AD

12 NW

Technical Paper 326

LEVEL II

EASE OF LEARNING ALTERNATIVE TOS MESSAGE REFERENCE CODES

Charles O. Nystrom
George M. Gividen

ARI FIELD UNIT AT FORT HOOD, TEXAS

U. S. Army
Research Institute for the Behavioral and Social Sciences

September 1978

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	WILLIAM L. HAUSER Colonel, US Army Commander

NOTICES

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER Technical Paper 326	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) 6 EASE OF LEARNING ALTERNATIVE TOS MESSAGE REFERENCE CODES.		5. TYPE OF REPORT & PERIOD COVERED --
		6. PERFORMING ORG. REPORT NUMBER --
7. AUTHOR(s) 10 Charles O. Nystrom George M. Gividen		8. CONTRACT OR GRANT NUMBER(s) --
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Research Institute for the Behavioral and Social Sciences Alexandria, Va. 22333		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 16 2Q062106A723
11. CONTROLLING OFFICE NAME AND ADDRESS Assistant Chief of Staff for Force Development Combined Arms Center TRADOC Project Manager ARTADS		12. REPORT DATE 11 September 1978
		13. NUMBER OF PAGES 66
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.

9 Technical paper, 12 77 p.

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

-- 14 ARI-TP-326

18. SUPPLEMENTARY NOTES

--

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

Tactical Operations System (TOS)	screening
Input procedures	learning
User input-output device (UIOD)	Input error rates
Message reference codes	Message input time
User/computer language	Automatic data processing (ADP) system

TOS2

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

To interact with a tactical data processing system such as the DEVTOS or TOS^2, action officers and UIOD operators must correctly enter a message reference code. The senior author had participated in recommending that DEVTOS' letter-letter-number (LL#) codes be replaced by LLLL message reference codes for the forthcoming TOS^2 system, predicting in effect that the LLLL codes would be easier to learn. To confirm or disprove this prediction, 40 officers and 20 enlisted personnel were employed to learn one or

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

78 11 22 098

408 010

20.
the other of the code sets. Seated individually at a computer terminal, the learner was shown message category titles and action names. The learner entered the message reference code, transmitted it, and received feedback as to the correctness or incorrectness of his input, plus the correct code.

The error rate associated with the learning of the LLLL codes was less than half that associated with the learning of the LL# codes (13% versus 29% for EM working on the G2 message codes; 11% versus 21% for officers on the same G2 message codes; and 7% versus 15% errors for officers working on G3 message codes). The LLLL codes were learned in about 60% of the total time required by the LL# codes. Analysis of error rates by character position revealed that the old code's numeric character and arbitrary second letter were large sources of error. Several characters in the LLLL code produced undesirably high error rates; the reasons for this and possible corrections were usually obvious.

Technical Paper 326

EASE OF LEARNING ALTERNATIVE TOS MESSAGE REFERENCE CODES

Charles O. Nystrom
George M. Gividen

ARI FIELD UNIT AT FORT HOOD, TEXAS

Submitted as complete and technically accurate, by:
George M. Gividen
Field Unit Chief

Approved By:

A.H. Birnbaum, Acting Director
ORGANIZATIONS AND SYSTEMS RESEARCH LABORATORY

Joseph Zeidner
TECHNICAL DIRECTOR

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

September 1978

Army Project Number
2Q062106A723

Tactical Operations System

ARI Research Reports and Technical Papers are intended for sponsors of R&D tasks and other research and military agencies. Any findings ready for implementation at the time of publication are presented in the latter part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

FOREWORD

Technological advances have led to increased speed, mobility, and destructive power of military operations. So that commanders can make tactical decisions consistent with the rapid change and succession of events, information on military operations must be processed and used more effectively than ever before. To meet this need, the Army is developing automated systems for receipt, processing, storage, retrieval, and display of vast amounts and different types of military data. There is a concomitant requirement for research to determine how human abilities can be used to insure that command information processing systems function with maximum effectiveness.

Manned systems research in this area done by the U.S. Army Research Institute (ARI) is directed toward enhancement of human performance and improvement of man-machine interaction in relation to total system effectiveness. The research involves experimentation with various configurations of system components, considering interactions and tradeoffs. The end products--immediate or ultimate--are scientific findings on human capabilities under varying conditions within the system. These findings have implications for system design, development, and operational use. This publication describes the evaluation of the relative ease of learning two message reference code sets used in inputting, editing, and obtaining displays of information within the context of a computer-assisted tactical operations system.

The entire research effort is responsive to requirements of Army Project 2Q062106A723, "Enhancement of Performance in Military Organizations," Fiscal Year 1974 Work Program, and to special requirements of the Assistant Chief of Staff for Force Development, the Combined Arms Center of the U.S. Army Training and Doctrine Command, and the U.S. Army Tactical Data Systems Project.

JOSEPH ZEIDNER
Technical Director

EASE OF LEARNING ALTERNATIVE TOS MESSAGE REFERENCE CODES

BRIEF

Requirement:

To evaluate the relative ease or difficulty of learning two alternative message reference codes used during inserting, editing, and extracting information from an Army tactical system.

Procedure:

Forty officers representative of potential G2 and G3 action officers and 20 enlisted personnel representative of potential TOS input-output device operators were given 2 minutes to examine tabular information on describing the message titles and action in association with a message reference code consisting of either two letters and a number (LL#) or four letters (LLLL). Then, seated at a computer terminal with an input keyboard and a cathode ray tube (CRT) display device, the soldiers individually typed and transmitted message reference codes in response to displays of message titles and action names. They had to learn a list of G2 messages or G3 messages. On the first pass through the list, titles were displayed in an orderly sequence. On subsequent passes, titles were in random order. Subjects had to make an error-free pass before they were considered to have met the criterion of learning and were considered finished.

Findings:

The error rate associated with learning the LLLL codes was less than half that associated with learning the LL# codes (13% versus 29% errors for enlisted personnel working on the G2 list; 11% versus 21% for officers working on the G2 list; and 7% versus 15% for officers working on the G3 list). Time required to meet the learning criterion for those learning the LLLL codes was about 60% of that required to learn the LL# codes. Analysis of errors by character position revealed that the old code's numeric character and arbitrary second letter were important sources of error.

Utilization of Findings:

A version of the new LLLL code has now been specified/incorporated into the Tactical Operations System, Operable Segment (TOS^2) computer system as the result of having been jointly recommended for such incorporation by members of a TOS^2 working group that included the senior author as a participant. The findings support the previous hypothesis that the LLLL code would be easier to learn than the LL# code used by Development Tactical Operating System (DEVTOS) personnel.

EASE OF LEARNING ALTERNATIVE TOS MESSAGE REFERENCE CODES

CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF FIGURES

EASE OF LEARNING ALTERNATIVE TOS MESSAGE REFERENCE CODES

INTRODUCTION

Designers, developers, analysts, and researchers of Army tactical data systems continue to seek software, display, and procedural means of facilitating the task of translating free-text message information into computer-acceptable input. This report is closely related to previous Army Research Institute (ARI) publications[1,2] and is part of a long-term concern with problems of information presentation, processing, and utilization in Command and Control Systems.

A specific requirement for the research reported here was first stated in early 1972. Anticipating the replacement of the Development Tactical Operating System (DEVTOS) by the TOS-operable Segment (TOS^2), the Combat Developments Command (CDC) directed the formation of an ad hoc committee to (a) recommend revisions of TOS^2 formats, incorporating DEVTOS and (MASSTER) experience where applicable; and (b) evaluate such revisions using subjective analysis and DEVTOS testing.

Representatives of CDC, Modern Army Selected System Test, Evaluation, and Review (MASSTER), Computer Systems Command (CSC), Project Manager, Army Tactical Data Systems (PM ARTADS), and ARI (then BESRL) formed the committee. Their work produced four recommendations:

1. Consolidation of message formats,
2. Use of variable field data entry,
3. Map reference coordinate "packing," and
4. Use of a new message reference code system.

A very limited try-out of all these revisions on the DEVTOS facility produced encouraging results. However, it was clear that more testing was needed to assess separately the influence of each change on TOS operators' performance, to determine if each change facilitated the interaction of the operator with the semiautomated information system.

---

[1] Baker, J. D., Mace, D. J., and McKendry, J. M. The Transform Operation in TOS: Assessment of the Human Component. ARI Technical Research Note 212, August 1969.

[2] Strub, M. H. Evaluation of Man-computer Input Techniques for Military Information Systems. ARI Technical Research Note 226, May 1971. (NTIS No. AD 730 315)

The recommended message reference code set uses four alphabetic characters for each member of the code set. In most cases, these characters comprise "acronyms" of the message titles and action names. The DEVTOS code set, by contrast, uses two alphabetic characters to represent the message title and one numeric character to represent the action name. The TOS^2 system managers have replaced their DEVTOS-like letter-letter-number (LL#) code set with the four-letter (LLLL) code set recommended by the TOS^2 Format Revision Committee. This report compares the "learnability" of the two code sets.

METHOD

Subjects

The test subjects were 20 enlisted personnel and 40 officers from MASSTER who successfully learned one of four message reference code sets.[3] A requirement for the enlisted men was that they have an Armed Forces Qualification Test General Technical (GT) score of 90 or higher; such enlisted men presumably would be more representative of those who might function as TOS^2 MIOD (message input-output device) operators than would a random sample of Fort Hood enlisted men. A requirement for all subjects was that they must not have had prior experience in using the DEVTOS message reference codes. Officer grades ranged from O1 to O5; enlisted grades ranged from E2 to E7.

The enlisted personnel were randomly assigned to learning one of the two G2 message reference code sets. Officers were randomly assigned to learning one of these two G2 code sets or to one of the two G3 message reference code sets.

Equipment and Workspace

All subjects accomplished their learning task, one at a time, at the same computer terminal. The terminal equipment includes a Hazeltine 2000 cathode ray tube (CRT) and a separate keyboard input device. A third component, a hard-copy output device, was not used. The equipment was situated on a table in a large, well-lighted room. The keyboard was located immediately in front of the CRT, and either item could be moved to suit the comfort of the subject seated in front of them.

---

[3] The learning performance data of an additional six officers and nine enlisted personnel was incomplete and, hence, not usable. In nine of these cases malfunctions of some component of the terminal/computer disrupted and/or terminated operations. In three cases the subject did not cooperate properly, and in another three cases the subject was called away on higher priority business.

The computer terminal was linked to an IBM 370 computer system[4] at Central Texas College, Killeen, Tex. A computer program presented the message format titles and appropriate feedback displays, and recorded/compiled data regarding response times and errors. Listings of these recorded performance measures were subsequently used in performing statistical analyses of the performance data.

Procedure

Instructions to Subjects. Each participant, on arrival, was greeted, offered coffee, and seated at a chair facing the CRT. The experimenter or an assistant sat with the participant to demonstrate keyboard usage and control the duration of exposure. The subject of tabular information regarding the message titles was displayed, along with action names and their associated title codes and action codes, which jointly comprise the message reference code. For uniformity of presentation, instructions were read to each subject. Some procedural variation was introduced when subjects asked questions regarding procedures or purposes; they received answers that others did not. Performance variation due to differences among the presenters of instructions, if any occurred, is likewise co-mingled with the effects of the main independent variables: type of code, G2 versus G3 list, and rank of learner.

The instructions and the four sets of three tables describing each of the four code sets are presented in Appendix A.

In addition to describing keyboard usage, CRT display content, and timing relationships, the instructions indicated that subjects were to continue at the task until they made a "perfect pass," that is, the subject must have gone through the entire list of either 26 G2 message format titles or 57 G3 titles with no errors. The orderly arrangement of titles during the first pass through the list and the random ordering of the items on subsequent passes were described. Each subject was told the purpose of the experiment.

As the subject began working, the experimenter stayed beside him to detect any misunderstanding the subject might have concerning how to respond. When the experimenter judged that these procedural difficulties, if any, were resolved, he moved across the room out of the subject's vision.

