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**OPERATOR PERFORMANCE ON TWO OFFICE DATA
ENTRY SYSTEM TESTBEDS: PRELIMINARY
ANALYSIS**

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**NAVY PERSONNEL RESEARCH
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San Diego, California 92152**

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**OPERATOR PERFORMANCE ON TWO OFFICE DATA
ENTRY SYSTEM TESTBEDS: PRELIMINARY ANALYSES**

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office data entry system provided a distinct advantage over the self-contained system in reducing errors in the information system without adding to the office workload. Also, using this distributed system to make changes resulted in a 75 percent time savings over the manual method. The time saved in making changes would be, by itself, a significant factor in evaluating the cost effectiveness of systems employing computer data bases.

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FOREWORD

This effort was conducted under subproject Z1170-PN.03, Improving the Accuracy and Usability of Automated Personnel Information Systems. The objective of this subproject is to resolve fundamental human engineering design issues for Navy personnel office information systems that will be implemented in the mid-1980s. Candidate solutions to specific design issues are to be tested for application in the user environment.

The objective of this effort was to test two methods of reducing the number of errors in the data entering the Manpower and Personnel Training Information System (MAPTIS) and the Joint Uniform Military Pay System (JUMPS) from local personnel offices. Two computer data entry systems were developed to analyze the performance times and error rates associated with the use of optical character recognition forms.

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Commanding Officer

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Technical Director



SUMMARY

Problem

At present, using optical character recognition (OCR) forms, it takes at least 14 days to enter new information into the master data base of the Navy's Manpower and Personnel Training Information System (MAPTIS) or the Joint Uniform Military Pay System (JUMPS). This may stretch to 90 days if the forms must be returned to the submitting office for correction of errors (from 10 to 30% of the OCR forms contain significant errors). Although the Navy employs over 200 people to check and correct OCR forms, the Navy's personnel data base still contains significant errors that lead to an uncertain knowledge of force strength, imprecise budgetary and training control, suboptimal detailing of personnel, and delayed distribution of orders.

Purpose

The purpose of this effort was to test the effectiveness of two computerized data entry systems designed to improve operator efficiency and reduce the number of errors in Navy personnel records.

Approach and Results

Detailed data were collected on operator performance times and on the quantities and types of errors made using (1) a stand-alone, self-contained system and (2) a distributed system that used an off-site computer in tandem with an on-site micro-processor. Preliminary analyses of performance times and error rates were conducted to assess user acceptance so that modifications, if needed, could be implemented before the system testbed was installed in the Point Loma Pay/Personnel Administrative Support System (PASS) office located in San Diego, California.

PHASE I - Trial Use of a Self-Contained Office Data Entry System

A self-contained data entry system was installed in the Point Loma PASS office. NAVCOMPT form 3060, used for pay and personnel record changes, was presented in a query/menu mode that incorporated extensive "help" messages. The results of the office test met with resistance from PASS office personnel and proved unsuccessful. The resistance was due largely to delays caused by a long computer response time. After a short trial period, PASS office use of the self-contained system was discontinued. Entry time comparisons performed subsequently in a NAVPERSRANDCEN laboratory indicated that it took almost twice as long to prepare a 3060 OCR form using the computer system than when using an electric typewriter.

PHASE II - Preliminary Analysis of a Distributed Office Data Entry System

In response to the criticism that the response time of the self-contained system was "too long," a faster "distributed" office data entry system incorporating an off-site minicomputer was developed. NAVPERS 1070/P602R (Dependency Application/Record of Emergency Data) ("602" form) was chosen for testing the distributed system because it was rated by personnelmen as the most difficult and the most time-consuming form to complete. The investigators believed that the PASS office personnel would be more likely to cooperate in the implementation of the distributed data entry system if they perceived that there would be some significant benefit to the PASS office.

The distributed office data entry system was set up in a NAVPERSRANDCEN laboratory. Subjects used the distributed system to complete two 602 forms and an electric typewriter to complete a second set of forms. The two sets of "personnel data" generated for this test were matched for number of keystrokes and placement of fingers to simulate data that could be found on completed 602s in any PASS office.

Performance times and error rates for both the computerized and manual methods were compared. Additionally, the time required to make changes to a form stored in the computer's data base was compared with the time required to make the same or similar changes with the electric typewriter. Each operator completed an attitudinal questionnaire at the end of the testing session.

There was no significant difference between the times needed for initial completion of the 602 forms by either method, but twice as many errors would have entered the PASS information system from the manual task. The time required to make changes to a personnel record already in the computer data base was one-fourth the time required to make the same change manually, since any manual change necessitated retyping the complete form.

Conclusions

1. The distributed office data entry system provided a distinct advantage over the self-contained system in attaining the goal of reducing errors in the information system without adding to the office workload.
2. PASS offices could substantially reduce their error rates by using a system similar to the distributed system used in this test.
3. Using the distributed system to make changes resulted in a 75 percent time savings over the manual method.
4. The time saved in making changes would be, by itself, a significant factor in evaluating the cost effectiveness of systems employing computer data bases.

Follow-on Effort

A distributed office data entry system is currently being installed in the Point Loma PASS office to collect the data required for fundamental research in the design of man/computer interface systems. This system will: (1) replace OCR forms with computer-printed forms, (2) use a data base that will permit previous entries to be recalled for modification, and (3) print summary reports for office use.

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INTRODUCTION

Problem

At present, using optical character recognition (OCR) forms, it takes at least 14 days to enter new information into the master data base of the Navy's Manpower and Personnel Training Information System (MAPTIS) or the Joint Uniform Military Pay System (JUMPS). This may stretch to 90 days if the forms must be returned to the submitting office for correction of errors (from 10 to 30% of the OCR forms contain significant errors) (Michna, Laidlaw, & Obermayer, 1978). Although the Navy employs over 200 people to check and correct OCR forms, the Navy's personnel data base still contains significant errors that lead to an uncertain knowledge of force strength, imprecise budgetary and training control, suboptimal detailing of personnel, and delayed distribution of orders.

