division of the user's/operator's attention. If the error results in entry of an illegal code, the system will detect the error and issue an error and warning message. Otherwise, detection depends upon the user/operator.

  Consequences of the Problem. Erroneous data may be stored in the computer. Overall system efficiency is reduced. Targets may be lost and/or fires may be misdirected.

  Recommended Resolution. Provide easily accessed on-line checklists of legal entries organized by message type and data entry field identifier.

3.2 Unburdening of Input

- *Transaction Feature*. Cursor control.

  Description. Cursor placement on the display (other than at the home position) is controlled by use of four cursor control keys.

  Behavioral Implications. During text editing operations to update data files or correct errors, the user/operator must move the cursor to the desired location by repeated use of the cursor control keys. This requirement imposes an excessive keystroke burden on the user/operator; to reach an element field in which only one character is required, 75 or more cursor control keystrokes could be required.

  Transactional Implications. Time is lost while the user/operator positions the cursor.

Consequences of the Problem. The rate of artillery information processing is reduced. System throughput, therefore, is reduced.

Recommended Resolution. Provide a capability to skip field-by-field instead of character-by-character once the desired line is reached with the "↓" or "↑" key. Alternatively provide the software capability to move the cursor to a specified line and column. The two error message lines could be used for this purpose. Implementation might be as follows. Any time the "HOME" key is pressed, the system checks the cursor's location. If the cursor is anywhere except the home position, the system moves the cursor to the home position. If the cursor is already at the home position when the key is pressed, the system moves the cursor to column 1 of line 8. (Note that, in this implementation, if the user/operator inadvertently presses the key too many times, the error can be corrected by one more press.) The user/operator then could enter, say, "L4 C50" to move the cursor to column 50 of line 4. Even if the user/operator estimates the desired cursor location inaccurately (e.g., the desired location was actually line 5, column 56), the number of cursor control keystrokes would be reduced drastically.

Transaction Feature. Message input queue.

Description. Messages coming into the battalion or division computer are stacked in a queue until the ACC operator can call them up for processing. The order of stacking is determined by a seven-level priority scheme; within each priority level, messages are processed in the order received. TACFIRE provides a warning when the queue is nearly full, but provides no information about its status or content.

Behavioral Implications. To determine its content, the user/operator must page through the queue one message at a time. During busy periods, the user/operator is unlikely to take time to perform this operation.

Transactional Implications. A message of equal or even lower priority may in some situations be more urgent than others ahead of it in the queue. For example, a fire mission will generally be more time sensitive than a fire plan, even though both are priority two. If the fire mission is behind one or more fire plans, the user/operator may not become aware of its presence until the fire plan(s) and any other priority two messages ahead of the fire mission have been processed.

Consequences of the Problem. In the particular example cited above, fire missions might be delayed until the target has moved, increasing the burden on maneuver units. In other situations, less critical but still urgent transactions might be delayed sufficiently to degrade overall field artillery effectiveness.

Recommended Resolution. A subject matter expert at Fort Sill indicated that a "workaround" would be implemented in the next TACFIRE tape version to correct the specific problem cited above. However, the expert was unsure whether the more general solution has been included. That is, TACFIRE messages should be examined carefully by knowledgeable personnel. Within each priority level, any messages that are particularly time sensitive should be identified. When such a message arrives, and is placed in the queue behind a message of equal priority, an alerting message should be displayed in the error message portion of the ACC RD (e.g., "FIRE MISSION WAITING").

- *Transaction Feature*. Cursor positioning.

Description. On the ACC and the VFMED, the cursor does not automatically home to the first data entry position in the display when a message format is called up.

Behavioral Implications. The user/operator must move the cursor to the first data entry position before beginning data entry. Particularly when under stress, he or she may fail to do so.

Transactional Implications. There is a high potential for overprinting protected fields and for entering data into the wrong field by not moving the cursor appropriately.

Consequences of the Problem. Entering data in the wrong location typically will result in an error. Thus, time is lost during error detection, diagnosis, and correction. The result is loss of efficiency in artillery information processing, and reduction in overall field artillery effectiveness.