Display Characteristics. A given message title, a hyphen, and the name of an action were initially displayed in capital letters on the bottom line (of 15 lines total) of the CRT. This stimulus display then appeared rolled upward to the 11th line. The subject's answer (the

---

[4] Commercial designations are given only in the interest of precision of reporting. Their use does not constitute endorsement by the U.S. Army Research Institute or the U.S. Army.

attempt at providing the message reference code) appeared on the 12th line as the subject pressed the keys to enter an answer. When the subject pressed the "ESC" key to transmit a code-answer to the computer, the display characters shifted up two lines, and a feedback display appeared on the empty 11th line. If the answer (e.g., UL3) was correct, the feedback display would read as follows:

UL3 IS CORRECT

If UL3 was wrong and the subject should have answered UL2, the feedback display would read thus:

ERROR
UL2 IS CORRECT

The *ERROR* appeared first on line 11; all displayed characters were shifted up a line; then UL2 IS CORRECT was displayed on the now-vacant 11th line.

This technique of shifting or rolling displayed lines upward was used so that the subject could anticipate coming events. Inserted five lines before each title display was this instruction:

ENTER ANSWER, THEN PRESS "ESC" TO CONTINUE

The separations among displayed lines were arranged so that when a new title rolled up to line 11, the feedback display for the previous title disappeared at the top of the CRT. The following two display lines appeared at the end of a pass through the list of titles wherein one or more incorrect answers had been given:

YOU HAVE COMPLETED PASS
YOU ARE REQUIRED TO CONTINUE

When the subject met the criterion of learning by making a perfect pass, these two display lines appeared:

YOU HAVE COMPLETED PASS
YOU HAVE FINISHED

Experimental Variables

Independent Variables. Three independent variables were used in this experiment; the one called "code type" or "type of code" is of primary interest. One of the two types of codes used consists of two alphabetic characters followed by a digit, i.e., the old DEVTOS LL# code. The two letters represent the title of a message category, and the digit represents the type of action the user desires to take with respect to that category. Note, however, that in this experiment, message formats were not displayed--only the names/titles of the message categories and associated permissible actions.

The second type of code used is a four-letter code. The first three letters represent the title of a message category, and the fourth letter represents the type of action desired.

The "rules" or schemes by which the two code sets are generated are different. It is judged that the rules regarding the new four-letter code are simpler to state (see Tables 1 and 2), partly because there are fewer exceptions. An individual learning the new LLLL codes is typically forming acronyms by using the first letter of each word. Most of the difficulty in learning the LLLL codes should arise when the message category title contains other than three words. In the old LL# code, the first letter sorts between friendly, enemy, and "common" message categories, with an exception included ("F" for aircraft-related message categories). The second letter is arbitrarily assigned to the messages within each of the friendly or enemy categories, but it is always an "A" for the common messages. For the action code, the numbers 1 through 6 are used for the six permitted actions, but exceptions arise with the common messages where 0, 8, and 9 replace the 1, 3, and 4 to enable the computer program to discriminate among actions. The preceding description of the rules by which the two code sets are generated is incomplete, but it helps to show why the four-letter code was recommended for incorporation in the TOS^2 system and why it was predicted that learning the four-letter code would be easier than learning the LL# code.

A second independent variable sorts learners into two categories: officers and enlisted men. Both may be employed in roles wherein, among component tasks, they must use the message reference code.

Subjects learned either the codes for the G2 message, plus action terms, or the codes for the G3 terms; thus G2 versus G3 becomes the third independent variable whose effects on performance can be assessed. This assessment can be made only for the officers, however, as the available number of enlisted men did not allow assigning them to the G3 code learning task.

Dependent Variables. The percentage of message reference codes input with one or more characters in error (or not supplied) is judged to be the most pertinent measure of learning performance (dependent variable) in this experiment. Another dependent variable is the number of passes through the code list that each learner made in reaching the success criterion of a perfect (error-free) pass. This measure counts a pass with one error the same as a pass with many errors and therefore is a less sensitive measure of performance than the error rate measure mentioned above; however, the two measures should be positively correlated.

Table 1

Message Titles with Old (LL#) and New (LLLL) Codes

G2 message titles	Message title code Old	New
Enemy Unit Status	EA	EUS
Enemy Situation Data	EC	ESD
(Enemy) Intelligence Summary	ED	EIN
(Enemy) Intelligence Working File	EE	EWF
Enemy Situation Data Base Index	EG	EDX
Relay[a]	AA	REL
Named Area of Interest[a]	AA	NAI
Standing Request for Information File[a]	AA	SRI
G3 message titles		
Task Organization	UA	UTO
Task Force	UB	UTF
Tactical Dispositions	UD	UTD
Unit Disposition, One Coordinate	UE	UDC
Unit Disposition, One Unit	UF	UDU
Unit Disposition, General	UG	UDG
Air Control Measure	UH	ACM
Operations Journal	UL	UOJ
Situation Report	UM	USI
Pending Change	UN	UPC
Spot Report	US	USR
Aircraft Available	FA	AAV

[a] These messages are also used for G3 functions and were displayed as G3 message titles as well.

Table 2

Action Names with Old and New Codes

Action name	Action code Old[a]	Action code New
Add	1	A
Change	2	C
Delete	3	D
Query	4	Q
Special processing	5	P
Establish standing request for information	6	S

[a]Plus these special cases:

1. Use an action code of 0 to add a Relay message.
2. Use an action code of 8 to delete an "SRI File" message.
3. Use an action code of 9 to query the "SRI File."

Instructions to the subjects did not suggest that they emphasize speed of response. Explicit emphasis such as "Be accurate, not fast" was not given. However, the weight of the instructions is thought to favor accuracy and to ignore speed. At any rate, the dependent variable of time to input a message reference code was computed for each learner, averaged over the 26 or 57 code inputs for each pass, and over all passes.

Supplementary analyses of error rates were made for the action code alone (last character), for the message title code (first two or first three characters), and for each character position. This was done to determine if the arbitrariness in the second letter's assignment and the exceptions in the action code (previously pointed out regarding the LL# code) inflated the error rates in comparison to corresponding error rate scores for the four-letter code.

RESULTS AND DISCUSSION

Effects of Type of Code

LLLL codes were clearly superior to LL# codes in that subjects learned the LLLL codes in fewer passes and with a lower rate of errors.

Number of Passes to Criterion. Subjects learning the LLLL code achieved the goal of successful code learning in fewer passes, on the average, than did subjects learning the LL# code (see Table 3). This result was obtained for enlisted personnel (5.2 versus 9.2 passes) and for officers (3.8 versus 6.8 passes) working on the G2 message reference codes and again for the officers (2.9 versus 4.7 passes) working on the G3 message reference codes. Among these three comparisons of LLLL versus LL#, there is a strong consistency of relationship; i.e., the mean number of passes needed to learn the LLLL code is, respectively, 57%, 56%, and 62% of the number of passes needed to learn the LL# code. Number of passes is, of course, higher correlated with total time to learn.

Statistical analysis of these results indicates that the differences favoring learning of the four-letter code are statistically significant for each of the three comparisons ($p < .01$; $p < .01$; $p < .05$ respectively) noted above. Analysis of variance tables relating to these and other dependent variables are presented in Appendix B.

Percentage of Errors. The mean percentage of errors (responses containing at least one error) made by each of the six groups of subjects is shown in Table 3 and Figure 1. Those learning the four-letter message reference codes had smaller percentages of errors than did those learning the LL# codes. As with number of passes, this result was obtained for the two groups of enlisted personnel (13.2% versus 29.1%) and the two groups of officers (10.6% versus 21.4%) working on the G2 message reference codes, and also for the two groups of officers (6.5% versus 15.1%) who learned the G3 message reference codes. All three differences are statistically significant ($p < .01$ in each case). The error rates associated with the LLLL codes are 45%, 50%, and 43% of the size of the error rates associated with the learning of the LL# codes for the three comparisons, respectively. The consistency of these error rate relationships (45% and 50%) for the enlisted men and officers working with the G2 message titles is reflected in the analysis finding of a nonsignificant and very small interaction of learner's rank with type of code.

Time To Input a Message Reference Code. Results for this dependent variable are shown in Table 3. The mean time to input a message reference code (averaged across inputs for a given learner, and then averaged across learners within a group) was not significantly nor practically influenced by code type: i.e., LLLL code versus LL# code. This result appears to be consistent with the lack of emphasis on inputting code responses quickly. Recall also that subjects had 20 seconds to input each code response; this was 13 to 14 seconds more than the average time taken. No one complained that this length of time was a source of pressure, irritation, or other concern; neither did the monitors judge it to be such.

Table 3

Error Rate, Passes, and Code Input Time

Rank	List	No. of items	Code type	No. of subjects	Mean % errors	Mean no. of passes	Mean input time (sec.)
EM	G2	26	LL#	10	29.1	9.2	6.50
EM	G2	26	LLLL	13	13.2	5.2	6.44
OFF	G2	26	LL#	10	21.4	6.8	6.28
OFF	G2	26	LLLL	10	10.5	3.8	6.53
OFF	G3	57	LL#	9	15.1	4.7	5.64
OFF	G3	57	LLLL	8	6.5	2.9	5.54

Note. Errors refers to codes input with at least one character incorrectly supplied or not supplied.

Officer-Enlisted Personnel Differences

The median GT score for the enlisted personnel participating in this experiment was 124. Despite their high GT score, the enlisted personnel took more passes in learning the LL# codes (9.2 versus 6.8 passes) and in learning the LLLL codes (5.2 versus 3.8 passes) than did the officers. Analysis of variance of the 2 x 2 factorial design (2 ranks x 2 code types on G2 messages) indicated that the overall difference between the two groups' performances was statistically significant ($.01 < p < .05$).

In terms of mean percentage of errors made while learning the G2 message reference codes, EM had a higher error rate in learning the LL# codes (29.1% versus 21.4%) and in learning the LLLL codes (13.2% versus 10.6%) than did the officers. The EM-officer overall error rate comparison (21.14% versus 16.0%) was associated with a probability of .053, which just barely fails to meet the null hypothesis rejection level of .05.

Given either a larger sample size and/or a lower distribution of EM's GT scores, these error rate differences would probably have been significant at the .05 level. Also, the gap between officer and EM error rates is greater for the more difficult LL# codes than for the LLLL codes. If LLLL message reference codes do close the gap between officer and EM performance, this might be exploited beneficially in future TOS operations.

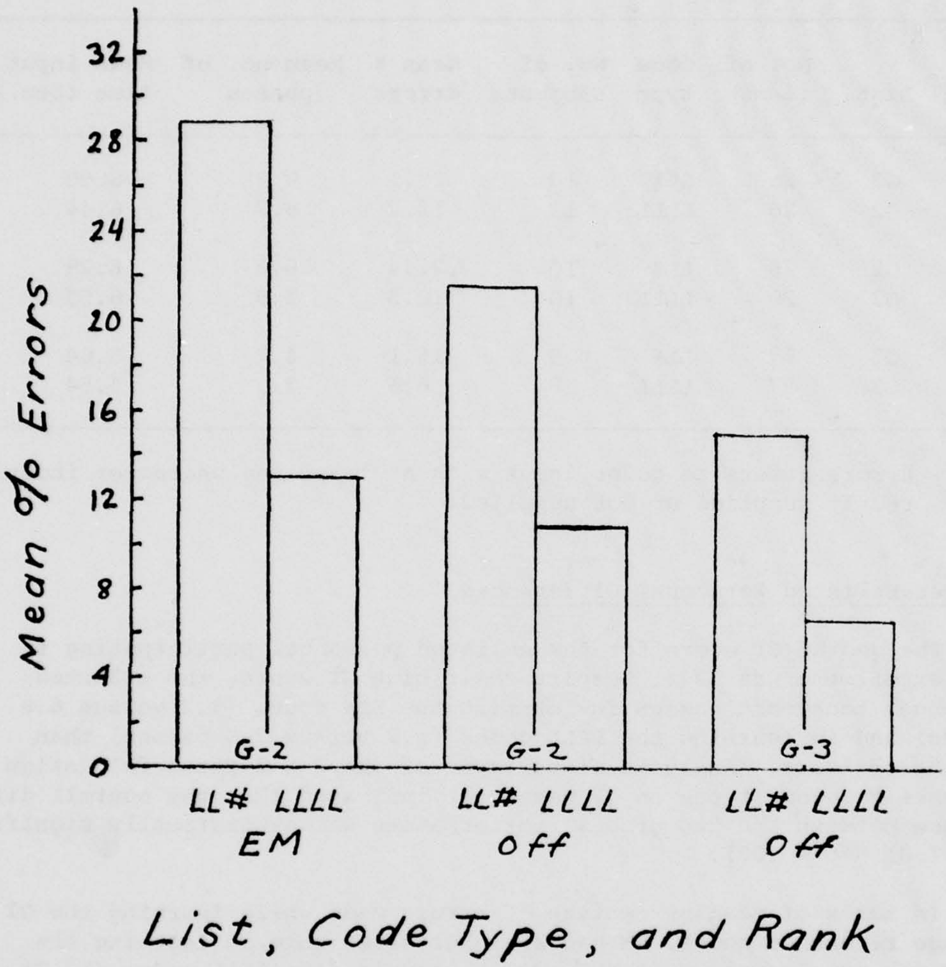

Figure 1. Mean percentage of code responses containing at least one error as a function of code type, list, and rank.