Purpose

The purpose of this effort was to test the effectiveness of two computerized office data entry systems designed to improve operator efficiency and reduce the number of errors entered into Navy personnel records. The first was a self-contained system using an on-site microprocessor and the second was a distributed system that used an off-site computer in tandem with the microprocessor.

Background

Data entry is an essential part of any large information system. If the products of the data entry system are inaccurate or out-of-date, the information system is degraded correspondingly. The entry of pay and personnel data is accomplished in the Navy primarily through the use of manually typed OCR forms. The personnel or pay information is typed in the appropriate boxes of specific forms, and the forms are then mailed to central computer facilities in Washington, D.C. (MAPTIS) or Cleveland, Ohio (JUMPS). At each of these sites, the OCR forms are scanned by special machines and transformed into an electronic format suitable for further processing by a large digital computer. Computer error checks are made at the scanner (i.e., the scanner checks for those errors that can be identified from other information on the form), and again at the large computer (i.e., edits that include checking against previously stored information from many sources). Some errors are corrected by error research teams at the MAPTIS and JUMPS sites but many of the forms must be returned to the originating field office for correction.

This process is both slow and inaccurate. Although full audits of the personnel data base are not available, corrections were required in more than 80 percent of the records examined in two surveys.^{1,2} In the first survey, 500 interviews yielded 477 errors. The second survey yielded 4792 errors from 5708 records (Michna et al., 1978). These errors, which found their way into the data base in spite of herculean efforts, are presumably an indication of as yet undiscovered errors in the MAPTIS and JUMPS data bases.

¹BUPERS, Source data automation study group (Final Draft). Washington, DC: Bureau of Naval Personnel, 24 February 1975.

²CHNAVPERS (PERS-53) Naval Speedletter, 15 January 1976.

OCR errors detected by the scanners range from 10 to 20 percent, depending on which one of the approximately 30 forms is being reviewed. Additional errors are found when the large computer updates the data base and when new information is compared with existing data base information (Michna et al., 1978, and footnotes 1 and 2).

Table 1 lists the types of errors found on two OCR forms. Form 3060 is for pay purposes and Form 610 is for personnel information changes. Both forms occur in high volume and many types of errors are detected and corrected manually; however, only the primary types of errors that are applicable to this report are shown. The error data presented in Table 1 were collected in 1977, before the Navy's consolidation of field pay and personnel offices.

Table 1
OCR Form Errors

Error Type	Percent of Total Errors	
	Form 3060 ^a	Form 610 ^b
Undecipherable entry	25.0	40.0
No cross-check	12.3	7.7
Characters in error	5.6	16.2
Entry missing	5.4	21.3
Invalid date	8.9	13.4
Invalid amount	5.1	NA
Name/SSN mismatch	6.7	NA
Total	69.0	98.6

^aMilitary Pay Order (NAVCOMPT 3060).

^bRecord of Personnel Actions (NAVPERS 1710/610).

Prior to 1979, there were more than 3000 Navy field units submitting OCR documents. It was clearly not feasible to automate so many small offices, especially since half of the field units submitted less than 1000 documents per year, and half of these submitted less than 500 per year. With the advent of the Pay/Personnel Administrative Support System (PASS), which integrated pay and personnel functions, the number of submitting offices was reduced to approximately 500.

PHASE I--TRIAL USE OF A SELF-CONTAINED OFFICE DATA ENTRY SYSTEM

Purpose

The purpose of Phase I was to test the effectiveness of using a self-contained computer configuration for detecting errors at PASS field offices as data are being entered onto the OCR form.

Approach

A self-contained, computerized, office data entry system was designed in a preliminary effort to collect detailed data on the quantities and types of errors made in local PASS offices. The self-contained system was tested both in a PASS office and in a NAVPERSRANDCEN laboratory. The system had a capability for automatic error detection, provision for manual corrections, and a printer for processing the OCR form. The form used for this test was the one used for military pay actions, NAVCOMPT 3060 (see Figure 1). The self-contained system also automatically recorded errors for later analysis.

The software, written in BASIC, presents NAVCOMPT 3060 in a query/menu mode. The numbered "blocks" of the form are presented as two series on the CRT display screen. The first series consists of information specific to the originating office, and the second, information specific to the individual service member. The computer flow diagram is shown in Figure 2. A hierarchical system of prompts, cues, and detailed explanations allowed the novice to use the system as well as the highly trained personnelman.

The "reason for change" block is the main source of errors, and software was developed in a menu format to help in the selection of the proper entry code. Cues, helps, and project aids allowed complex abbreviations to be selected from a menu-type list on the CRT, and the correct abbreviations or codes were entered automatically. The menu format eliminated errors due to spelling or selection of inappropriate codes. Information was transcribed onto the 3060 OCR form through use of a Diablo printer equipped with an OCR font. The capability for repeatedly printing the completed form at the time of data entry, without reentering the information, was made available.

The self-contained system also included the capability for counting entries to ensure that all necessary entries, but no extra ones, were made. Edits were designed to scan the OCR form for appropriate alpha, numeric, and special characters, and for the total number of characters, among other features. Errors detected by the computer edits, including undecipherable entries, were presented to the data entry operator as they were detected so that corrections could be made on the CRT before the form was printed. These errors accounted for two-thirds of the total errors found. The errors were displayed as shown in Figure 3 and recorded for subsequent statistical analysis.

