JOB PERFORMANCE AIDS RESEARCH

SUMMARY AND RECOMMENDATIONS

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INTRODUCTION

A job performance aid is something that a maintenance man uses to guide himself while he is performing a task of his job. It provides step-by-step instructions for the job at hand. The most systematic exploratory development work to be found in the research literature concerning job performance aids has been conducted by the Air Force Human Resources Laboratory since 1960 and has been concerned primarily with aiding the performance of electronic maintenance tasks. Most of the other exploratory development have likewise been concerned with electronic tasks but more specifically with electronic troubleshooting tasks. Although the AFHRL work has considered many factors related to job performance aids area, its most unique and far reaching contribution has been fully proceduralized or non-decision aids for all electronic maintenance activities. The laboratory development and tryout of these non-decision aids was completed in 1968 with the report by Elliott. Currently the AFHRL is preparing fully proceduralized aids for an Air Force electronics subsystem.

Another large Air Force Project that has considered other factors concerning job performance aids has been Air Force Project PIMO (Presentation of Information for Maintenance and Operations). The PIMO project was started in 1964 under the management of the Ballistic Systems Division of the Air Force Systems Command. The project had both exploratory and advanced development phases. The experiment has been completed and the final report is being prepared. Although this was a BSD project, AFHRL was represented on the working group of this project from its start. In its final form the PIMO project developed aids for both mechanical and electronic tasks. It was, however, limited to flight line maintenance.

Most researchers have had as their general objective the improved effectiveness of systems maintenance. Some have accepted current selection and training practices and have concentrated on improved effectiveness of maintenance only. Others have added such variables as length and content of training and aptitude of trainees. The exploratory development efforts of the Training Research Division of the Air Force Human Resources Laboratory have generally followed the latter approach.

The experimental evidence, to date, indicates that great savings both in system maintenance efficiency and in training efficiency can be obtained by well designed job performance aids. If a maintenance man uses a good job performance aid, he requires less training and he makes fewer errors in his work. But, there seems to be some confusion as to the contribution that each of the important job performance aids efforts can make to improving maintenance and reducing training time. The purpose of this technical report is to summarize the findings, ~~both~~ the AFHRL work and the PIMO work as well as other important projects, to compare the scope of each of the important efforts, to identify areas of difficulty in implementing research findings, and to make recommendations for an implementation program that will obtain immediate as well as long range gains.

AIR FORCE HUMAN RESOURCES LABORATORY EXPLORATORY DEVELOPMENT PROGRAM

Since 1960, the Technical Training Branch has supported a small but continuing exploratory development program. From 1960 through FY 68 this was supported by a total expenditure of only $310K. This program has included (1) a systematic investigation to identify important variables concerning job performance aids and the study of the effects of such variables on actual performance and (2) field survey to determine both the current and future of Air Force Electronic Maintenance Technical Data Problems. For most of this effort, since 1962, the author of this summary, Dr. John P. Foley, Jr., of the Air Force Human Resources Laboratory, has been the Air Force technical monitor of this effort. All of this program has been conducted under contract and the results have been reported in 15 technical reports. Mr. Thomas K. Elliott of Applied Science Associates, Inc. (ASA) of Valencia has been the sole or primary author of 9 of these reports. Dr. John D. Folley, Jr., President of Applied Science Associates, Inc., has been the principal investigator for most of this effort and has been the sole or primary author of 5 of these reports. Elliott and Folley were joint authors of only 2 reports. Since 1964 most of the actual work has been performed by Thomas K. Elliott.

AFHRL Systematic Investigation

This systematic investigation has had three phases, namely the preliminary developments and investigations, the study of job performance aids variables and the field survey.