Recommended Resolution. Modify software to move the cursor to the first data entry position when a new message format is presented.

3.3 Interrupts and Work Recovery

No transaction features were observed in TACFIRE related to interrupts and work recovery that required Transaction Feature Analysis.

4. MESSAGE COMPOSITION AIDS

4.1 System Design Features

- *Transaction Feature*. Data entry keyboards on DMD and ACC.

Description. The two keyboards differ radically in configuration. The ACC keyboard has a modified standard "QWERTY" key arrangement; in contrast, DMD keys are arranged in alphabetic order. In addition, while the DMD uses a "desk top calculator" format for its numeric keypad, the ACC numeric keys are arranged in the touch telephone format.

Behavioral Implications. A user/operator who transfers from the DMD to the ACC will experience an immediate "negative transfer of training" problem. That is, having learned to use one device, the individual will tend to use the same performance habits on the other device. The result, of course, will be errors in performance. Error rates will be highest for the most experienced personnel, who will have learned the earlier device best.

Transactional Implications. Many or most errors will be detected, resulting in processing delays while correction procedures are performed. Undetected errors will be entered into the data base, contaminating its contents.

Consequences of the Problem. Error correction procedures will delay field artillery data processing. Such delays may result in missed fires and less timely reports to responsible officers. Data base degradation may contaminate reports and provide a misleading picture of the battlefield.

Recommended Resolution. Provide consistently arranged keyboards at all TACFIRE workstations.

Transaction Feature. Message sequences.

Description. Some tasks performed on TACFIRE require a sequence of messages. For example, to prepare a fire plan requires at least the AFU;BUILD, SPRT;BUILD, and SPRT;ZNE messages. The computer does not "know" that a fire plan requires all the messages in the sequence, and consequently cannot check to ensure that an input fire plan is complete.

Behavioral Implications. The individual preparing a fire plan or other processing task requiring multiple messages must rely on off-line documents for cues to message requirements. Distractions occurring during the process (or during message entry) may result in one or more messages being inadvertently left out.

Transactional Implications. The missing messages(s) will be detected only when the machine attempts to process the entire sequence. Completion of processing will be delayed while (1) the missing message is identified by paging back, and (2) the message is constructed and entered.

Consequences of the Problem. Timely completion of multiple-message tasks is inhibited. System throughput rates are reduced. System efficiency and its contribution to mission accomplishment is degraded.

Recommended Resolution. Provide software checklists of message requirements for multiple-message tasks. Check to ensure all required messages have been entered before starting to process the task. If one or more messages are missing, provide on-line feedback immediately, identifying the missing message(s).

- *Transaction Feature*. Message overprinting.

Description. Any portion of any message can be overprinted, because TACFIRE does not protect data element names (see above).

Behavioral Implications. The user/operator is free to alter any message in any way desired. Thus, for example, a VFMED operator could call up a message format which is legal for that terminal, and then alter it to a message which is not legal. Alternatively, the VFMED operator could type in an entire message, character-by-character, that is not authorized for that terminal. If the ACCO is not alert when that message is transmitted, it will be accepted by the machine and processed.

Transactional Implications. An unauthorized message can be used to contaminate the data base.

Consequences of the Problem. Subversive elements (or even bored or discontented soldiers unmindful of the full implications of such an act) could endanger friendly forces or protect enemy forces by changing no-fire zones and the like. Also, false information could severely distort the commander's picture of the battle. The mission could be affected, perhaps catastrophically.

Recommended Resolution. Protect element names by modifying software to skip past them automatically.

- *Transaction Feature*. DMD message transmission.

Description. The DMD transmits messages as digital information "piggy-backed" onto voice radio channels; however, voice traffic has precedence over digital traffic. If voice is transmitted during digital transmission, part or all of the digital message will be lost.

Behavioral Implications. The DMD user/operator apparently has no way to notify other users of the radio channel when the channel is required for digital transmission.

Transactional Implications. Digital messages that are overridden by voice transmissions are partially or totally lost. The system provides no feedback to the user/operator to indicate such an event.