Results and Conclusions

The tests conducted in the PASS office met with resistance from PASS office personnel, due mainly to a long computer response time. PASS personnel determined it was easier and quicker to prepare the 3060 form on a standard electric typewriter. At the PASS supervisory level, it was determined that the error reduction factor did not compensate for the lost operator time; consequently, the local office perceived no benefit. The office test was therefore terminated early and the system was moved to a NAVPERSRANDCEN laboratory for further tests.

Four subjects used the self-contained system and standard electric typewriters to prepare NAVCOMPT 3060 forms under controlled conditions in a NAVPERSRANDCEN laboratory. All of the subjects were experienced in the preparation of OCR forms using an electric typewriter. One subject was tested first after a short orientation period on the self-contained system, and again after several weeks' experience with the system. The subjects' experience on the computer system was labeled as either "inexperienced" (less than 1 week) or "experienced" (6-9 weeks).

	3060	
MILITARY PAY ORDER (SINGLE)		
1. NUMBER OF ORDER 2. DATE (YR/MO/DA)	IT IS HEREBY AUTHORIZED THAT THE PAY ACCOUNTS OF THE INDIVIDUALS LISTED BELOW BE ADJUSTED AS INDICATED HEREIN	
3. NAME (LAST, FIRST, MIDDLE INITIAL)		
4. ORGANIZATION AND STATION		
5. FROM HR	6. DATE (YR/MO/DA)	7. TO HOUR
8. DATE (YR/MO/DA)		
9. SSN	10. AMOUNT	11. REASON FOR CHANGE
12. REMARKS		
13. NAME (LAST, FIRST, MIDDLE INITIAL)		
14. ORGANIZATION AND STATION		
15. FROM HR	16. DATE (YR/MO/DA)	17. TO HOUR
18. DATE (YR/MO/DA)		
19. SSN	20. AMOUNT	21. REASON FOR CHANGE
22. REMARKS		
23. NAME (LAST, FIRST, MIDDLE INITIAL)		
24. ORGANIZATION AND STATION		
25. FROM HR	26. DATE (YR/MO/DA)	27. TO HOUR
28. DATE (YR/MO/DA)		
29. SSN	30. AMOUNT	31. REASON FOR CHANGE
32. REMARKS		
33. NAME (LAST, FIRST, MIDDLE INITIAL)		
34. ORGANIZATION AND STATION		
35. FROM HR	36. DATE (YR/MO/DA)	37. TO HOUR
38. DATE (YR/MO/DA)		
39. SSN	40. AMOUNT	41. REASON FOR CHANGE
42. REMARKS		
43. NAME (LAST, FIRST, MIDDLE INITIAL)		
44. ORGANIZATION AND STATION		
45. FROM HR	46. DATE (YR/MO/DA)	47. TO HOUR
48. DATE (YR/MO/DA)		
49. SSN	50. AMOUNT	51. REASON FOR CHANGE
52. REMARKS		
53. NAME (LAST, FIRST, MIDDLE INITIAL)		
54. ORGANIZATION AND STATION		
55. FROM HR	56. DATE (YR/MO/DA)	57. TO HOUR
58. DATE (YR/MO/DA)		
59. SSN	60. AMOUNT	61. REASON FOR CHANGE
62. REMARKS		
63. TOTAL NUMBER OF PAGES IN PAGE		64. SIGNATURE OF CERTIFYING OFFICER
65. OFFICER NAME AND GRADE (PRINT NAME AND GRADE)		

Figure 1. NAVCOMPT 3060 (Military Pay Order).