Observed differences between officers and enlisted personnel for mean time to input a message reference code averaged only .1 and .2 seconds for the two comparisons. These differences were far from being statistically or practically significant.

G2 Versus G3 Differences

Subjects learned message reference codes related to G3 operations in fewer passes than they learned the G2 codes. For the LL# type of code, the comparison is 4.7 passes versus 6.8 passes. For the LLLL codes, those applying to G3 were learned in 2.9 passes, on the average, versus 3.8 passes for the G2 list.

Error rate data also favored the learning of codes related to G3 operations over codes related to G2 operations. The overall comparison is 10.8% errors on the G3 lists versus 16.0% errors on the G2 lists. This difference is statistically significant ($p < .01$). For the LL# codes, officers working on the G3 list made 15.1% errors compared to 21.4% errors for the officers working on the G2 list. For the LLLL codes, there were 10.8% G3 errors versus 16.0% G2 errors.

Overall, the mean time to input a code while learning was 0.87 seconds faster for the G3 list of codes (5.60 seconds) than for the G2 list (6.47 seconds). The probability of obtaining a time difference this large or larger by chance, under the hypothesis of no difference, falls short ($p = .08$) of the rejection level of .05. If reliable, the smaller mean time to input a G3 message reference code may be attributed to the fact that the G3 list has a larger number and proportion of message titles that could be responded to correctly; hence, the overall mean time to input a message reference code is shorter.

Errors by Character Position

To gain a better understanding of the sources of error and difficulty in learning the LL# and LLLL codes, an analysis of errors by character position was made for each officer within each of the four combinations of list type (G2 and G3) and code type. The results of this analysis are presented in Appendix C. (The actual individual performance data are shown in Appendix D.)

Alternative Message Reference Code Schemes

As noted, subjects learned the LLLL code with about half the error percentage associated with learning the LL# code. However, the analysis of errors by character position (Appendix C) revealed that seven of the new code's characters were associated with excessively high error rates in the learning situation used in the experiment. Thus, it seems possible to further reduce error rates in learning and using message reference codes. Four alternative approaches to achieving this additional error reduction are described and discussed in the paragraphs that follow.

Approach A: Partial Revision. If only those message titles, action names, and code characters associated with excessively high error rates (10% or more) were revised, a substantial further reduction in error rates in learning the message reference codes could be expected. Table 4 shows the message reference titles (split into message titles and action names) and code characters for both G2 and G3 operations. An asterisk indicates that a revision has been made. Note that the message titles do not all contain exactly three words. Consequently the three-character code associated with the message titles cannot be completely acronymic. This means that the procedure by which the code has been generated cannot be explained to a potential learner with a fairly simple, easy-to-remember statement. However, approaches B, C, and D all have the advantage of being easy to explain to a learner.

Approach B: Three-Word Message Titles, Three-Letter Acronyms. In this approach, all message titles are forced to have exactly three words so that the first letter of each word (in the message title) can be used to form an acronym. This, in turn, permits using a sentence such as the following to describe to a learner how to determine the code for any message title plus action name combination: "The message reference code consists of the first letter of each word in the message title followed by the first letter of the first word in the action name." Table 5 displays the message reference titles and codes in the same format as Table 4. The use of this approach raises this question--Does the availability of the exact three-letter acronym "rule" compensate for the many changes in the message titles that are involved?

Approach C: Variable-Length Acronymic Code. This approach requires presumably minor computer program revision so that the action officer may input message reference codes of 2, 3, or 4 characters according to the presence in the message titles of 1, 2, or 3 words. (The action code adds the additional character, of course.) The explanation given a learner of this message reference code could be as follows: "The code consists of the first letter of each word in the message title, then the first letter of the first word of the action name."

Implementation of this code requires message titles to consist of three words or less with no ambiguities; e.g., two titles generating the same code. Table 6 displays the message titles, action names, and code letters involved in this variable-length, acronymic code.

This approach involves changes to 8 message titles, compared to 16 title changes for approach B.

Table 4

A Partial Revision of the LLLL Code and Titles

Message title	Code letters
Task Organization	UTO
Task Force	UTF
Tactical Dispositions	UTD
Unit Disposition, One Coordinate	UDC
Unit Disposition, One Unit	UDU
Unit Disposition, General	UDG
Air Control Measure	ACM
Operations Journal	UOJ
SITREP*	SIT*
Pending Change	UPC
Spot Report	USR
Aircraft Available	UAA*
Common Relay Message*	CRM*
Named Area of Interest	NAI
Standing Request for Information*	SRI
Enemy Unit Status	EUS
Enemy Situation Data	ESD
(Enemy) Intelligence Summary	EIS*
Intelligence Work File*	IWF*
Situation Data Index*	SDI*

Action name	Code letter
Add	A
Change	C
Delete	D
Query	Q
Special Processing	S*
Establish Standing Request for Information	E*

*Changed from current version.

Table 5

Three-Word Message Titles with Three-Letter Acronymic Codes

Message title	Code letters
Unit Task Organization*	UTO
Unit Task Force*	UTF
Unit Tactical Dispositions*	UTD
Unit Disposition, Coordinate*	UDC
Unit Disposition, Unit*	UDU
Unit Disposition, General	UDG
Air Control Measure	ACM
Unit Operations Journal*	UOJ
Tactical Situation Report*	TSR*
Unit Pending Change*	UPC
Unit Spot Report*	USR*
Friendly Aircraft Available*	FAA*
Common Relay Message*	CRM*
Named Interest Area*	NIA*
Standing Information Request*	SIR*
Enemy Unit Status	EUS
Enemy Situation Data	ESD
Enemy Intelligence Summary*	EIS*
Intelligence Work File*	IWF*
Situation Data Index*	SDI*

Action name	Code letter
Add	A
Change	C
Delete	D
Query	Q
Special Processing	S*
Establish Standing Information Request*	E*

*Changed from current version.

Table 6

Message Titles, Action Names, and Code Letters
Required by a Variable Length Acronymic Code

Message title	Code letter(s)
Task Organization	TO*
Task Force	TF*
Tactical Dispositions	TD*
Unit Disposition, Coordinate*	UDC
Unit Disposition, Unit*	UDU
Unit Disposition, General	UDG
Air Control Measure	ACM
Operations Journal	OJ*
SITREP*	S*
Pending Change	PC*
Spot Report	SR*
Aircraft Available	AA*
Relay	R*
Named Interest Area*	NIA*
Standing Information Request*	SIR*
Enemy Unit Status	EUS
Enemy Situation Data	ESD
Intelligence Summary*	IS*
or INTSUM*	I*
Intelligence Work File*	IWF*
Situation Data Index*	SDI*

Action name	Code letter
Add	A
Change	C
Delete	D
Query	Q
Special Processing	S*
Establish Standing Information Request*	E*

*Changed from current version.

Approach D: A Three-Letter Code Based on First and Last Words of Message Title. Approach D could be explained with a statement such as "The code consists of the first two letters of the first word of the message title, plus the first letter of the last word, followed by the first letter of the first word of the action name." This approach does not employ an exact acronym, although the code letters form a partial or incomplete acronym. (Webster's Seventh New Collegiate Dictionary defines acronym as "a word (as radar, snafu) formed from the initial letter or letters of each of the successive parts or major parts of a compound term.") This approach requires the change of only one message title. Table 7 displays the message titles, action names, and code letters involved in this three-letter, incomplete acronymic code.

Which Approach Is Best? It is expected that all four approaches to revising or designing a message reference code would result in further reduction of error rates; however, approaches B, C, and D are believed to be capable of bringing about more error reduction than the partial revision described in approach A. A further experiment is needed to determine which of the three approaches is best at reducing errors; such an experiment is being prepared.

CONCLUSIONS AND RECOMMENDATIONS

It may be reliably concluded that the four-letter message reference code set recommended for use with the TOS^2 can be learned more quickly and with less error than the alternative two-letter, one-number code set that had been used by DEVTOS personnel.

It is recommended that consideration be given to revising the current four-letter code version in accordance with Table 4 or changing it to one of the three versions shown in Tables 5, 6, and 7. Adoption of any of these four versions should further reduce the number of errors made by code learners.

Table 7

Message Titles, Action Names, and Code Letters Required by a Three-Letter Partially Acronymic Code

Message title	Code letters
Task Organization	TAO*
Task Force	TAF*
Tactical Dispositions	TAD*
Unit Disposition, One Coordinate	UNC
Unit Disposition, One Unit	UNU
Unit Disposition, General	UNG
Air Control Measure	AIM*
Operations Journal	OPJ*
Situation Report	SIR*
Pending Change	PEC*
Spot Report	SPR*
Aircraft Available	AIA*
Relay Message*	REM*
Named Area of Interest	NAI
Standing Request for Information File	STF*
Enemy Unit Status	ENS*
Enemy Situation Data	END*
Intelligence Summary	INS*
Intelligence Work File	INF*
Enemy Situation Data Base Index	ENI*

Action name	Code letter
Add	A
Change	C
Delete	D
Query	Q
Special Processing	S*
Establish Standing Request for Information	E*

*Changed from current version.

APPENDIX A

INFORMATION AND INSTRUCTIONS FOR SUBJECTS

Information and Instructions Read to Subjects

MASSTER, the Computer Systems Command, the Army Tactical Data Systems Project, and the Army Research Institute have been experimentally using computer systems to assist in message processing. For this test we have taken one of the G2 or G3 officer's sub-tasks, and will have you learn it.

The G3 (or G2) must use a message reference code to tell the computer which of 6 actions he wants to take on any of the 15 (or 8) categories of messages that he handles. (Show Tables 1 and 2)

In table a you'll see the names of message categories and the code that stand for each.

In table b you'll see the names of the six actions that can be taken, along with the single character action code.

The message reference code which you will be learning during this experiment is formed by adding these two codes, as shown in table c.

Would you please read aloud the names and codes from table a and b so that I'll know you have paid some attention to each one.

(After he's read aloud, take away the tables.)

After we get the program going, you will see a message and action name appear here at the bottom of the CRT. It will roll up (move your finger up 4 times) one, two, three four lines and stop. After it stops rolling, you will have 20 seconds to type in the message reference code. What you type will appear on the CRT. After you've typed in what you think the code is, then hit this "ESC" button to tell the program that you are finished making your response.

The program will then give you feedback. If your answer is correct, it will repeat your answer and say it is correct. If your answer is wrong, the word "ERROR" will be displayed and then the correct answer will be displayed. This feedback will last for 5 seconds and then the program will go on to the next item.

If you see that you've typed in something wrong and haven't yet hit the "ESC" button, then here's how to correct it. You must replace the wrong character and all characters to the right. Tell the program how many characters you're going to replace by pressing the shift key and hitting this arrow (upper case O). Then type in the correction and send it.

There are 26 (57) titles in the list you will be learning. On the first pass through the list the titles will be displayed in this order (point at table c). On the second and later passes the titles will appear in a random order. You will be finished when you make a perfect pass; i.e., go through the whole list without making an error.

The purpose of this experiment is to get performance data on how easy or difficult various message reference codes are to learn. When the experiment is over, we'll inform the ARTADS people of our findings and they will make use of them in a new computer system that will be coming here in about a year.