Consequences of the Problem. At best, lost messages must be reconstructed and retransmitted. Because of the positions of DMD user/operators (FIST teams, sound and flash observers and centrals), the probability is great that a lost message will result in delayed fire missions. Such delays could seriously affect the mission.

Recommended Resolution. At present, no complete solution is apparent. However, the feasibility should be investigated of a partial software solution. That is, the system might "remember" which message format is transmitted most recently to a DMD. When a message is received from the DMD, the incoming message could be checked to ensure that the full message is present. If not, a warning could be sent to the DMD, such as "LAST TRANSMISSION GARBLED. MESSAGE FORMAT MUST BE ENTERED AGAIN. PRESS 'XMIT' WHEN READY TO RECEIVE FORMAT." The "remembered" format could then be sent to the DMD for reentry of the message. This procedure would provide the user/operator a clear and positive indication of what had happened, and eliminate the necessity for him or her to deduce why the requested fire mission (or other action) was not forthcoming.

4.2 Format for Alphanumeric Messages

- *Transaction Feature*. TACFIRE input message formats.

Description. TACFIRE input messages provide no separation between data elements. Each element starts with the first character of the element name. The last character of the element name is followed by a colon, and the element field begins in the space following the colon. If sufficient space remains on the line for the next data element, the first character of the element name for the next data element immediately follows the semicolon that terminates the preceding element field. (If there is not enough space remaining on the line for an entire data element, the remaining space is left empty, because TACFIRE data elements are not allowed to carry over from one line to the next.)

Behavioral Implications. As the user/operator enters data into successive elements, the message begins to appear densely packed. Consequently, the user/operator must monitor cursor position in the format very closely, often while referring intermittently to off-line data records and/or user's manuals. This situation increases the likelihood that the user/operator will erroneously associate an element field with the wrong element name, become confused about the element currently being worked on, or be forced to reduce his or her input rate to avoid errors.

Transactional Implications. At a minimum, the requirement for extra care reduces the rate at which transactions will be processed by the system. More seriously, confusion about relationships between element name and element field, or about the element being worked on, can lead to erroneous entries. These errors will not be detected by the machine in the coincidental event that they are legal entries (but inappropriate for the transaction) for the field.

Consequences of the Problem. The data base may be contaminated, with unpredictable but certainly undesirable results. System efficiency is reduced, both by the user's/operator's requirement for extra care in data entry and by time required to diagnose and correct detected errors. The system's ability to contribute to the success of the mission is reduced.

Recommended Resolution. In the next generation of TACFIRE, provide highlighting of element names, such as brightness control. Highlighting of data element names would help the user/operator to discriminate element names and element fields and thereby more easily keep track of the transaction's progress, helping to reduce the likelihood of confusion and errors. In the meantime, TACFIRE software could be revised to display message formats in a tabular format. By arranging element names in columns, the user/operator would have a visual cue to help in discriminating data element names from data element fields. Figure A-4 provides an example of a format redesigned to use a tabular format. Coupled with protection for data element names (see Section 4.1: System Design Features), this format could increase system throughput and reduce errors significantly. Of course, Figure A-4 shows that the FM;RFAF message would have to be divided into 2 segments, a clear tradeoff between storage space and user/operator aids. However, many formats are not so densely packed as the FM;RFAF and could be redesigned to fit in the same segment.

```
        ;P:  ;SB: / / / /      ;C:UN ;SG:   . ;DT:   .  / /     ;ID:      ;A: ;
FM;RFAF:  ;MYEFF:   ;TGT:         ;KNPT:   ;CORD:          /             ;GS:  ;
SPHERE: ;DER:      /   ;DIST:       ;SHIFT: /      / /    / /   ;ASF:  /     ;
AUF: / / /  /       ;TYPE:        /         ;DOP:      ;SIZE:      /   ;ATT:   ;
STR:     ;RV:     ;LAS:     /  ;TOT:   /    ;ME:     /   ;CONT:      /  ;ZF:  / ;
UFFE: / / /   /  , / / /  /         ;SH:     /     ;FZ:     /   ;LOT: / /  ;EFF: ;
VOL:   ;OB:    ;CHG: ;EOM:  ;RAT:  ;MIS:  ;ADD: ;ALTER: ;DELETE:    ;BD:        ;
```