1. The Preliminary Developments and Investigations - This phase was begun by a 1960 review of the job performance aids literature by Folley and Munger. This was followed by the development and tryout of preliminary procedures for systematically designing job performance aids (Folley, 1961a and Folley and Shettel, 1962). These efforts pointed to the fact that insufficient hard data existed for the guidance of job performance aid developers and an attempt was made to isolate problems requiring further exploratory development (Folley, 1961b). In addition, a maintenance task simulator was developed to simulate and measure human activity during the performance of front panel checkout routines and during the solving of between stage troubleshooting problems. This simulator also included actual circuits for the study of human behavior relative to solving between stage troubleshooting problems. Three reports have been published describing this simulator - Elliott and Folley, 1964; Elliott, 1967a and Elliott 1967b.

1. Dr. John P. Foley, Jr. and Dr. John D. Folley, Jr. are not the same person. Dr. John D. Folley, Jr. (middle initial D, and Folley spelled with

2. Study of Job Performance Aid Variables - A number of reports have resulted from the investigation of variables such as the following. (These reports will be referenced later in this summary.)

a. Structure of Electronic Maintenance Tasks

(1) Equipment checkout procedures.
(2) Align, adjust and calibrate procedures.
(3) Between stage troubleshooting procedures.
(4) Within stage troubleshooting procedures.
(5) Remove and replace activities.

b. Structure of Content - The effectiveness of both decision and non-decision (fully-proceduralized) aids have been studied and reported.

c. Electronic Aptitude - Subjects with both electronic aptitude (75-95 percentile) and medium aptitude (40-60 percentile) were used in our investigations.

d. Level of Experience - Naive high school subjects as well as experienced Air Force technicians were used as subjects.

e. Level of Detail - Block vs Schematic were studied.

f. Presentation Format - Automatic retrieval of visual information vs. Manual retrieval of visual information vs Automatic retrieval of audio information were compared.

3. Field Survey of Technical Data Problems - A field survey of electronic maintenance technical data problems was made in the 1966-67 time period (Folley and Elliott, 1967).

AFHRL Exploratory Development Results

Results of the AFHRL Systematic Investigation - The outcomes and findings of our systematic investigations are summarized below:

1. A Classification of Maintenance Activities - It is rather difficult to determine the many sources that contributed to the following classification of electronics maintenance activities but the author's work with this AFHRL exploratory development, with his work concerning job oriented training and his investigation of job performance measurement contributed

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two "l") has been president of Applied Science Associates since 1961. Prior to 1961 he was with the American Institutes for Research. Dr. John P. Foley, Jr. (middle initial P and Foley spelled with only one "l") has been an Air Force employee since 1942. He has been an Air Force research psychologist since 1962 at the Training Research Division (AFHRL), Wright-Patterson AFB, Ohio.

to its development. It first appeared in substantially this form in 1957 (Foley, 1957). It has proven to be a very useful structure for the analysis and organization of much of our current and proposed work in training, aiding, and evaluating Air Force technicians in their job performance.

a. Job activities or tasks associated with electronic equipment

(1) performing equipment checkout procedures
(2) adjusting, aligning, and calibrating
(3) isolating between-stage faults to particular stage
(4) isolating within-stage faults to defective component
(5) replacing of components

b. Information gathering activities of electronic technician jobs

(1) Using oscilloscope to: measure voltage, measure frequency, compare waveshape to waveshape standard, make high accuracy time base measurements and comparisons
(2) Using electronic voltmeter
(3) Using ohmmeter
(4) Using signal generator
(5) Using tube checker to estimate quality of electron tubes
(6) Using transistor checker to estimate quality of transistors

c. Some handtools used in electronics technician jobs

(1) screwdrivers
(2) pliers
(3) diagonal cutters
(4) soldering iron
(5) soldering gun
(6) wire strippers
(7) machinist' s wrenches
(8) light machinist' s hammer

2. The Structure of Job Performance Aid Content - The effects of both decision and non-decision aids routines on the quality of job-task performance and on training time requirements has been studied extensively. Subjects of various levels of aptitude and experience have been included. This study has resulted in the following significant developments and findings.

a. The development of fully proceduralized routines for between stage and within stage troubleshooting of electronic equipments has been a unique contribution of AFHRL exploratory development (Elliott, 1967b).