Tables Shown to Subjects

On the following pages are the tables that were shown to subjects as part of their information and instructions. A given subject saw only three tables a, b, and c. Which set of three he was shown - set 1, 2, 3 or 4 - depended on which code (LL# or LLLL) and which area of operations (G2 or G3) he was assigned to learn.

Table A-1a

Message Titles And Their Abbreviations, For G2 Functions

No.	Message Title	Message Title Abbreviations
1	*Enemy Unit Status*	EUS
2	Enemy Situation Data	ESD
3	(Enemy) Intelligence Summary	EIN
4	(Enemy) Intelligence Working File	EWF
5	Enemy Situation Data Base Index	EDX
6*	Relay	REL
7*	Named Area of Interest	NAI
8*	Standing Request for Information File	SRI

*These types of messages are also used for G-3 functions.

Table A-1b

Types of Actions and the Letter Code for Each

Action Desired Regarding Message	Action Code
ADD (to data base)	A
CHANGE (the data base)	C
DELETE (from data base)	D
QUERY (the data base)	Q
SPECIAL PROCESSING (of some message types)	P
ESTABLISH STANDING REQUEST FOR INFORMATION	S

Table A-1c

Message Code List To Be Learned In Response To Message Title And Type Of Action In The Area Of G2 Functions

No.	Message Title And Action	Message Code
1	Enemy Unit Status-ADD	EUSA
2	Enemy Unit Status-DELETE	EUSD
3	Enemy Unit Status-QUERY	EUSQ
4	Enemy Situation Data-ADD	ESDA
5	Enemy Situation Data-CHANGE	ESDC
6	Enemy Situation Data-DELETE	ESDD
7	Enemy Situation Data-QUERY	ESDQ
8	Enemy Situation Data-ESTABLISH SRI	ESDS
9	(Enemy) Intelligence Summary-ADD	EINA
10	(Enemy) Intelligence Summary-CHANGE	EINC
11	(Enemy) Intelligence Summary-DELETE	EIND
12	(Enemy) Intelligence Summary-SPECIAL PROCESSING	EINP
13	(Enemy) Intelligence Work File-ADD	EWFA
14	(Enemy) Intelligence Work File-CHANGE	EWFC
15	(Enemy) Intelligence Work File-DELETE	EWFD
16	(Enemy) Intelligence Work File-QUERY	EWFQ
17	Enemy Situation Data Base Index-ADD	EDXA
18	Enemy Situation Data Base Index-CHANGE	EDXC
19	Enemy Situation Data Base Index-QUERY	EDXQ
20	Relay-ADD	RELA
21	Named Area of Interest-ADD	NAIA
22	Named Area of Interest-CHANGE	NAIC
23	Named Area of Interest-DELETE	NAID
24	Named Area of Interest-QUERY	NAIQ
25	Standing Request For Information File-DELETE	SRID
26	Standing Request For Information File-QUERY	SRIQ

Table A-2a

Message Titles And Their Abbreviations, For G2 Functions

No.	Message Title	Message Title Abbreviation
1	Enemy Unit Status	EA
2	Enemy Situation Data	EC
3	(Enemy) Intelligence Summary	ED
4	(Enemy) Intelligence Working File	EE
5	Enemy Situation Data Base Index	EG
6*	Relay	AA
7*	Named Area of Interest	AA
8*	Standing Request For Information File	AA

*These types of messages are also used for G3 functions.

Table A-2b

Types Of Actions And The Numerical Code For Each

Action Desired Regarding Message	Action Code
ADD (to data base)	1
CHANGE (the data base)	2
DELETE (from data base)	3
QUERY (the data base)	4
SPECIAL PROCESSING (of some message types)	5
ESTABLISH STANDING REQUEST FOR INFORMATION	6

Special Cases:
(1) Only an Action Code of 0 may be used with the relay message.
(2) Use an Action Code of 8 to delete an SRI File message.
(3) Use an Action Code of 9 to query the SRI File.

Table A-2c

Message Code List To Be Learned In Response To Message Title And Type Of Action In The Area Of G2 Functions

No.	Message Title And Action	Message Code
1	Enemy Unit Status-ADD	EA 1
2	Enemy Unit Status-DELETE	EA 3
3	Enemy Unit Status-QUERY	EA 4
4	Enemy Situation Data-ADD	EC 1
5	Enemy Situation Data-CHANGE	EC 2
6	Enemy Situation Data-DELETE	EC 3
7	Enemy Situation Data-QUERY	EC 4
8	Enemy Situation Data-ESTABLISH SRI	EC 6
9	(Enemy) Intelligence Summary-ADD	ED 1
10	(Enemy) Intelligence Summary-CHANGE	ED 2
11	(Enemy) Intelligence Summary-DELETE	ED 3
12	(Enemy) Intelligence Summary-SPECIAL PROCESSING	ED 5
13	(Enemy) Intelligence Work File-ADD	EE 1
14	(Enemy) Intelligence Work File-CHANGE	EE 2
15	(Enemy) Intelligence Work File-DELETE	EE 3
16	(Enemy) Intelligence Work File-QUERY	EE 4
17	Enemy Situation Data Base Index-ADD	EG 1
18	Enemy Situation Data Base Index-CHANGE	EG 2
19	Enemy Situation Data Base Index-QUERY	EG 4
20	Relay-ADD	AA 0
21	Named Area of Interest-ADD	AA 1
22	Named Area of Interest-CHANGE	AA 2
23	Named Area of Interest-DELETE	AA 3
24	Named Area of Interest-QUERY	AA 4
25	Standing Request For Information File-DELETE	AA 8
26	Standing Request For Information File-QUERY	AA 9

Table A-3a

Message Titles And Their Abbreviations, For G3 Functions

No.	Message Title	Message Title Abbreviation
1	Task Organization	UTO
2	Task Force	UTF
3	Tactical Dispositions	UTD
4	Unit Disposition, One Coordinate	UDC
5	Unit Disposition, One Unit	UDU
6	Unit Disposition, General	UDG
7	Air Control Measure	ACM
8	Operations Journal	UOJ
9	Situation Report	USI
10	Pending Change	UPC
11	Spot Report	USR
12	Aircraft Available	AAV
13	Relay	REL
14	Named Area of Interest	NAI
15	Standing Request for Information	SRI

Table A-3b

Types of Action and the Letter Code for Each

Action Desired Regarding Message	Action Code
ADD (to data base)	A
CHANGE (the data base)	C
DELETE (from data base)	D
QUERY (the data base)	Q
SPECIAL PROCESSING (of some message types)	P
ESTABLISH STANDING REQUEST FOR INFORMATION	S

Table A-3c

Message Code List To Be Learned In Response To Message Title And Type Of Action In the Area Of G3 Functions

No.	Message Title And Action	Message Code
1	Task Organization-ADD	UTOA
2	Task Organization-CHANGE	UTOC
3	Task Organization-DELETE	UTOD
4	Task Organization-QUERY	UTOQ
5	Task Organization-ESTABLISH SRI	UTOS
6	Task Force-ADD	UTFA
7	Task Force-CHANGE	UTFC
8	Task Force-DELETE	UTFD
9	Task Force-QUERY	UTFQ
10	Task Force-ESTABLISH SRI	UTFS
11	Tactical Dispositions-QUERY	UTDQ
12	Tactical Dispositions-SPECIAL PROCESSING	UTDP
13	Tactical Dispositions-ESTABLISH SRI	UTDS
14	Unit Disposition, One Coordinate-ADD	UDCA
15	Unit Disposition, One Coordinate-CHANGE	UDCC
16	Unit Disposition, One Coordinate-DELETE	UDCD
17	Unit Disposition, One Coordinate-QUERY	UDCQ
18	Unit Disposition, One Coordinate-ESTABLISH SRI	UDCS
19	Unit Disposition, One Unit-ADD	UDUA
20	Unit Disposition, One Unit-CHANGE	UDUC
21	Unit Disposition, One Unit-DELETE	UDUD
22	Unit Disposition, One Unit-QUERY	UDUQ
23	Unit Disposition, One Unit-ESTABLISH SRI	UDUS
24	Unit Disposition, General-ADD	UDGA
25	Unit Disposition, General-CHANGE	UDGC
26	Unit Disposition, General-DELETE	UDGD
27	Unit Disposition, General-QUERY	UDGQ
28	Unit Disposition, General-ESTABLISH SRI	UDGS
29	Air Control Measure-ADD	ACMA
30	Air Control Measure-CHANGE	ACMC
31	Air Control Measure-DELETE	ACMD
32	Air Control Measure-QUERY	ACMQ
33	Air Control Measure-ESTABLISH SRI	ACMS

Table A-3c, Continued

No.	Message Title and Action	Message Code
34	Operations Journal-ADD	UOJA
35	Operations Journal-DELETE	UOJD
36	Operations Journal-QUERY	UOJQ
37	Operations Journal-SPECIAL PROCESSING	UOJP
38	Situation Report-CHANGE	USIC
39	Situation Report-SPECIAL PROCESSING	USIP
40	Pending Change-ADD	UPCA
41	Pending Change-CHANGE	UPCC
42	Pending Change-DELETE	UPCD
43	Pending Change-QUERY	UPCQ
44	Spot Report-ADD	USRA
45	Spot Report-QUERY	USRQ
46	Aircraft Available-ADD	AAVA
47	Aircraft Available-CHANGE	AAVC
48	Aircraft Available-DELETE	AAVD
49	Aircraft Available-QUERY	AAVQ
50	Aircraft Available-ESTABLISH SRI	AAVS
51	Relay-ADD	RELA
52	Named Area of Interest-ADD	NAIA
53	Named Area of Interest-CHANGE	NAIC
54	Named Area of Interest-DELETE	NAID
55	Named Area of Interest-QUERY	NAIQ
56	Standing Request for Information File-DELETE	SRID
57	Standing Request for Information File-QUERY	SRIQ

Table A-4a

Message Titles And Their Abbreviations, For G3 Functions

No.	Message	Message Title Abbreviation
1	Task Organization	UA
2	Task Force	UB
3	Tactical Dispositions	UD
4	Unit Disposition, One Coordinate	UE
5	Unit Disposition, One Unit	UF
6	Unit Disposition, General	UG
7	Air Control Measure	UH
8	Operations Journal	UL
9	Situation Report	UM
10	Pending Change	UN
11	Spot Report	US
12	Aircraft Available	FA
13	Relay	AA
14	Named Area of Interest	AA
15	Standing Request for Information File	AA

Table A-4b

Types of Actions And The Numerical Code For Each

Action Desired Regarding Message	Action Code
ADD (to data base)	1
CHANGE (the data base)	2
DELETE (from data base)	3
QUERY (the data base)	4
SPECIAL PROCESSING (of some message types)	5
ESTABLISH STANDING REQUEST FOR INFORMATION	6

Special Cases:
(1) Only an Action Code of 0 may be used with the Relay Message.
(2) Use an Action Code of 8 to delete an SRI File message.
(3) Use an Action Code of 9 to query the SRI File.