Figure A-4a. Current Format of the FM;RFAF Message.

```
        ;P:   ;SB: / / /  /      ;C:UN ;SG:   . ;DT:  .  / /    ;ID:      A: ;
FM;RFAFI:       MYEFF:   ;    ASF:            ;    TOT:  /  ;   OB:    ;  ALTER: ;
TGT:            SPHERE:  ;    F               ;    ZF:  / ;     CHG:   ;
DOP:            ATT:     ;    D      .        ;    GZ:     ;    EOM:   ;
LAS:     /      STR:     ;    M               ;    RV:     ;    RAT:   ;
SH:    /        DELETE:  ;    B               ;    EFF:    ;    MIS:   ;
DIST   -        KNPT     ;    L                    VOL:    ;    ADD:   ;
```

Figure A-4b. First Segment of FM;RFAF After Redesign for Tabular Format.

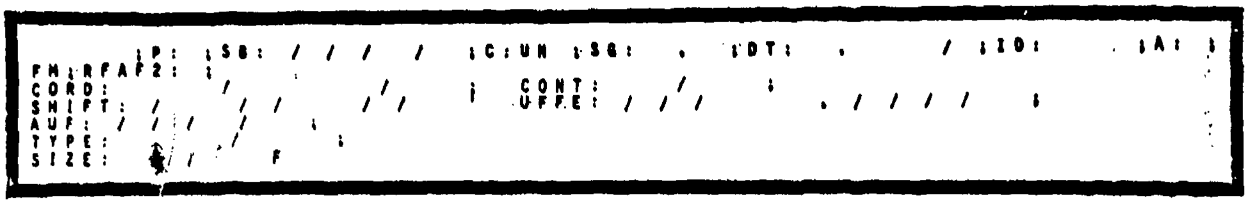

Figure A-4c. Second Segment of FM;RFAF After Redesign for Tabular Format.

- *Transaction Feature*. TACFIRE message formats.

  Description. Many of the TACFIRE message formats do not correspond to the formats of data provided by FSOs, FDOs, etc.

  Behavioral Implications. When formats are inconsistent, the operator often skips around in the machine format instead of going sequentially from one field to the next, and line by line. This procedure increases the probability of error, particularly errors of omission.

  Transactional Implications. The extra cursor movement required to permit data entry when skipping around the format consumes time and encourages the operator to make errors, particularly errors of omitting a necessary field.

  Consequences of the Problem. Overall efficiency of the system is impaired; the probability of contaminating the data base is increased.

  Recommended Resolution. Require that the formats be consistent between hardcopy data sources and TACFIRE input formats.

4.3 Graphic Messages

No graphic messages were observed in TACFIRE.

5. DATA RETRIEVAL ASSISTANCE

5.1 Query Method

- *Transaction Feature*. On-line query messages.

  Description. Requests for similar data from different files requires a separate query message for each file.

Behavioral Implications. The requirement to construct a separate message for each file queried imposes an administrative burden on the user/operator. Also, the user/operator must rely on memory or consult off-line references in calling up query formats.

Transactional Implications. Constructing additional query messages creates additional opportunities for error. Also, time required to construct separate messages is time lost to other functions, and stretches out the time required to complete a query transaction.

Consequences of the Problem. Overall system efficiency is reduced, thereby reducing system throughput and the system's contribution to performance of the mission.

Recommended Resolution. Provide a capability for the user/operator to specify a particular data category, and for the system then to retrieve all data in this category, from whatever files contain such data. This capability would have to include methods for limiting the retrieved data based on the user's/operator's particular need.

5.2 Query Structures

Query structures are embodied in message formats that are similar in construction to other TACFIRE messages. Query structures therefore are not discussed separately in this report.

6. GLOSSARIES

6.1 Standard Terms

- *Transaction Feature*. Element names for TACFIRE data elements.