b. High Aptitude (70-95) subjects perform between stage electronics troubleshooting tasks better than medium (40-60) aptitude when using decision type aids. These subjects were high school students with approximately eight hours of training who had no previous electronics training or experience (Elliott, 1967a).

c. But, on the same between stage troubleshooting tasks medium aptitude subjects perform as well as high aptitude subjects when using non-decision or fully-proceduralized Job Performance Aids (Elliott, 1967a).

d. With only 12 hours of training on the use of the fully proceduralized or non-decision aids, on the use of test equipment and on the use of hand-tools, both high aptitude and medium high school subjects were able to perform equipment checkout procedures, between stage troubleshooting, within stage troubleshooting, and the removal and replacement of parts (Elliott, 1967c). The electronics system used was the Maintenance Task Simulator (Elliott, 1967d) which compares in size and complexity with a medium sized weapons control system.

e. Using the within stage troubleshooting and the removal and replace portions of the above tasks, an experimental comparison was made between the performance of these high school students and the performance of Air Force technicians averaging 7 years experience. The high school subjects received only 12 hours of training but used fully proceduralized aids. The Air Force technicians used Technical Order - like aids. These technicians had received many months of training. There were no substantial differences in performance between the two groups (Elliott and Joyce, 1968).

3. Presentation Format - no significant differences in effectiveness between the manual and automatic retrieval of visual information, but both were superior to audio presentation of job aid information (Elliott, 1966).

4. Level of Detail - increased level of detail interfers with both speed and accuracy of electronic between stage troubleshooting task performance. The implication is that block diagram presentations of information flow data is superior to schematic presentation (Elliott, 1965 and Elliott, 1967a).

5. Field Survey Concerning Electronic Maintenance Technical Data - (Folley and Elliott, 1967). The following are but a few of the topics discussed in the report of this survey.

a. Job Task Content - Many variations of job structures are found in the Air Force. At one extreme, the technician is required to identify and replace faulty components to the piece-part level such as resistors and capacitors. At the other extreme, the technician makes use of semi-automatic test equipment and a fixed procedure as in the Minuteman System. If the semi-automatic test equipment and the procedure do not solve the problem, it is passed on to the depot for correction.

b. Troubleshooting Procedures - Apparently many technicians frequently proceed on unverified assumptions, use incorrect logic, and come to erroneous conclusions on the basis of imcomplete evidence. Technicians do not keep adequate records of information gathered in a troubleshooting sequence. Not once was a technician observed to have written down information from his troubleshooting checks. Information gathered early in a troubleshooting sequence was forgotten before the end of the sequence.

c. Retrieval of Technical Order Information - Most currently used job performance aids are found in technical orders. Provisions are generally inadequate for retrieval of information by technicians from Technical Orders even though most of the required information is actually in the technical order. After a series of unsuccessful searches for information of a particular type, technicians tend to stop trying to find that type of information.

d. Performance Aids and Limited War - Nine technicians who had recently returned from Southeast Asia were interviewed, and discussions were held with responsible persons at Headquarters Tactical Air Command. There appear to be no unique problems with performance aids in limited war and counterinsurgency operations.

e. Automatic Test Equipment - The increased use of automatic or semi-automatic test equipment has great implication for simplification of maintenance jobs. Such equipment generally produce procedural tasks for the technician. The implications for performance aid design and use are no different than those for any other procedural tasks.

f. Miniaturization - Miniaturization, microcircuitry and integrated circuits will probably reduce the importance of within-stage troubleshooting to the piece part level, even more. This type of troubleshooting may largely disappear.

g. Infrared Pattern Interpretation - The Air Force Aero Propulsion Laboratory has supported exploratory development concerning the infrared scanning of electronic equipment as a means of equipment checkout and trouble isolation (See Stahl and others, 1967 and Vanzetti, Bobo, and Stoddard, 1966). Such scannings result in patterns for good and defective equipment. The Laboratory testing of this methodology has been quite successful. To date its application is aimed at depot level maintenance since this method requires controlled ambient temperatures. The optimum presentation of infrared pattern information is a performance aid problem.