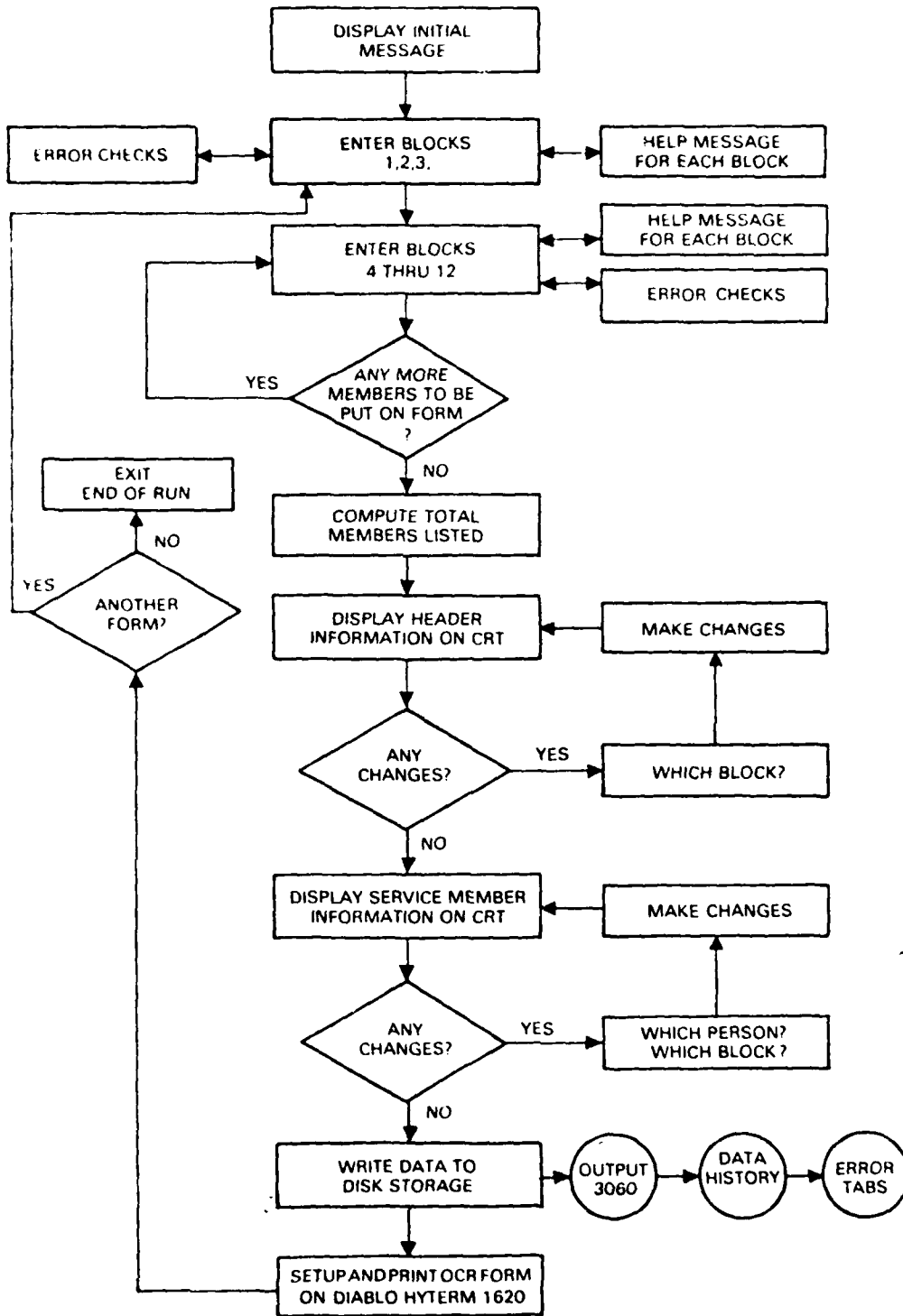


Figure 2. Computer flow diagram for processing NAVCOMPT 3060 on the self-contained system.

Message	Applicable Block Numbers
00007 TOO FEW CHARACTERS	1, 5, 7, 9
00020 TOO MANY CHARACTERS	1
00017 INCORRECT CHARACTERS	1, 2, 4, 5, 6, 7, 8, 9, 10
00006 BLANK FIELD	1, 2, 3, 4, 9, 10, 11, 68
00016 INVALID DATE DATE OF THIS TRANSACTION MUST BE LESS THAN OR EQUAL TO TODAY'S DATE	2, 6, 8 6, 8
<u>ADDITIONAL HELP MESSAGES</u>	
BLOCK 7 IS BLANK. IS IT SIGNIFICANT TO PAY ACTION OR IS THERE A DATE TO BE PUT IN BLOCK 8?	7
BLOCK 10 IS BLANK. IS THERE TO BE A MONETARY AMOUNT FOR THIS PERSON?	10

Figure 3. Error messages displayed by self-contained system (typical).

Overall, the individual and total time comparisons indicated that using the self-contained system required more time than using the standard electric typewriter. Where only one transaction for a single service member was to be recorded, data could be entered in approximately 50 percent less time when using a standard typewriter than when using the self-contained computer system. Even forms requiring multiple entries were produced faster (80% of the computer time) when using a standard typewriter. The time required for the manual task did not, however, include any of the normal editing time, either by the personnelmen or by the supervisor. In addition to the entry time, the operator using the self-contained system was required to display the completed form on a CRT for editing and then print the final form. The error checking features were not considered to be an offsetting factor by the test subjects.

A major factor in user acceptance of any new system is that the user must perceive a distinct advantage in using the new system (the computer system in this case) over the current system (filling out forms manually using an electric typewriter). A reduction of

the office workload, which should be a primary consideration of any computer configuration, was not effected by the self-contained system.

PHASE II--PRELIMINARY ANALYSIS OF A DISTRIBUTED DATA ENTRY SYSTEM

Purpose

The purpose of Phase II was to develop and test the effectiveness of a faster and more efficient office data entry system employing distributed data processing capabilities. This system incorporated an off-site minicomputer for detecting errors at the field offices as data were entered into a master information system. For a preliminary assessment, the distributed data entry system was tested in a laboratory at NAVPERS-RANDCEN to establish performance times and error rates. After completion of the preliminary assessment, the distributed system was removed from NAVPERSRANDCEN and installed in the Point Loma PASS office, where additional research will be performed.

Approach

The Distributed System Testbed

The distributed office data entry system testbed was an expanded reconfiguration of the self-contained system. New software was designed so that the entries or "blocks" on the OCR form were individually displayed on the CRT screen in a manner similar to the display shown on the self-contained system. If an incorrectly formatted entry was made, an error message was displayed that was specific to that block. Erasures were made by backspacing, and the operator was not allowed to proceed until the error had been corrected.

An expanded edit mode provided capabilities for displaying the recorded data and for correcting any errors that might be found without reentering the complete form. Only the keystrokes required for the specified change were necessary to update the data base.

One of the criticisms of the self-contained system was the "long" computer response time. Williges (1980) reported that operators will tolerate a maximum system delay of 2 to 4 seconds before experiencing irritation and work degradation. In response to this criticism, a PDP 11/45 minicomputer was included in the distributed configuration. The addition of increased memory assured faster response time and the ability to include a data base that could provide many side benefits to the user.

The Dependency Application/Record of Emergency Data (NAVPERS 1070/P602R) form was singled out as the most difficult and time consuming form to complete. The 602 is used as a legal document with the service member's signature attesting to claims of dependency and to disposition of assets in case of death; every service member is required to have a 602 form in his or her personnel jacket.