  Description. Some TACFIRE data element names have different meanings in different messages. For example, in the SYS;ADDR message, the code "D" refers to a subscriber index number, while in the AFU;SR message, "D" refers to both a command post location and its closing time. Additionally, different names are used in different messages for the same data element. For example, "CORD," "CORDI," "COORD," and "COORDI" are merely four of the codes used for "coordinates," and "FZE," "FUZE," and "FUTYPE" are only three of the codes used for "fuse type."

  Behavioral Implications. The use of the same code for different data elements requires the user/operator to learn message-dependent meanings. The use of different codes for the same data element requires the user/operator to learn what amounts to a synonym list for a given meaning. Both situations impose an additional and unnecessary memory burden, and both increase the likelihood of errors.

Transactional Implications. Errors in recalling element names encourage errors in filling out element fields. Errors detected by the system will lead to rejection and error correction procedures; errors undetected by the system will lead to contamination of the data base.

Consequences of the Problem. Data base contamination will result in erroneous outputs, possibly causing loss of targets, misdirected fires, or distortion in the commander's picture of the battlefield. Error correction procedures will delay completion of transactions, reducing the rate of artillery information processing. Both situations reduce the overall effectiveness of field artillery.

Recommended Resolution. Associate only one unique code with each TACFIRE data element. Use that same code in every message format in which the given data element appears.

- *Transaction Feature*. Element names for TACFIRE data elements.

Description. TACFIRE provides approximately 225 formatted messages for user/operator transactions. Collectively, these message formats contain in excess of 900 element names, some of which are redundant (See Section 6: Glossaries). No on-line information is available for decoding these names.

Behavioral Implications. The typical TACFIRE user/operator cannot reasonably be expected to memorize such a large number of codes, nor to associate a meaning with each unique code. The user/operator, therefore, must depend on off-line manuals for memory assistance.

Transactional Implications. Time to complete transactions is increased by the need to look up element names in manuals. Failure to use manuals--or unavailability of manuals (a distinct possibility under combat conditions)--will increase error rates, perhaps drastically.

Consequences of the Problem. The rate of artillery information processing is reduced. Errors may enter the data base. Overall field artillery effectiveness is reduced.

Recommended Resolution. Use the two-line error message area on the display to provide on-line definitions of data element names. Such information need not be presented automatically for every data element in a message. Instead, give the user/operator the capability to call for definitions when needed. For example, to call for a definition, the user/operator might enter an asterisk in the element field of the data element for which the element name definition is required. The system would then present the definition, and return the cursor to the first character position of the element field.

- *Transaction Feature*. Message format designators.

  Description. TACFIRE uses two different messages to update ammunition inventories, one for DIVARTY and one for the FA BN. The two message formats are generally similar, differing only in details. However, they have distinctively different desigator codes (AFU;BAMOUP for BN and AFU;AMOUPD for DIVARTY).

  Behavioral Implications. A user/operator transferring from FA BN to DIVARTY (or vise-versa) will experience confusion, at least initially, in updating the unit's ammo inventory. Under stress, the user/operator may "regress" to using the code learned earliest, and become confused when the request for, say, AFU;BAMOUP (instead of AFU;AMOUPD) is rejected by the computer. In this case, the penalty is heaviest for the most experienced personnel, for they are the ones who have learned their "old" format designators most thoroughly.

  Transactional Implications. Completion of ammo inventory updating transactions will be delayed until the user/operator realizes the source of the error and requests the proper format for the appropriate echelon.

  Consequences of the Problem. Overall FA command and control information processing is delayed, thereby reducing system throughput. In some cases, the delays could result in loss of targets.

  Recommended Resolution. Give both formats comparable designators: AFU;BAMOUP for battalion and AFU;DAMOUP for division, for example.

- *Transaction Feature*. Codes used in data field labels.

  Description. At least nine of the codes used as data field labels in TACFIRE differ from the corresponding doctrinal codes published in FM 6-20 and presumably taught in the artillery school. The differences are illustrated in Figure A-5.