Table A-4c

Message Code List To Be Learned In Response To Message Title And Type Of Action In The Area Of G3 Functions

No.	Message Title And Action	Message Code
1	Task Organization-ADD	UA 1
2	Task Organization-CHANGE	UA 2
3	Task Organization-DELETE	UA 3
4	Task Organization-QUERY	UA 4
5	Task Organization-ESTABLISH SRI	UA 6
6	Task Force-ADD	UB 1
7	Task Force-CHANGE	UB 2
8	Task Force-DELETE	UB 3
9	Task Force-QUERY	UB 4
10	Task Force-ESTABLISH SRI	UB 6
11	Tactical Dispositions-QUERY	UD 4
12	Tactical Dispositions-SPECIAL PROCESSING	UD 5
13	Tactical Dispositions-ESTABLISH SRI	UD 6
14	Unit Disposition, One Coordinate-ADD	UE 1
15	Unit Disposition, One Coordinate-CHANGE	UE 2
16	Unit Disposition, One Coordinate-DELETE	UE 3
17	Unit Disposition, One Coordinate-QUERY	UE 4
18	Unit Disposition, One Coordinate-ESTABLISH SRI	UE 6
19	Unit Disposition, One Unit-ADD	UF 1
20	Unit Disposition, One Unit-CHANGE	UF 2
21	Unit Disposition, One Unit-DELETE	UF 3
22	Unit Disposition, One Unit-QUERY	UF 4
23	Unit Disposition, One Unit-ESTABLISH SRI	UF 6
24	Unit Disposition, General-ADD	UG 1
25	Unit Disposition, General-CHANGE	UG 2
26	Unit Disposition, General-DELETE	UG 3
27	Unit Disposition, General-QUERY	UG 4
28	Unit Disposition, General-ESTABLISH SRI	UG 6
29	Air Control Measure-ADD	UH 1
30	Air Control Measure-CHANGE	UH 2
31	Air Control Measure-DELETE	UH 3
32	Air Control Measure-QUERY	UH 4
33	Air Control Measure-ESTABLISH SRI	UH 6
34	Operations Journal-ADD	UL 1
35	Operations Journal-DELETE	UL 3
36	Operations JOurnal-QUERY	UL 4
37	Operations Journal-SPECIAL PROCESSING	UL 5

Table A-4c, Continued

No.	Message Title And Action	Message Code
38	Situation Report-CHANGE	UM 2
39	Situation Report-SPECIAL PROCESSING	UM 5
40	Pending Change-ADD	UN 1
41	Pending Change-CHANGE	UN 2
42	Pending Change-DELETE	UN 3
43	Pending Change-QUERY	UN 4
44	Spot Report-ADD	US 1
45	Spot Report-QUERY	US 4
46	Aircraft Available-ADD	FA 1
47	Aircraft Available-CHANGE	FA 2
48	Aircraft Available-DELETE	FA 3
49	Aircraft Available-QUERY	FA 4
50	Aircraft Available-ESTABLISH SRI	FA 6
51	Relay-ADD	AA 0
52	Named Area of Interest-ADD	AA 1
53	Named Area of Interest-CHANGE	AA 2
54	Named Area of Interest-DELETE	AA 3
55	Named Area of Interest-QUERY	AA 4
56	Standing Request for Information File-DELETE	AA 8
57	Standing Request for Information File-QUERY	AA 9

APPENDIX B

STATISTICAL ANALYSIS TABLES

This appendix contains tabular presentations of the results of the several analyses of variance performed on the data. The ordering of the tables follows the order in which the dependent variables are presented for a given independent variable; i.e., number of passes to reach the learning criterion, percent errors made, and time to input a message reference code following presentation of a message title and action name.

Because the number of subjects in the six groups was not equal (n = 10, 10, 10, 13, 9, 8) calculation of sums of squares by usual procedures produced some negative interaction sums of squares and mean squares. The method recommended by Walker and Lev* on pp. 381-382 to handle unequal frequencies was followed in all of the 2x2 ANOVAS performed.

*Walker, H.M. & Lev, J. Statistical Inference, Henry Holt and Company New York: 1953.

Table B-1

ANOVA OF NUMBER OF PASSES ON G2 LIST
FOR LL# vs. LLLL CODES AND OFFICERS vs. EM

Source	S.S.	df	M.S.	F	Prob.
Code	12.0895	1		15.81	$p < .001$
Rank	3.5231	1		4.61	$.01 < p < .05$
C x R	0.2736	1		0.36	$p > .50$
Error	a	39	0.7645[a]	- - -	- - -

[a]Error Mean Square = 316.4923 ÷ 39 x 0.0942 = 0.7645
where 0.0942 = mean reciprocal of sample sizes and
316.4923 = Error S.S. from usual ANOVA.

Table B-2

ANOVA OF NUMBER OF PASSES BY OFFICERS
FOR LL# vs. LLLL CODES AND G2 vs. G3 LISTS

Source	S.S.	df	M.S.	F	Prob.
Code	5.8153	1	5.8153	18.63	$p < .001$
List	2.2907	1	2.2907	7.34	$p = .01$
C x L	.3838	1	0.3838	1.23	$.25 < p < .30$
Error	a	36	0.3121[a]	- - -	- - -

[a]Error Mean Square = 108.7827 ÷ 36 x 0.1033 = 0.3121
where 0.1033 = mean reciprocal of sample sizes, and
108.7827 = Error S.S. from usual ANOVA.

Table B-3

ANOVA OF PERCENT ERROR ON G2 LIST FOR LL# vs. LLLL CODES AND OFFICERS vs. EM

Source	S.S.	df	M.S.	F	Prob.
Code	179.1583	1	179.1583	26.94	$p < .001$
Rank	26.6773	1	26.6773	4.012	$p = .053$
C x R	6.0269	1	6.0269	0.91	$.35 < p < .40$
Error	a	39	6.6495[a]	-----	-------

[a]Error Mean Square = 70.5891 $\div$ 39 x 0.0942 = 6.6495, where 0.0942 = mean reciprocal of sample sizes, and 70.5891 = Error S.S. from usual ANOVA.

Table B-4

ANOVA OF PERCENT ERROR BY OFFICERS FOR LL# vs. LLLL CODES AND G2 vs. G3 LISTS

Source	S.S.	df	M.S.	F	Prob.
Code	95.6484	1	95.6484	29.60	$p < .001$
List	26.5226	1	26.5226	8.21	$p < .01$
C x L	1.3224	1	1.3224	0.41	$p > .50$
Error	a	36	3.2309[a]	----	----

[a]Error Mean Square = 31.2768 $\div$ 36 x 0.1033 = 3.2309, where 0.1033 = Mean reciprocal of sample sizes, and 31.2768 = Error S.S. from usual ANOVA.

Table B-5

ANOVA OF TIME TO INPUT A MESSAGE REFERENCE CODE
FOR G2 LIST FOR LL# vs. LLLL CODE AND OFFICERS vs. EM

Source	S.S.	df	M.S.	F	Prob.
Code	.0092	1	.0092	0.04	$p > .50$
Rank	.0037	1	.0037	0.02	$p > .50$
C x R	.0234	1	.0234	0.11	$p > .50$
Error	a	39	.2052[a]	- - -	- - -

[a]Error Mean Square = $84.9721 \div 39 \times 0.0942 = 0.2052$,
where 0.0942 = mean reciprocal of sample sizes,
and 84.9721 = Error S.S. form usual ANOVA.

Table B-6

ANOVA OF TIME TO INPUT A MESSAGE REFERENCE CODE
BY OFFICERS FOR LL# vs. LLLL CODES AND G2 vs. G3 LISTS

Source	S.S.	df	M.S.	F	Prob.
Code	.0018	1	.0018	0.01	$p > .50$
List	.6942	1	.6942	3.26	$p = .08$
C x L	.0629	1	.0629	0.30	$p > .50$
Error	a	36	.2130[a]	- - -	- - -

[a]Error Mean Square = $74.2774 \div 36 \times 0.1033 = 0.2130$,
where 0.1033 = mean reciprocal of sample sizes,
and 74.2774 = Error S.S. from usual ANOVA.

Table B-7

t-TESTS OF DIFFERENCE BETWEEN MEANS OF CORRELATED MEASURES OF PERCENT ERRORS FOR 1st and 2nd CHARACTER OF THE LL# CODE (Officer Data Only)

	G2 List	G3 List	Overall
1st Letter	4.55%	3.49%	4.05%
2nd Letter	13.34%	10.99%	12.23%
Difference	8.79%	7.50%	8.18%
$S_{\bar{D}}$	1.3924%	1.1404%	0.8983%
t	6.31	6.576	9.10
Probability*	< .001	< .001	< .001

*two-tailed

Table B-8

t-TESTS OF DIFFERENCES BETWEEN MEANS OF CORRELATED MEASURES OF PERCENT ERRORS FOR 1st, 2nd and 3rd CHARACTERS OF THE LLLL CODE (Officer Data Only)

	G2 List	G3 List
1st Letter	3.25%	3.81%
2nd Letter	5.35%	2.10%
Difference	2.092%	-1.7125%
$S_{\bar{D}}$	0.6180%	0.4991%
t	3.39	3.43
d.f.	12	7
Probability*	< .01	< .02
2nd Letter	5.35%	2.10%
3rd Letter	7.13%	3.65%
Difference	1.7846%	1.55%
$S_{\bar{D}}$	0.6299%	0.2449%
t	2.83	6.33
d.f.	12	7
Probability*	< .02	< .001
1st Letter	3.25%	3.81%
3rd Letter	7.13%	3.65%
Difference	3.877%	-0.1625%
$S_{\bar{D}}$	0.9809%	0.5318%
t	3.95	-0.31
d.f.	12	7
Probability*	< .005	>.50

*two-tailed

Table B-9

t-TESTS OF DIFFERENCES BETWEEN MEANS OF CORRELATED MEASURES OF PERCENT ERRORS FOR MESSAGE TITLE CODES AND ACTION NAME CODES (Officer Data Only)

LL# CODE

	G2 List	G3 List	Overall
Title Code	8.96%	7.23%	8.14%
Action Code (#)	13.11%	6.24%	9.86%
Difference	-4.15%	0.9888%	-1.7158%
$S_{\bar{D}}$	1.0772%	0.7873%	0.8953%
d.f.	9	8	18
t	-3.85	1.25	-1.92
Probability*	< .01	= .26	= .074

*two-tailed

LLLL CODE

	G2 List	G3 List	Overall
Title Code	5.25%	3.20%	4.47%
Action Code (L)	4.22%	1.60%	3.22%
Difference	1.0385%	1.60%	1.2524%
$S_{\bar{D}}$	0.5763%	0.7300%	0.4451%
d.f.	12	7	20
t	1.80	2.19	2.81
Probability*	= .098	= .068	= .011

*two-tailed

Table B-10

t-TESTS OF DIFFERENCES IN MEAN PERCENT ERRORS FOR NUMERIC VERSUS ALPHABETIC ACTION CODES.
(Officer Data Only)

	G2 List	G3 List	Overall
Mean (#)	13.11%	6.24%	9.86%
Mean (L)	4.22%	1.60%	3.22%
Variance (#)	25.2277	6.4903	27.9026
n(#)	10	9	19
Variance (L)	6.3664	1.7114	6.1126
n (L)	13	8	21
S.D. (diff. of means)	1.7356%	0.9670%	1.3265%
d.f.	13*	13*	26*
t	5.12	4.80	5.01
Probability	< .001	<.001	<.001

*Computed by Walker and Lev's formula (7.26) on page 158.

APPENDIX C

ANALYSIS OF ERRORS BY CHARACTER POSITION

Errors By Character Position

To gain a better understanding of the sources of error and difficulty in learning the LL# and LLLL codes, a count of errors by character position was made for each officer within each of the four combinations of list type (G2 and G3) and code type. These error counts were then divided by each officer's number of chances to err. Summing across officers by character position and, for other comparisons, across the message title character positions as well, a measure of the mean percent error by character position (or by set of character positions) was calculated. The results reveal some differences not capable of being shown by the previously discussed dependent variable, percent of responses containing at least one error.

Effect of the Second Letter of the LL# Code

Error data regarding the second letter of the LL# codes give strong support to the prediction that its arbitrariness and the gaps in its alphabetic sequence would be a major source of error in learning the LL# codes. Computed over the G2 and G3 lists (Table C-1), the mean percent error for the second letter (12.23%) was three times that for the first letter (4.05%). The ratio is slightly less than 3 to 1 for the G2 list and slightly more than 3 to 1 for the G3 list. Three t-tests of these differences between means (13.34% vs. 4.55%, 10.99% vs. 3.49%, and 12.23% vs. 4.05%) each indicated statistical significance (see Table B-7)

Table C-1

SUMMARY OF MEAN ERROR PERCENTAGES BY CHARACTER POSITION
(Officer Data Only)

List	Code	Message Title Code Characters 1st	2nd	3rd	Title Code Overall	Action Code Character	Message Reference Code
G2	LL#	4.55	13.34	NA	8.96	13.11	10.34
G2	LLLL	3.25	5.35	7.13	5.25	4.22	5.00
G3	LL#	3.49	10.99	NA	7.23	6.24	6.91
G3	LLLL	3.81	2.10	3.65	3.20	1.60	2.80
---	LL#	4.05	12.23	NA	8.14	9.86	8.72
---	LLLL	3.47	4.11	5.80	4.47	3.22	4.16

with the probability of obtaining at least the observed differences being less than .001 under an hypothesis of no difference. Examination of Tables C-1 and C-2 shows that the mean percent errors made on the second letter exceed those for the first letter for 16 of the 17 message title codes other than the "AA" codes. The "AA" codes are especially complicated, the result being that similar error rates were associated with each of the two letters. The remaining exception is the "FA" message code where 6.2% errors were associated with the "F" and 4.3 errors with the "A" (Table C-3).