The difficulty with the 602 stems partially from its complexity. It is two records combined into one and consists of 80 entry blocks (see Figure 4). There are five copies to each form. The first three are sent to Cleveland, the fourth to Washington, and the last copy is retained in the service member's folder. However, if there are no changes in dependencies, only the last two copies are filled out. Further, to add to the problem, the backs of Parts I and II of the form are different. Precisely because of these difficulties and because of the time involved in filling it out, the 602 was chosen as the experimental

DEPENDENCY APPLICATION / RECORD OF EMERGENCY DATA

1. NAME OF STATION _____

2. NAME OF SPOUSE _____ 6. LAST DATE OF BIRTH OF SPOUSE _____ 7. WE ARE NOW _____

8. PLACE OF MARRIAGE (CITY & STATE OR COUNTRY) _____ 9. DATE MARRIED _____ 10. CHILDREN (SEE BLOCK 11)

11. ADDRESS OF SPOUSE _____

12. NAME OF CHILD OR DEPENDENT _____ 14. DATE OF BIRTH _____ 15. RELATIONSHIP _____

16. ADDRESS (INCLUDE NAME OF CUSTODIAN IF OTHER THAN CLAIMANT) _____ 17. DEP. _____

18. NAME OF CHILD OR DEPENDENT _____ 19. DATE OF BIRTH _____ 20. RELATIONSHIP _____

21. ADDRESS (INCLUDE NAME OF CUSTODIAN IF OTHER THAN CLAIMANT) _____ 22. DEP. _____

23. NAME OF CHILD OR DEPENDENT _____ 24. DATE OF BIRTH _____ 25. RELATIONSHIP _____

26. ADDRESS (INCLUDE NAME OF CUSTODIAN IF OTHER THAN CLAIMANT) _____ 27. DEP. _____

28. NAME OF CHILD OR DEPENDENT _____ 29. DATE OF BIRTH _____ 30. RELATIONSHIP _____

31. ADDRESS (INCLUDE NAME OF CUSTODIAN IF OTHER THAN CLAIMANT) _____ 32. DEP. _____

33. NAME OF FATHER _____

34. ADDRESS OF FATHER (SEE SPECIAL INSTRUCTIONS BEFORE COMPLETING BLOCK 35) _____ 35. DEP. _____

36. NAME OF MOTHER _____

37. ADDRESS OF MOTHER (SEE SPECIAL INSTRUCTIONS BEFORE COMPLETING BLOCK 38) _____ 38. DEP. _____

39. MARRIAGE PREVIOUSLY MARRIED: YES NO 43. PRIOR MARRIAGE DISSOLVED BY: DEATH ANNULMENT DIVORCE 41. DATE _____ 42. PLACE (CITY & STATE OR COUNTRY) _____

44. MARRIAGE PREVIOUSLY MARRIED: YES NO 44. PRIOR MARRIAGE DISSOLVED BY: DEATH ANNULMENT DIVORCE 45. DATE _____ 46. PLACE (CITY & STATE OR COUNTRY) _____

47. OTHER _____ 48. ADDRESS _____ 49. RELATIONSHIP _____

50. NEXT OF KIN OR SPOUSE (NOT HUSBAND, WIFE OR MINOR CHILD) _____ 51. ADDRESS _____ 52. RELATIONSHIP _____

53. BENEFICIARY FOR UNPAID PAY AND ALLOWANCES _____ 54. ADDRESS _____ 55. RELATIONSHIP _____ 56. % _____

57. PERSON TO RECEIVE ALLOWMENT IF IN A MISSING STATUS SUBJECT TO SERVICE DETERMINATION _____ 58. ADDRESS _____ 59. % _____

60. BENEFICIARY FOR CHARITY PAY AND ALLOWANCE OR CHILD SUPPORT (DEPENDENT) _____ 61. ADDRESS _____ 62. RELATIONSHIP _____ 63. % _____

64. LIFE INSURANCE DATA (NAME OF POLICY, POLICY NO., DATE OF ISSUE) _____ 65. ADDRESS _____ 66. POLICY NUMBER _____

67. RELIGION _____ 68. _____ 69. _____ 70. RANK / RATE _____ 71. PAGE _____ 72. OF PAGES _____

73. NAME OF DESIGNATOR (SGLI, RPL, MURLEY) _____ 74. USN _____ 75. USN _____ 76. USN _____

NAVPERS 1070 / 602 (Rev. 7/72) S. M. 0128 018622 PART II SERVICE RECORD

Pts. I&II
Copies 1-5

Pt. II
Copies 4-5

Pts. I&II
Copies 1-5

Figure 4. Dependency Application/Record of Emergency Data Form, front page of Part II (NAVPERS 1070/P602R).

form. It was believed that the PASS office would be more willing to cooperate in the implementation of the distributed data entry system if it could be demonstrated that the office would reap a significant benefit from the faster handling of this troublesome form.

An immediate advantage was seen with the addition of a data base that would allow the personnelman to reprint the form, with changes, without manually reentering all of the data on the form. Using the manual method of preparation, the form must be completely retyped each time a change is required. When an error occurs, it must be over-typed with the OCR "tree block." If an uncorrectable error occurs (where the correct information will no longer fit in the prescribed block), the form must be discarded and a new form retyped.

With the addition of the data base, the number of keystrokes required for initial completion of the form remained the same but, as changes became necessary, only the keystrokes pertinent to the changes would be necessary. Additionally, the data base would be available for the printing of summary reports and audit trails for other office needs.

Procedure

The participants in the laboratory test were seven males and three females who were randomly selected from a pool of Navy personnelmen (PN rating) from the Point Loma PASS office and Navy civilian clerical personnel from NAVPERSRANDCEN. The mean age was 34.8 years. All of the participants were experienced typists familiar with Navy procedures and the general format of Navy OCR forms.

The participants were given brief written instructions that explained the experiment. They were encouraged to ask questions at any time to clarify their role in the experiment and its specific intent. The participants were told that the current manual system was being compared to the proposed microcomputer system. It was emphasized that the participants themselves were not being tested but, rather, that the purpose was to evaluate the ease of understanding and operating the two systems and to assess timing issues involved in each system.