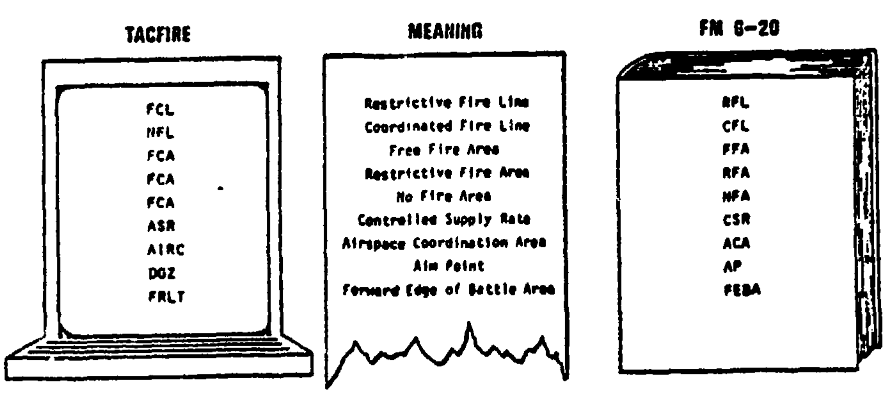

Figure A-5. Comparison of TACFIRE Codes with Standard Codes from FM6-20.

Behavioral Implications. The user must learn an alternative set of codes for familiar functional concepts. This requirement to remember two code sets for a single set of concepts imposes an unnecessary memory burden on the user.

Transactional Implications. Completion of transactions will be delayed if user must look up codes in off-line documents. Errors will be introduced into the data base if the user/operator relies on memory and recalls the wrong interpretation.

Consequences of the Problem. Fires may be misdirected. In an extreme case, a user/operator might intend to enter coordinates for a No Fire Area (FCA) but enter them instead as a Free Fire Area (also FCA). This could result in fires delivered onto friendly forces, although the Restrictive Fire Line entry might prevent such a catastrophe.

Recommended Resolution. Revise TACFIRE software to agree with doctrine.

6.2 Character Sets and Labels

No features were observed in TACFIRE characters sets and labels that required Transaction Feature Analysis (data element names are treated in other parts of this appendix).

6.3 Glossary Availability and Use

- *Transaction Feature*. Glossary of TACFIRE terms.

  Description. Glossary of TACFIRE terms are contained only in off-line manuals. The system provides no on-line glossary assistance.

  Behavioral Implications. To obtain assistance on any term in a message, the user/operator must turn attention from the computer to off-line manuals. Upon returning attention to the screen, the user/operator must visually locate the element field into which data are to be entered. Switching attention between screen and document consumes time and increases the likelihood of errors.

  Transactional Implications. At best, completion of transactions will be delayed while users/operators search off-line manuals for glossary information. Additional delay will be imposed when users/operators diagnose and correct errors detected by themselves or the system. Undetected errors will allow erroneous information into the data base.

Consequences of the Problem. System throughput rates will be reduced. During fast-moving tactical operations, reduced throughput may result in loss of targets and reductions in the currency of artillery target intelligence. Erroneous information in the data base may cause misdirected fires and distort the commander's picture of the battlefield.

Recommended Resolution. Use the two-line error message area of the screen to provide glossary information. Of course, TACFIRE examines data elements only after the message is completed and entered for processing. Therefore, a method is required to implement on-line glossary information within this constraint. For example, to obtain a definition for a given element name, the user/operator would enter a question mark and then signal for computer action. As it would normally, the computer would then begin scanning the message. Upon encountering the question mark, the machine would retrieve the appropriate glossary item and display it in the error message area. Then, it would display the message, completed up to the point at which the user/operator entered the question mark. However, the question mark would be deleted, and the cursor would be positioned at the first space in the element field.

6.4 Abbreviations and Coding

- *Transaction Feature.* TACFIRE data element names.

Description. Most element names in TACFIRE formatted messages consist of abbreviations, mnemonics, or codes. No consistent rule for forming these element names is apparent.

Behavioral Implications. The user/operator must decode abbreviations, mnemonics, and codes from memory, or else refer to off-line manuals. Variations in element names (See Section 6.1: Standard Terms) from one format to another create a distinct possibility for confusion of common elements from message to message.