It seems clear that the second letter of the LL# code was a major source of error because its characters had very little mnemonic value and was even difficult to learn as a sequence of the alphabet because of gaps. It also appears that other factors, such as relative frequency and recency of occurrence, influence the learning of the code characters so that in a certain minority of cases the first character is as hard or harder to learn than the second character.

Error Relations in the Message Portion of the LLLL Code

Neither the second nor third character of the LLLL code has three times the error percentage of the first character, as was noted for the LL# code. Yet, in the case of the G2 list, higher error percentages occur for the second character than for the first character, and still higher error percentages occur for the third than for the second character (3.25%, then 5.35%, then 7.13%; see Table C-1). From data in Table

Table C-2

MEAN PERCENT ERRORS BY CHARACTER POSITION
G2 List, LL# Code, 10 Officers

Message Title Code			Action Code								
E	A		1	*	3	4					
4.7	6.6		10.4		14.4	4.3					
E	C		1	2	3	4		6			
4.3	20.7		3.3	9.9	8.6	4.0		49.5			
E	D		1	2	3		5				
4.0	16.9		4.8	6.4	6.1		45.4				
E	E		1	2	3	4					
1.4	11.0		3.1	3.7	3.2	2.8					
E	G		1	2		4					
5.4	22.6		4.0	2.8		13.0					
A	A								0		
13.6	9.9								20.1		
A	A		1	2	3	4					
2.4	1.8		9.6	13.6	8.9	5.0					
A	A									8	9
10.8	11.0									45.1	38.6
1st	2nd	3rd	1	2	3	4	5	6	0	8	9
4.6	13.3	13.1	5.9	7.3	8.2	5.8	45.4	49.5	20.1	45.1	38.6

*Gaps such as this occur because not all action codes are applicable to each message category.

Table C-3

MEAN PERCENT ERRORS BY CHARACTER POSITION
(G3 List, LL# Code, 9 Officers)

Message Title Code			Action Code 1	2	3	4	5	6	0	8	9
U 0.4	A 3.9		1.9	3.7	0	0		20.5			
U 3.9	B 8.9		7.1	1.6	1.9	4.4		5.3			
U 4.3	D 20.4					12.5	21.4	7.5			
U 1.5	E 19.2		6.5	0	2.8	11.2		3.4			
U 0.6	F 19.0		1.6	5.6	0	0		3.4			
U 0.6	G 4.0		0	9.1	9.3	3.2		0			
U 6.4	H 9.1		0	0.4	5.9	6.9		0			
U 0.7	L 16.1		0		17.7	0	12.1				
U 4.2	M 21.3			3.4			14.4				
U 6.2	N 17.5		0	7.5	0	12.4					
U 2.8	S 15.7		0			3.7					
F 6.2	A 4.3		0	0	2.8	3.8		2.8			
A 20.9	A 20.9								35.2		
A 2.9	A 2.5		1.6	5.3	5.6	4.4					
A 6.7	A 8.7									38.0	26.5
1st 3.5	2nd 11.0	3rd 6.2	1.7	3.7	4.6	5.2	16.0	5.4	35.2	38.0	26.5

A-4, one can infer that the higher error rates for the second and third characters are mainly the result of troubles in learning E<u>IN</u> for (Enemy) Intelligence Summary, E<u>WF</u> for (Enemy) Intelligence Work File, and E<u>DX</u> for Enemy Situation Data Base Index. The third character incurred higher error rates than the second character primarily because learners persisted in responding "EI<u>S</u>"rather than "EI<u>N</u>" to the title (Enemy) Intelligence Summary. The difference in mean percentage errors between the first and second characters of the G2 list, LLLL code, was statistically significant ($p < .01$) and so was the difference between the second and third characters ($p < .02$; see Table B-8).

The pattern of errors among the first three characters on the G3 list (Table C-1) was different from that of the G2 list. For the G3 list, the mean percent errors for the second character (2.10%) was less than that associated with either the first character (3.81%) or the third character (3.65%). While these differences were statistically significant ($p < .02$ and $p < .001$), the difference between the first and third character's error rates was not statistically significant. A likely reason for the lower error rates for the second character is that many of the G3 titles contained just two words. In these cases subjects appeared to learn rather quickly that they should enter a "U" for the first character and then enter the acronym of the first title word as the <u>second</u> character of the code.

Message Title Errors Versus Action Name Errors

For just one of the four combinations of list and code type was the

Table C-4

MEAN PERCENT ERRORS BY CHARACTER POSITION
(G2 List, LLLL Code, 13 Officers)

Message Title Code

E 4.1	U 4.1	S 2.9
E 2.5	S 2.7	D 2.4
E 3.8	I 3.8	N 13.2
E 4.5	W 10.0	F 9.7
E 2.1	D 12.7	X 14.2
R 12.4	E 12.2	L 12.2
N 1.3	A 1.7	I 1.7
S 1.3	R 1.9	I 5.1

1st	2nd	3rd	4th
3.3	5.4	7.1	4.2

Action Code

A	C	D	Q	P	S
1.5		2.0	4.1		
0	4.5	2.6	0		17.9
5.1	4.1	1.9		23.8	
9.0	1.9	0	3.8		
5.1	1.3		5.8		
6.4					
0	1.5	2.6	1.3		
		1.3	1.3		
3.9	2.7	1.7	2.7	23.8	17.9

mean error percentage for the action code greater than that for the message title code. The numeric action codes of the G2 list incurred 13.11% errors while the message title characters of this list incurred 8.96% errors. The difference between these means was statistically significant ($p < .01$; see Table B-9). For the G3 list, LL# code, the action portion had a lower error rate (6.24%) than the title portion (7.23%) but the difference was not significant ($p = .26$).

For the LLLL Code, a statistically significant difference was obtained only when error percentages were computed over both G2 and G3 lists. For this comparison the title portion incurred 4.47% errors while the alphabetic action code portion incurred 3.22% errors ($p = .011$).

Overall, the action code letter was input with 3.22% errors while the action code as a number was input with 9.86% errors (a statistically significant difference; $p < .001$ from Table B-10). Since the error rate for the message title portion dropped from 8.14% for the LL# codes to 4.47% for the LLLL codes, we find the new LLLL code has been more helpful in reducing action code error rates than in reducing message title code error rates. Evidently the numeric action codes with their exceptions were somewhat more difficult than expected. On the other hand, the new LLLL title codes were somewhat less of an improvement than had been hoped for.

Action Code Problems

The LL# code contains nine different action codes, all numbers, compared to only six different letters serving as the action codes in the

LLLL code system. The extra three action codes (0, 8, 9) apply to action names that most often require a response of 1, 3, and 4. Apparently a system designer felt that the fact that the three message categories involved (Relay, Named Area of Interest, and SRI File) were common to both G2 and G3, warranted giving them all the same letter-letter (AA) designation. Then, to provide unique action code numbers, for the computer program, he was forced to use a "0" to distinguish Relay-Add from Named Area of Interest-Add; to use an "8" to distinguish Standing Request For Information File-Delete, from Named Area of Interest-Delete; and to use a "9" to distinguish SRI File-Query from Named Area of Interest-Query. The high error rates for the 0, 8, 9 action code numbers show clearly that the use of the common AA designation was an unnecessary and undesirable complication (See Tables C-2 and C-3).

For the LLLL code and the G2 list (Table C-4) the worst action code letter is the "P" standing for "Special Processing." This should be considered in conjunction with the "S" that stands for Establish Standing Request for Information. These two had error rates of 23.8% and 17.9% for the G2 list, where they occurred only once per pass. On the G3 list, (Table C-5) "P" was required three times per pass and "S" was required six times per pass. Since their error rates dropped to 2.9% and 1.3% overall on the G3 list, their rarity or low frequency would appear to be the major factor producing the high error rates on the G2 list. G2 learners need help; G3 learners apparently need little help if any, with the "P" and "S." Review of the G2 learners' wrong responses indicated that many were responding with an "S" to Special Processing and with an

"E" to Establish SRI. They were using the acronym rule that most often did apply. Unfortunately for their learning's success, these two codes were requiring use of the first letter of the second word of the action name instead of the first letter of the first word. The reason for the original assignment of "S" to Establish SRI was that it seemed appropriate or naturally associated with SRI. But this assignment ignored the need to use the verb "establish" to describe/explain the action involved, and it took insufficient account of the error-producing consequences of letting "P" stand for Special Processing now that the "S" was pre-empted. It is thought that changing the code letter for Special Processing to "S" and the code letter for Establish SRI to "E" would aid the learning of the G2 list.

"Establish SRI" is quite clear in its meaning of the action. "Initiate SRI" seems a bit more precise, but to change the name of the action to this (with a code letter of "I") seems unlikely to reduce error rates below that which the use of "E" would produce. The action name of "Start SRI," using a code of "S," would allow retention of the "S" code with perhaps not too significant a loss in conveying the meaning of the action to the learner.

Individual Message Title Code Problems

The letters EIN were the code response required to the message category titles displayed as (Enemy) Intelligence Summary. The "N" has a 13.2% error rate, and the common error was to give "S" as the third letter. It seems obvious that, given this display of the message title, EIS should have been the required code. The situation here has been complicated by the addition of (Enemy) in the display of the message title; this word does not appear in the title printed on message format sheets. It was displayed parenthetically to justify the use of "E" as the first letter of the code and to create three words in the title thus allowing straightforward application of the three letter acronym rule for this title. If all message reference codes must have four letters, "EIS" coupled with the use of "(Enemy) Intelligence Summary" as a title, is judged to be a combination that would produce a lower error rate than "EIN" did.

In the next case, however, the addition of "(Enemy)" to "Intelligence Work File" disallowed simple application of the three letter acronym rule. The "W" and "F" each had a 10% error rate. Subjects were charged with an error for inserting the letter "I" and were unfortunately required to leave this letter out of the code. The title displayed should have been simply "Intelligence Work File" and the code for it should be "IWF" plus the appropriate action code.

The next G2 problem is the five-word title "Enemy Situation Data Base Index" (code is EDX) where use of a three letter title code requires the subject to learn which three of the five words contain the code letters. The "E" is the best first letter code; while the "D" was assigned without expectation that it would be more readily learned than "S" or "B," the two remaining words' first letters. "X" stands out as a cue for index, but creates an unnecessary exceptional case, for it's not the first letter of a word. The error responses were usually "ESD." Again, this shows that on these occasions the learners were trying to follow a simple acronym rule. Unfortunately, the existence of another message category title "Enemy Situation Data" pre-empts the use of "ESD" as a code. A change in title seems much needed in this case in order to permit simple application of the three letter acronym procedure for generating or determining the title code. "Situation Data File" (Code to be "SDF") and "Situation Data Index" (Code to be "SDI") are candidate title reductions. It is thought that either (the latter is somewhat preferred) would reduce error rates below what are produced by the present combination of "EDX" and a five word title.

"Relay-Add" is used by both G2 and G3 operations. The error rate for the three code letters "REL" was virtually the same (12.4%, 12.2%, and 12.2%) for each letter for the G2 list and was the same (15%) for each letter when being learned by subjects assigned to the G3 list. Most of the errors regarding the "R" were of a premature commission nature - subjects input the R before the display had stopped "rolling up." It is apparently coincidental that the error rates for the R match those for the other two letters. Given a one-word message title and a three-letter code input requirement, "REL" seems fairly obvious. Combined with "A," the only action code permitted, produces "RELA" which seems inspired or at least clever. To adapt it to a three word and three letter acronym scheme, the cumbersome title "Common Relay Message" and associated code "CRM" is a possibility.