A user's manual, designed to serve as a training guide and job aid, was given to each subject. A researcher reviewed the manual with the subject just prior to the start of each computer-assisted task. A flowchart in the user's manual delineated the operator's procedures and decision points (see Figure 5). The manual described in detail the procedure for filling out the 602 form for each of the computer conditions. Using the manual, the operator could see what would be displayed on the CRT during initial entry of a form, how to display data, how to make corrections, and how to print the data on an OCR form or transmit the data on-line to a remote point. The operator could see in a block-by-block printed format the exact sequence of events that would occur. Additionally, the user's manual contained detailed explanations for those blocks that had specific restrictions (see Figure 6). The operators were allowed as much time as necessary to read and understand the computer operation. The mean time spent on the user's manual was 17.7 minutes. The operators were asked to enter two practice forms on the computer before beginning the experimental forms. Mean time spent in the practice session was 44.2 minutes.

The computer-assisted task consisted of subjects filling out two separate 602 forms on the computer (80 blocks on each form). After the forms were completed, subjects were asked to make two changes on a 602 form that was already on file (in the data base). The spouse's citizenship was to be changed to indicate naturalized citizenship and the "effective date" was to be changed to reflect this action. This meant that the subject had

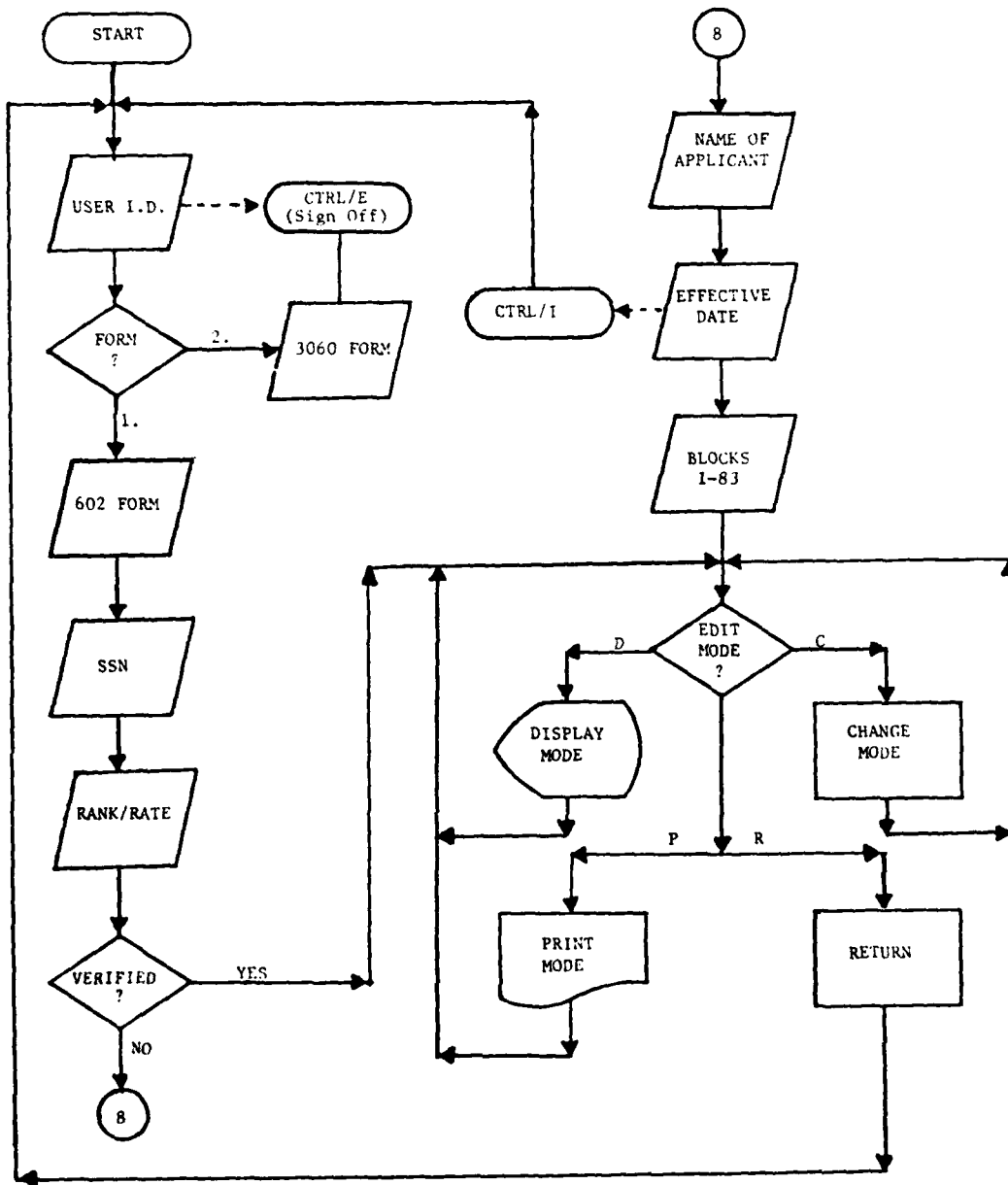


Figure 5. Distributed data entry system operations flowchart for processing the NAVPERS 1070/P602R form on the distributed system.

(MEMBER NOT ON FILE)

When a social security number is not found in either the Officer or Enlisted data base file, and this information is verified by the operator, the 602 (Page 2) messages will appear block by block in the following order:

Block Number

Prompt Message

73. Name of Applicant/Designator: 73. NAME OF APPLICANT (LAST, FIRST MID)
See Rules for Shortening Names, page 6.

69. Effective Date
69. EFFECTIVE DATE:
ENTER DATE THAT MEMBERS STATUS CHANGED.
REFER TO USER'S MANUAL FOR SPECIFIC INSTRUCTIONS.