Transactional Implications. If the user/operator attempts to decode element names from memory, the probability of erroneous decoding is increased. Errors in decoding may lead to erroneous inputs. If the user/operator decodes element names by reference to manuals, time required to complete transactions is increased.

Consequences of the Problem. Accuracy of the data base may be degraded, leading to errors in system outputs. The rate of artillery information processing may be reduced. Overall field artillery effectiveness may be reduced.

Recommended Resolution. Replace abbreviations, mnemonics, and especially codes with a set of element names developed in accordance with consistent rules. For example, use the first 3 characters of the full element name. Where duplication occurs (e.g., more than one element named "FUZE"), use a fourth character (e.g., FUZ1, FUZ2, FUZ3). The first 3 (or even 4) characters rule is probably among the most applicable rules, according to research.

7. ERROR HANDLING

7.1 Error Prevention

TACFIRE's only error prevention techniques appear to be data element names and off-line manuals. These topics are discussed extensively in other sections of this appendix.

7.2 Error Detection

- *Transaction Feature*. Field-by-field error checking.

  Description. Only after an entire message is filled in and the message is input (by pressing RD COMPTR ACTION) is there an indication of an error in the message (through an error alarm). If there are multiple errors, there is no indication of this. Errors are indicated sequentially one-by-one and corrected one-by-one by input of the message and receipt of the next error alarm and correction--until the message is completely accurate.

  Behavioral Implications. The repetitive process of error correction is an annoyance to an operator.

  Transactional Implications. Overall processing of messages is delayed by multiple corrective actions and unnecessary extra cursor manipulation.

  Consequences of the Problem. System efficiency is reduced.

  Recommended Resolution. The problem could be resolved by one of two options: (1) provide an error indication as an erroneous entry is made, or (2) provide concurrent feedback of all erroneous information after the message has been fully constructed and entry is attempted.

7.3 Error Feedback

- *Transaction Feature*. TACFIRE error feedback methods.

  Description. TACFIRE error messages contain little or no diagnostic information. To discover the cause of an error, the user/operator must either (1) page back to the error location; or (2) read an error code from a panel on the main computer. This code is displayed in binary lights; the user/operator must convert the binary code to octal, and then look up the octal code in an off-line manual to obtain error diagnostics.

  Behavioral Implications. The machine's error feedback facilities force the user/operator to divide attention between the display screen, the SPA (to page back) or the binary display, and off-line documents. This procedure consumes time and increases the likelihood of errors. Converting binary to octal provides an additional opportunity for error.

  Transactional Implications. Error diagnostic and correction procedures require more time than necessary, thus delaying completion of transactions. Additional error entries further delay the process, and could introduce errors into the data base.

  Consequences of the Problem. System efficiency is reduced as transactions are delayed. Accuracy of the data base is reduced if errors are not detected. The system's contribution to mission accomplishment is reduced.

  Recommended Resolution. Revise TACFIRE to provide error feedback on-line. This feedback should contain sufficient diagnostic information to indicate the source of the error.

7.4 Error Correction/Recovery

- *Transaction Feature*. Orientation of the DPM.

  Description. The SPRT;MAP preformatted message is used to align and orient the DPM to the current area of interest. Four coordinates are entered, expressed as easting and northing, to identify the locations of the four corners of the map. Any error in filling out the SPRT;MAP message requires the user/operator to start over.

  Behavioral Implications. When entering coordinates, the user/operator must exercise great care to avoid errors, since the occurance of an error requires reentry of any correct information already entered. This procedure imposes an excessive burden on the user/operator during data entry. The necessity to reenter correct information will be frustrating, particularly in stress situations, and will tend to increase the probability of additional errors.

Transactional Implications. Completion of orienting transactions is made unnecessarily difficult and time-consuming by the requirement to restart the process, particularly when the error occurs near the end of the message.

Consequences of the Problem. In operational situations, delays in orienting the SPM will delay graphic presentation of artillery target intelligence and thereby delay artillery command and control functions. This delay in turn may result in loss of important targets.

Recommended Resolution. Provide a capability to edit the SPRT;MAP message so that only incorrect entries need to be changed, without the requirement to reenter correct coordinates.