Only one other character on the G3 list stands out with a high error rate. Situation Report is encoded as "USI," and the error rate for the "I" (Table C-5) is 27.2%. The bulk of the "I" errors come about because the subjects are inputting "USR." "USR" is the more appropriate code, but it is already the code for "Spot Report." This duplication of first letters ("S" and "R") for two different titles is not simple resolvable while staying within the acronym procedure. It seems necessary to change one of the two titles to enable formulation of a different acronymic code. The short form "SITREP" could be used, and as with "Relay" the first three letters "SIT" employed as a (nonacronymic) code. However, the dropping of "U" from the code should cause error rates to stay fairly high, for "U" (standing for "unit") is frequently used in the G3 list as a filler letter when the message title contains only two words.

Table C-5

MEAN PERCENT ERRORS BY CHARACTER POSITION
(G3 List, LLLL Code, 8 Officers)

Message Title Code				Action Code					
U 10.8	T 5.6	O 6.3		A 15.6	C 7.3	D 6.3	Q 4.2		S 6.3
U 1.8	T 1.3	F 3.8		A 2.5	C 6.3	D 0	Q 0		S 4.2
U 0	T 0	D 0					Q 0	P 8.8	S 0
U 1.5	D 2.7	C 2.7		A 4.2	C 0	D 0	Q 0		S 0
U 2.0	D 0.6	U 1.8		A 0	C 0	D 0	Q 0		S 0
U 3.4	D 0.6	G 0.6		A 0	C 0	D 0	Q 3.1		S 0
A 7.2	C 1.9	M 0.6		A 0	C 3.1	D 0	Q 0		S 0
U 4.0	O 3.0	J 2.3		A 3.1		D 0	Q 0	P 0	
U 7.8	S 4.7	I 27.2			C 0			P 0	
U 2.3	P 0	C 2.6		A 0	C 0	D 2.5	Q 0		
U 0	S 0	R 3.6		A 0			Q 0		
A 5.3	A 2.6	V 4.5		A 0	C 0	D 2.5	Q 0		S 0
R 15.0	E 15.0	L 15.0		A 6.3					
N 0.6	A 0	I 0		A 0	C 0	D 0	Q 0		
S 0	R 3.1	I 5.2				D 2.1	Q 0		
1st 3.8	2nd 2.1	3rd 3.7	4th 1.6	A 2.6	C 1.7	D 1.2	Q 0.6	P 2.9	S 1.3

APPENDIX D

INDIVIDUAL PERFORMANCE DATA

Table D-1

ERRORS BY PASS: EM, G2 LIST, LL# CODE

PASS

SUBJECT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	ΣE
E4 Ri	13	18	13	8	1	3	1	0									57
E4 Re	6	7	3	0													16
E4 Le	9	15	15	11	8	5	4	3	1	0							71
E4 Lo	10	16	8	12	8	5	2	0									61
E4 Sa	12	21	13	12	12	9	7	7	5	3	4	3	3	4	3	0	118
E3 Mo	4	2	0														6
E5 De	12	22	23	21	18	20	13	13	12	6	1	0					161
E7 Ad	11	15	12	13	10	12	5	7	4	5	3	3	1	2	1	0	104
E4 Th	18	21	10	8	6	2	0										65
E4 Gu	20	22	17	15	9	4	2	0									89

Table D-2

ERRORS BY PASS: EM, G2 LIST, LLLL CODE

PASS

SUBJECT	1	2	3	4	5	6	7	8	9	10	ΣE
E2 Ta	4	4	2	1	0						11
E4 RC	14	11	7	7	6	5	1	2	5	0	58
E4 CR	5	7	3	2	3	1	0				21
E4 Na	4	1	0								5
E4 Ma	1	0									1
E6 WT	6	4	0								10
E5 WB	10	13	4	2	5	3	2	0			39
E5 Pa	8	7	3	2	0						20
E7 Ch	7	7	2	0							16
E8 Fi	15	6	2	2	0						25

Table D-3

ERRORS BY PASS: OFFICERS, G2 LIST, LL# CODE

SUBJECT	PASS 1	2	3	4	5	6	7	8	9	10	11	12	Σ E
04 Go	10	20	16	24	15	11	12	8	3	2	3	0	124
04 Sc	5	13	6	6	1	4	2	1	0				38
04 Gi	7	8	3	1	1	1	0						21
03 Wa	6	11	4	3	0								24
03 Ot	10	16	9	5	2	0							42
03 Sp	14	11	5	0									30
03 Ze	4	7	3	3	0								17
03 Qu	6	5	0										11
05 St	12	12	9	7	3	2	1	0					46
02 Br	10	21	7	4	4	4	4	1	0				55

Table D-4

ERRORS BY PASS: OFFICERS, G2 LIST, LLLL CODE

SUBJECT	PASS 1	2	3	4	5	6	Σ E
04 DS	4	7	0				11
04 Pr	5	12	6	5	2	0	30
04 Ke	1	0					1
04 WB	5	3	1	0			9
04 RG	4	2	0				6
04 Hi	7	7	0				14
04 Mu	4	4	0				8
04 JG	6	5	3	1	3	0	18
02 Bj	3	1	0				4
03 Lo	4	3	1	0			8
03 Re	3	1	2	0			6
03 Mi	9	5	1	0			15
04 NP	6	3	6	1	0		16

Table D-5

ERRORS BY PASS: OFFICERS, G3 LIST, LL# CODE

SUBJECT	1	2	3	4	5	6	7	ΣE
04 La	10	23	5	2	0			40
04 St	17	16	3	0				36
04 Pa	12	9	2	0				23
04 Su	5	19	5	0				29
04 Sl	11	15	0					26
04 Be	13	6	0					19
03 Mu	20	25	5	4	1	0		55
04 Br	18	35	13	11	11	2	0	90
05 Ch	13	33	14	3	1	0		64

Table D-6

ERRORS BY PASS: OFFICERS, G3 LIST, LLLL CODE

SUBJECT	PASS 1	2	3	4	5	ΣE
04 Al	6	4	0			10
04 Ma	7	0				7
03 Cu	7	1	0			8
03 La	8	0				8
03 Le	5	0				5
05 Su	8	6	4	3	0	21
03 Yo	15	3	4	0		22
03 Me	8	0				8

Table D-7

ERRORS BY CHARACTER POSITION AND BY OFFICER, G2 LIST, LL# CODE

Subject	1st Position Letter		2nd Position Letter		3rd Position Number		1st + 2nd Position		Chances Per Position
	E	%E	E	%E	E	%E	E	%E	
04 Go	24	7.7	80	25.6	63	20.2	104	16.7	312
04 Sc	4	1.7	23	9.8	25	10.7	27	5.8	234
04 Gi	5	2.7	15	8.2	12	6.6	20	5.5	182
03 Wa	6	4.6	17	13.1	13	10.0	23	8.8	130
03 Ot	11	7.1	30	19.2	24	15.4	41	13.1	156
03 Sp	5	4.8	16	15.4	23	22.1	21	10.1	104
03 Ze	5	3.8	8	6.2	11	8.5	13	5.0	130
03 Qu	3	3.8	6	7.7	8	10.3	9	5.8	78
05 St	6	2.9	25	12.0	31	14.9	31	7.5	208
02 Br	15	6.4	38	16.2	29	12.4	53	11.3	234
Total	84	45.5	258	133.4	239	131.1	342	89.6	1768
Mean		4.55		13.34		13.11		8.96	

Table D-8

ERRORS BY CHARACTER POSITION AND BY OFFICER, G2 LIST, LLLL CODE

	Letter 1		Letter 2		Letter 3		Letter 4		1+2+3		
Subject	E	%E	E	%E	E	%E	E	%E	E	%E	Chances per Position
04 DS	4	5.1	3	3.8	7	9.0	2	2.6	14	6.0	78
04 Pr	6	3.8	16	10.3	26	16.7	8	5.1	48	10.3	156
04 Ke	1	1.9	1	1.9	0	0.0	0	0.0	2	1.3	52
04 WB	2	1.9	4	3.8	5	4.8	3	2.9	11	3.5	104
04 RG	4	5.1	4	5.1	5	6.4	3	3.8	13	5.6	78
04 Hi	3	3.8	7	9.0	8	10.3	6	7.7	18	7.7	78
04 Mu	2	2.6	5	6.4	5	6.4	6	7.7	12	5.1	78
04 JG	5	3.2	7	4.5	8	5.1	10	6.4	20	4.3	156
02 Bj	0	0.0	1	1.3	4	5.1	1	1.3	5	2.1	78
03 Lo	1	1.0	4	3.8	7	6.7	3	2.9	12	3.8	104
03 Re	1	1.0	4	3.8	4	3.8	3	2.9	9	2.9	104
03 Mi	7	6.7	10	9.6	12	11.5	8	7.7	29	9.3	104
04 NP	8	6.2	8	6.2	9	6.9	5	3.8	25	6.4	130
Total	44	42.3	74	69.5	100	92.7	58	54.8	218	68.3	1300
Mean		3.25		5.35		7.13		4.22		5.25	

Table D-9

ERRORS BY CHARACTER POSITION AND BY OFFICER, G3 LIST, LL# CODE

Subject	1st Position Letter E	1st Position Letter %E	2nd Position Letter E	2nd Position Letter %E	3rd Position Number E	3rd Position Number %E	1st + 2nd Position E	1st + 2nd Position %E	Chances Per Position
4La	5	1.8	26	9.1	19	6.7	31	5.4	285
4St	10	4.4	26	11.4	13	5.7	36	7.9	228
4Pa	5	2.2	15	6.6	12	5.3	20	4.4	228
4Su	6	2.6	23	10.1	6	2.6	29	6.4	228
4Sl	8	4.7	19	11.1	15	8.8	27	7.9	171
4Be	7	4.1	12	7.0	7	4.1	19	5.6	171
3Mu	19	5.6	40	11.7	25	7.3	59	8.6	342
4Br	11	2.8	63	15.8	44	11.0	74	9.3	399
5Ch	11	3.2	55	16.1	16	4.7	66	9.6	342
	82	31.4	279	98.9	157	56.2	361	65.1	2394
		3.49		10.99		6.24		7.23	

Table D-10

ERRORS BY CHARACTER POSITION AND BY OFFICER, G3 LIST, LLLL CODE

	First Letter		Second Letter		Third Letter		Fourth Letter		1+2+3		
Subject	E	%E	E	%E	E	%E	E	%E	E	%E	Chances per Position
4Al	3	1.8	0	0.0	5	2.9	3	1.8	8	1.6	171
4Ma	3	2.6	2	1.8	3	2.6	5	4.4	8	2.3	114
3Cu	4	2.3	2	1.2	4	2.3	2	1.2	10	2.0	171
3La	3	2.6	4	3.5	6	5.3	1	0.9	13	3.8	114
3Le	4	3.5	2	1.8	3	2.6	0	0.0	9	2.6	114
5Su	13	4.6	3	1.1	7	2.5	4	1.4	23	2.7	285
3Yo	16	7.0	9	3.9	13	5.7	5	2.2	38	5.6	228
3Me	7	6.1	4	3.5	6	5.3	1	0.9	17	5.0	114
Total	53	30.5	26	16.8	47	29.2	21	12.8	126	25.6	1311
Mean		3.81		2.10		3.65		1.60		3.20	