If a member is joining the Navy or starting a period of active duty with dependents, this is the date active duty pay begins. For members already on active duty this is the date member lost or gained a dependent. The date will usually be one of the following:

- a. date of member's marriage,
- b. date child born,
- c. date child adopted,
- d. date following date of final divorce,
- e. date following date parent's dependency ended,
- f. date parent's dependency began,
- g. date following date a dependent died,
- h. date following date a dependent child married,
- i. date child became 21 years old,
- j. date following date spouse was released from active military service

1. UIC

UNIT I.D. (UIC):

If the UIC is one frequently used by your office the computer will automatically fill in BL2.

1. Message on OCR.

2. Message on CRT.

3. Additional explanatory information specific to the block number.

Figure 6. Excerpt from the distributed office system training/reference manual.

to call for a file from the data base (by entering the social security number and rank of the individual), verify that the correct file was displayed, go into the Change mode to make changes in two specific blocks, and print the corrected form. Entry time for a completed task was measured on the computer from the second that the operator chose the form to the time that the form was printed. A breakdown of the time spent in the Change, Display, and Print modes was available for each operator. No overt timing procedures were needed since the computer recorded all timing and error information.

The manual task consisted of the subjects typing two forms on an IBM Selectric typewriter following normal office procedures. The subjects were required to fill in blocks 1-46 and 67-76 on the front page for all five copies, remove the form from the typewriter, reinsert copies 4-5, and fill in blocks 47-66 (see Figure 3). The backs of Part I and Part II had to be filled out separately (turning them over and reversing the carbons) since they contained different types of information. A stopwatch accurate to the tenth of a second was used to time the subjects on each form starting with form insertion into the typewriter and ending when the finished form was handed to the experimenter.

Errors were separated into the two categories of "detected and corrected" errors and "undetected" errors (i.e., those that would have gone into the information system). The OCR "tree block" errors was used as the manual measure of detected errors. Errors detected on the computer-assisted task were tabulated and registered as error messages, backspace counts, and corrections made to a specific block in the Change mode. Undetected errors on both the computer and manual tasks were measured by discrepancies between the subjects' completed forms and the original experimental forms. "Detected and corrected" and "undetected" errors were analyzed between the manual and the computer system using t tests with correlated means.

Two equivalent sets of "personnel data" were designed for each experimental condition and designated 1.1 and 1.2 for the computer task and 2.1 and 2.2 for the manual task. The sets replicated data that might be found on a 602 form in any service member's file and were matched for number of keystrokes and placement of fingers. Sets 1.1 and 2.1 had 685 keystrokes; sets 1.2 and 2.2 had 644 keystrokes. The difference in keystrokes reflected the addition of two dependent children to sets 1.1 and 2.1.

To eliminate order effects, the subjects were randomly divided and half performed the computer-assisted task first and half performed the manual task first. At the end of the experimental session, each subject was asked to fill out a biographic/attitudinal questionnaire.

Apparatus

Computer Hardware. The distributed system used a Futuredata Microsystem microprocessor consisting of four modules: (1) a mainframe (8080 CPU, 65K bytes), (2) dual floppy disks, (3) a standard typewriter keyboard, and (4) a CRT video display.

Attached to this system was a Diablo Hyterm 1620 on-line printer. The microprocessor was connected, via telephone, to the PDP 11/45 minicomputer that was used later to store the data base for the PASS office.

Software. The software presented the 602 form in a block-by-block query/menu mode on the CRT. Edits for errors with messages appropriate to the specific block were included. A microsystem BASIC Editor, Monitor, and Utility, and a Time/Error file were also included in the software. The Editor provided the capability of creating or updating any text files; the Monitor created or deleted system files; the Time/Error file presented

a block-by-block listing of the selected program and identified system time, operator time, and types of errors (i.e., number of backspaces used, error message numbers, and the number of times that the Change mode was used to correct information in a specific block).

Manual Typewriter. Manual entry of the forms was accomplished using an IBM Selectric typewriter with an OCR font.

Results and Conclusions

A between-within-within (2x2x2) analysis of variance with repeated measures determined there was no significant difference between the times required to complete the forms on the computer (14.6 minutes) or to do them manually (16.5 minutes), $F(1, 24) = 1.88$. All tests were conducted at the $p < .05$ level of significance. Significance was found only between the first and second forms in both the computer-assisted and manual tasks, $F(1, 24) = 9.57$ (see Table 2).

Table 2
Times Required for Computer and Manual Tasks

Timing Measurement	Time by Task per Form 602 (in Minutes)		
	Completion of Form on Computer	Making Two Changes to a Form in File on Computer	Manually Completing Form or Making Two Changes ^a
Entry & Printing Times			
Mean	14.56	4.13	16.46
Median	14.20	4.11	14.60
Mode	11.18, 17.50	4.11	10.38
Variance	8.75	2.34	42.26
Standard Deviation	2.96	.58	6.50
Mean Entry Time	12.20	2.20	---
Mean Printing Time	2.40	1.89	---

^aSince making changes manually necessitated retyping the entire form, the times for initial preparation of form or for making changes would be the same.

The number of "undetected" errors that would have entered the Navy's master information system was significantly greater for forms filled out manually than for forms completed on the distributed system, $t(9) = 2.36$. That is, when operators filled out the forms manually, 30 percent of the errors (1.3 errors per form) would have been incorporated into the PASS information system, whereas forms entered on the computer yielded a 6 percent "undetected" error rate (0.55 errors per form) (see Table 3).

Table 3
Error Rates for Computer and Manual Tasks

Error Detection/Correction Categories	Mean Errors per Form 602 by Task		
	Completion of Form on Computer	Making Two Changes to a Form in File on Computer	Manually Completing form or Making Two Changes ^a
Operator detected/corrected (% of total errors)	8.25 (87)	0.10 (33)	3.00 (70)
Computer detected; operator corrected (% of total errors)	0.70 (7)	0.20 (67)	--
Total detected errors (% of total errors)	8.95 (94)	.30 (100)	3.00 (70)
Undetected errors ^b (% of total errors)	0.55 (6)	0.00 (0)	1.30 (30)
Total errors	9.50	0.30	4.30

^aSince making changes manually necessitated retyping the entire form, the times for initial preparation or for making changes would be the same.

^bErrors that would enter the information system.

Operators detected and corrected significantly more of their errors when using the distributed system than they did when preparing the forms manually, $t(9) = 5.00$. Forms entered on the computer had a "detected and corrected" error rate of 94 percent (8.95 errors per form), while those prepared manually had a 70 percent "detected and corrected" error rate (3.0 errors per form).

The mean time required to make two changes to a record already in the computer data base (4.1 minutes) was one-fourth of the mean time required for the manual task (16.5 minutes). This is an example where only two changes were made to the form (the date of the change plus the change); however, making the same two changes manually would have necessitated retyping the complete form. The "detected and corrected" error rate for forms already in file was .05 errors per form. There were no "undetected" errors that would have entered the information system.

There was no significant difference between the times needed to complete a form initially in the computer-assisted task or the manual task; however, twice as many errors would have entered the PASS information system from the manual task. Changes made to the 602 form using the computer Change mode resulted in a 75-percent time savings over the manual method.

On the attitudinal questionnaire (Figure 7), all operators indicated that they preferred the computer system. Reasons given for this preference were that (1) it was easier to find and correct mistakes, (2) the form did not have to be retyped, and (3) it was faster and cleaner (no carbon copies to "mess with"). All of the subjects recommended elimination of the OCR form, preferring on-line transmission of the data. The prompt messages and edits were categorized as "too easy" by 40 percent of the operators and it was suggested that the prompts could be streamlined with fewer "help" explanations. This would further decrease the computer entry time. As this effort was a preliminary analysis using a small N (10), caution should be used in generalizing the results beyond the sample.

602 DEPENDENCY FORM (PAGE 2)
Experimental Questionnaire

1. Your initials: _____ Date: _____
 2. Grade or Rank: _____
 3. Age: _____
 4. Sex: M F (Circle one)
 5. How many words per minute do you type? _____
 6. Did you prefer the manual typewriter or the automated system?
Manual Automated (Circle one)
 7. Did using the Microsystem make using this form (P602R) any easier?
Harder Same Easier (Circle one)
Why?
 8. What do you think about the microsystem generally?
 9. What features about the system do you like?
 10. Did the Users Manual and the Edits in the program give you enough information?
 11. Are the edits and prompts
too easy? good? too hard? (Circle one)
 12. Do you have any other observations regarding the system?
-

Figure 7. Attitudinal questionnaire.

DISCUSSION

The distributed system provided a distinct advantage over the self-contained system in reducing errors in the information system without adding to the office workload. Based on observation of the short time (one practice session) that it took the subjects to become familiar with the computer, it is estimated that entry of a complete form without errors could be accomplished in 8 minutes or less by an experienced operator.

Although fewer errors would have entered the PASS information system using the computer, users produced more errors during initial entry of the data. This phenomenon was also noted by Fields, Maisano, and Marshall (1978) in an experiment where subjects typed text into a computer system. Their system included both a spelling correction feature (comparing unknown terms with a list of correctly spelled terms) and an autocompletion feature (using initial parts of words or initial parts of established abbreviations). User error rates increased when the autocompletion feature was available. Fields et al. believe that, while inexperienced users show a strong preference for automatic correction options, they initially experience difficulty in using them correctly.

This could partially explain the increased error rates when using the computer system in this analysis. Another explanation, which would be more difficult to test, could be that, since users know error correction features are available and final products will be error-free, they experience a greater sense of freedom when using the computer system. This combination of "inexperience" and "sense of freedom" seems to contribute to increased error rates for inexperienced users.

In a service member's career, there are often changes of address and in dependencies, all of which currently necessitate retyping the entire 602 form. A 75-percent time savings in recording these changes would make computerization a significant factor in improving cost effectiveness. Since the mean printing time per form is 2.0 minutes, a remote printing procedure could be established as long as hard copy forms are required for legal purposes. This would free additional time for the operators, enabling them to proceed with other work tasks. PASS offices have expressed the need for management information and word processing capabilities, in addition to improved data entry. User acceptance is likely to be a problem if piecemeal automation increases office workload.

CONCLUSIONS

1. The distributed office data entry system provided a distinct advantage over the self-contained system in attaining the goal of reducing errors in the information system without adding to the office workload.
2. PASS offices could substantially reduce their error rates by using a system similar to the distributed system used in this test.
3. Using the distributed system to make changes resulted in a 75 percent time savings over the manual method.
4. The time saved in making changes would be, by itself, a significant factor in evaluating the cost effectiveness of systems employing computer data bases.

FOLLOW-ON EFFORT

A distributed office data entry system is currently being installed in the Point Loma PASS Office to collect the data required for fundamental research in the design of man/computer interface systems. This system will:

1. Replace the OCR with computer-printed forms. It is easier and faster to make corrections when a computer provides immediate feedback to the operator; consequently, the number of errors that enter the information system would be substantially reduced.

2. Use a data base that will permit previous entries to be recalled for modification. Time saved in entering and retrieving data from the master information system will reduce manpower costs (e.g., personnel could use the extra time to perform other office tasks). Additionally, once the information is correctly entered, the likelihood of creating new errors on previous data would be greatly reduced.

3. Print summary reports for office use. Audit trails for specific personnel, or summary reports of personnel actions, could be incorporated into the system to provide management with a convenient and useful management tool.

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