DISTRIBUTION

ARI Distribution List

4 OASD (M&RA)
2 HQDA (DAMI-CSZ)
1 HQDA (DAPE-PBR
1 HQDA (DAMA-AR)
1 HQDA (DAPE-HRE-PO)
1 HQDA (SGRD-ID)
1 HQDA (DAMI-DOT-C)
1 HQDA (DAPC-PMZ-A)
1 HQDA (DACH-PPZ-A)
1 HQDA (DAPE-HRE)
1 HQDA (DAPE-MPO-C)
1 HQDA (DAPE-DW)
1 HQDA (DAPE-HRL)
1 HQDA (DAPE-CPS)
1 HQDA (DAFD-MFA)
1 HQDA (DARD-ARS-P)
1 HQDA (DAPC-PAS-A)
1 HQDA (DUSA-OR)
1 HQDA (DAMO-RQR)
1 HQDA (DASG)
1 HQDA (DA10-PI)
1 Chief, Consult Div (DA-OTSG), Adelphi, MD
1 Mil Asst. Hum Res, ODDR&E, OAD (E&LS)
1 HQ USARAL, APO Seattle, ATTN: ARAGP-R
1 HQ First Army, ATTN: AFKA-OI-TI
2 HQ Fifth Army, Ft Sam Houston
1 Dir, Army Stf Studies Ofc, ATTN: OAVCSA (DSP)
1 Ofc Chief of Stf, Studies Ofc
1 DCSPER, ATTN: CPS/OCP
1 The Army Lib, Pentagon, ATTN: RSB Chief
1 The Army Lib, Pentagon, ATTN: ANRAL
1 Ofc, Asst Sect of the Army (R&D)
1 Tech Support Ofc, OJCS
1 USASA, Arlington, ATTN: IARD-T
1 USA Rsch Ofc, Durham, ATTN: Life Sciences Dir
2 USARIEM, Natick, ATTN: SGRD-UE-CA
1 USATTC, Ft Clayton, ATTN: STETC-MO-A
1 USAIMA, Ft Bragg, ATTN: ATSU-CTD-OM
1 USAIMA, Ft Bragg, ATTN: Marquat Lib
1 US WAC Ctr & Sch, Ft McClellan, ATTN: Lib
1 US WAC Ctr & Sch, Ft McClellan, ATTN: Tng Dir
1 USA Quartermaster Sch, Ft Lee, ATTN: ATSM-TE
1 Intelligence Material Dev Ofc, EWL, Ft Holabird
1 USA SE Signal Sch, Ft Gordon, ATTN: ATSO-EA
1 USA Chaplain Ctr & Sch, Ft Hamilton, ATTN: ATSC-TE-RD
1 USATSCH, Ft Eustis, ATTN: Educ Advisor
1 USA War College, Carlisle Barracks, ATTN: Lib
2 WRAIR, Neuropsychiatry Div
1 DLI, SDA, Monterey
1 USA Concept Anal Agcy, Bethesda, ATTN: MOCA-WGC
1 USA Concept Anal Agcy, Bethesda, ATTN: MOCA-MR
1 USA Concept Anal Agcy, Bethesda, ATTN: MOCA-JF
1 USA Artic Test Ctr, APO Seattle, ATTN: STEAC-MO-ASL
1 USA Artic Test Ctr, APO Seattle, ATTN: AMSTE-PL-TS
1 USA Armament Cmd, Redstone Arsenal, ATTN: ATSK-TEM
1 USA Armament Cmd, Rock Island, ATTN: AMSAR-TDC
1 FAA-NAFEC, Atlantic City, ATTN: Library
1 FAA-NAFEC, Atlantic City, ATTN: Hum Engr Br
1 FAA Aeronautical Ctr, Oklahoma City, ATTN: AAC-44D
2 USA Fld Arty Sch, Ft Sill, ATTN: Library
1 USA Armor Sch, Ft Knox, ATTN: Library
1 USA Armor Sch, Ft Knox, ATTN: ATSB-DI-E
1 USA Armor Sch, Ft Knox, ATTN: ATSB-DT-TP
1 USA Armor Sch, Ft Knox, ATTN: ATSB-CD-AD
2 HQUSACDEC, Ft Ord, ATTN: Library
1 HQUSACDEC, Ft Ord, ATTN: ATEC–EX–E–Hum Factors
2 USAEEC, Ft Benjamin Harrison, ATTN: Library
1 USAPACDC, Ft Benjamin Harrison, ATTN: ATCP–HR
1 USA Comm–Elect Sch, Ft Monmouth, ATTN: ATSN–EA
1 USAEC, Ft Monmouth, ATTN: AMSEL–CT–HDP
1 USAEC, Ft Monmouth, ATTN: AMSEL–PA–P
1 USAEC, Ft Monmouth, ATTN: AMSEL–SI–CB
1 USAEC, Ft Monmouth, ATTN: C, Facl Dev Br
1 USA Materials Sys Anal Agcy, Aberdeen, ATTN: AMXSY–P
1 Edgewood Arsenal, Aberdeen, ATTN: SAREA–BL–H
1 USA Ord Ctr & Sch, Aberdeen, ATTN: ATSL–TEM–C
2 USA Hum Engr Lab, Aberdeen, ATTN: Library/Dir
1 USA Combat Arms Tng Bd, Ft Benning, ATTN: Ad Supervisor
1 USA Infantry Hum Rsch Unit, Ft Benning, ATTN: Chief
1 USA Infantry Bd, Ft Benning, ATTN: STEBC–TE–T
1 USASMA, Ft Bliss, ATTN: ATSS–LRC
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA–CTD–ME
1 USA Air Def Sch, Ft Bliss, ATTN: Tech Lib
1 USA Air Def Bd, Ft Bliss, ATTN: FILES
1 USA Air Def Bd, Ft Bliss, ATTN: STEBD–PO
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: Lib
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: ATSW–SE–L
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: Ed Advisor
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: DepCdr
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: CCS
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCASA
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACO–E
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACC–CI
1 USAECOM, Night Vision Lab, Ft Belvoir, ATTN: AMSEL–NV–SD
3 USA Computer Sys Cmd, Ft Belvoir, ATTN: Tech Library
1 USAMERDC, Ft Belvoir, ATTN: STSFB–DQ
1 USA Eng Sch, Ft Belvoir, ATTN: Library
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL–TD–S
1 USA Topographic Lab, Ft Belvoir, ATTN: STINFO Center
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL–GSL
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: CTD–MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATS–CTD–MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–TE
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–TEX–GS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–CTS–OR
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–CTD–DT
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–CTD–CS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: DAS/SRD
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI–TEM
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: Library
1 CDR, HQ Ft Huachuca, ATTN: Tech Ref Div
2 CDR, USA Electronic Prvg Grd, ATTN: STEEP–MT–S
1 CDR, Project MASSTER, ATTN: Tech Info Center
1 Hq MASSTER, USATRADOC, LNO
1 Research Institute, HQ MASSTER, Ft Hood
1 USA Recruiting Cmd, Ft Sherdian, ATTN: USARCPM–P
1 Senior Army Adv., USAFAGOD/TAC, Elgin AF Aux Fld No. 9
1 HQ USARPAC, DCSPER, APO SF 96558, ATTN: GPPE–SE
1 Stimson Lib, Academy of Health Sciences, Ft Sam Houston
1 Marine Corps Inst., ATTN: Dean–MCI
1 HQUSMC, Commandant, ATTN: Code MTMT 51
1 HQUSMC, Commandant, ATTN: Code MPI–20
2 USCG Academy, New London, ATTN: Admission
2 USCG Academy, New London, ATTN: Library
1 USCG Training Ctr, NY, ATTN: CO
1 USCG Training Ctr, NY, ATTN: Educ Svc Ofc
1 USCG, Psychol Res Br, DC, ATTN: GP 1/62
1 HQ Mid–Range Br, MC Det, Quantico, ATTN: P&S Div

1 US Marine Corps Liaision Ofc, AMC, Alexandria, ATTN: AMCGS–F
1 USATRADOC, Ft Monroe, ATTN: ATRO–ED
6 USATRADOC, Ft Monroe, ATTN: ATPR–AD
1 USATRADOC, Ft Monroe, ATTN: ATTS–EA
1 USA Forces Cmd, Ft McPherson, ATTN: Library
2 USA Aviation Test Bd, Ft Rucker, ATTN: STEBG–PO
1 USA Agcy for Aviation Safety, Ft Rucker, ATTN: Library
1 USA Agcy for Aviation Safety, Ft Rucker, ATTN: Educ Advisor
1 USA Aviation Sch, Ft Rucker, ATTN: PO Drawer O
1 HQUSA Aviation Sys Cmd, St Louis, ATTN: AMSAV–ZDR
2 USA Aviation Sys Test Act., Edwards AFB, ATTN: SAVTE–T
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA TEM
1 USA Air Mobility Rsch & Dev Lab, Moffett Fld, ATTN: SAVDL–AS
1 USA Aviation Sch, Res Tng Mgt, Ft Rucker, ATTN: ATST–T–RTM
1 USA Aviation Sch, CO, Ft Rucker, ATTN: ATST–D–A
1 HQ, DARCOM, Alexandria, ATTN: AMXCD–TL
1 HQ, DARCOM, Alexandria, ATTN: CDR
1 US Military Academy, West Point, ATTN: Serials Unit
1 US Military Academy, West Point, ATTN: Ofc of Milt Ldrshp
1 US Military Academy, West Point, ATTN: MAOR
1 USA Standardization Gp, UK, FPO NY, ATTN: MASE–GC
1 Ofc of Naval Rsch, Arlington, ATTN: Code 452
3 Ofc of Naval Rsch, Arlington, ATTN: Code 458
1 Ofc of Naval Rsch, Arlington, ATTN: Code 450
1 Ofc of Naval Rsch, Arlington, ATTN: Code 441
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Acous Sch Div
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Code L51
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Code L5
1 Chief of NavPers, ATTN: Pers-OR
1 NAVAIRSTA, Norfolk, ATTN: Safety Ctr
1 Nav Oceanographic, DC, ATTN: Code 6251, Charts & Tech
1 Center of Naval Anal, ATTN: Doc Ctr
1 NavAirSysCom, ATTN: AIR–5313C
1 Nav BuMed, ATTN: 713
1 NavHelicopterSubSqua 2, FPO SF 96601
1 AFHRL (FT) William AFB
1 AFHRL (TT) Lowry AFB
1 AFHRL (AS) WPAFB, OH
2 AFHRL (DOJZ) Brooks AFB
1 AFHRL (DOJN) Lackland AFB
1 HQUSAF (INYSD)
1 HQUSAF (DPXXA)
1 AFVTG (RD) Randolph AFB
3 AMRL (HE) WPAFB, OH
2 AF Inst of Tech, WPAFB, OH, ATTN: ENE/SL
1 ATC (XPTD) Randolph AFB
1 USAF AeroMed Lib, Brooks AFB (SUL–4), ATTN: DOC SEC
1 AFOSR (NL), Arlington
1 AF Log Cmd, McClellan AFB, ATTN: ALC/DPCRB
1 Air Force Academy, CO, ATTN: Dept of Bel Scn
5 NavPers & Dev Ctr, San Diego
2 Navy Med Neuropsychiatric Rsch Unit, San Diego
1 Nav Electronic Lab, San Diego, ATTN: Res Lab
1 Nav TrngCen, San Diego, ATTN: Code 9000–Lib
1 NavPostGraSch, Monterey, ATTN: Code 55Aa
1 NavPostGraSch, Monterey, ATTN: Code 2124
1 NavTrngEquipCtr, Orlando, ATTN: Tech Lib
1 US Dept of Labor, DC, ATTN: Manpower Admin
1 US Dept of Justice, DC, ATTN: Drug Enforce Admin
1 Nat Bur of Standards, DC, ATTN: Computer Info Section
1 Nat Clearing House for MH–Info, Rockville
1 Denver Federal Ctr, Lakewood, ATTN. BLM
12 Defense Documentation Center
4 Dir Psych, Army Hq, Russell Ofcs, Canberra
1 Scientific Advsr, Mil Bd, Army Hq, Russell Ofcs, Canberra
1 Mil and Air Attache, Austrian Embassy
1 Centre de Recherche Des Facteurs, Humaine de la Defense Nationale, Brussels
2 Canadian Joint Staff Washington
1 C/Air Staff, Royal Canadian AF, ATTN: Pers Std Anal Br
3 Chief, Canadian Def Rsch Staff, ATTN: C/CRDS(W)
4 British Def Staff, British Embassy, Washington
1 Def & Civil Inst of Enviro Medicine, Canada
1 AIR CRESS, Kensington, ATTN: Info Sys Br
1 Militaerpsykologisk Tjeneste, Copehagen
1 Military Attache, French Embassy, ATTN: Doc Sec
1 Medecin Chef, C.E.R.P.A.–Arsenal, Toulon/Naval France
1 Prin Scientific Off, Appl Hum Engr Rsch Div, Ministry of Defense, New Delhi
1 Pers Rsch Ofc Library, AKA, Israel Defense Forces
1 Ministeris van Defensie, DOOP/KL Afd Sociaal Psychologische Zaken, The Hague, Netherlands