6. Design Handbook Information - As a further result of the AFHRL exploratory development program, information was furnished for the chapter on Job Performance Aids in Handbook of Instructions for Aerospace Personnel Subsystem Design. (HIAPSD).

7. Civilian Usage and Recognition - The AFHRL reports were referenced extensively in a U. S. Department of Labor Technical Report concerning the impact of job performance aids on manpower utilization (Chalupsky and Kopf, 1967).

PROJECT PIMO

Description

PIMO is an acronim for Presentation of Information for Maintenance and Operations. This AFSC project has not been an AFHRL project although the Training Research Division has been represented on the PIMO working group since it started in 1964. It has been under the management of the Ballistic Systems Division at Norton AFB, California (now the Space and Missile Systems Office - AFSC). The project has included 2 early exploratory development efforts and an advanced development operational experiment. From a money point of view this has been a much larger effort than the AFHRL effort. To date, the project has cost $2700K as compared to $310K for the AFHRL effort.

The PIMO advanced development experiment as planned was to include the development and operational evaluation of advanced type job performance aids for both flight line and field shop maintenance tasks for the C-141A aircraft. Fully proceduralized (non-decision) aids were to be developed for all tasks except electronic troubleshooting tasks and engine tasks. Previously developed advanced decision type SIMMS charts were to be used for electronic troubleshooting. The non-decision aids were to be presented in both a hardback or book mode and rapid access, visual aid mode. A large scale field evaluation was planned to compare the relative maintenance effectiveness of current Air Force maintenance documents, hardback PIMO type aids, and the audio-visual PIMO type aids. Due to a cutback in funding, the aids for the field shop maintenance tasks were not developed. This experiment was originally designed for obtaining systems effectiveness information using gross effectiveness measures, such as down time and turn-around time using only those maintenance tasks that presented themselves in the operational flight line environment. The design was later modified to include like maintenance tasks for all groups under study.

Results of the PIMO Project

The PIMO experiment has been completed and the final reports are being completed (Goff and others, 1969). The following is a summary of the results of the experiment comparisons.

1. Essentially no difference in performance time for experienced specialists[1] performing with PIMO aids and for those performing with conventional T. O. aids and information.

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1. The experienced specialists averaged 25 years of age and approximately 19. 2 months experience (5 and 7 skill level).

2. The experienced specialists made errors when performing with T.O.'s. No errors were made when these specialists used PIMO aids.

3. The apprentices[1] performing with PIMO aids required slightly less time on the average to complete the maintenance tasks than the experienced specialists performing with PIMO aids.

4. No errors were made by the apprentices when using PIMO aids.

5. These same apprentices required approximately 1/3 more time to perform the tasks using conventional T.O. aids and information and made more errors. The apprentices used the T.O. aids and information after they had performed the tasks several times using PIMO aids. (Surprisingly, they made fewer errors than the experienced specialists using conventional T.O.'s).

6. A second group of apprentices were allowed to use only conventional T.O.'s. This group required much more time and made many more errors than either the experienced specialists or the apprentices in the comparative experiment. In two of the three jobs, these apprentices were unable to complete the jobs.

7. A group of individuals from unrelated career fields were, also given the same tasks to perform using PIMO aids. Their performance was similar to that of the apprentices used in the comparative experiment (see para 3 and 4 above). They were able to perform the tasks very well with no errors.

8. No significant difference was found between audio-visual and visual (booklet) presentation of data.

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1. The apprentices averaged 20 years of age and approximately 5 months exposure to the C-141A, but they had no previous experience on the tasks used in the experiment.

OTHER IMPORTANT JOB PERFORMANCE AIDS PROJECTS

Decision Type Projects

A number of decision type job performance aid systems have been developed. Some of these have been evaluated by well designed controlled studies others have not. Shriver and Trexler (1966) have described and discussed several of these systems.

SIMMS or SIMS (Symbolic Integrated Maintenance Manuals) - A good description of SIMMS aids can be found in Shriver and Trexler (1966) and therefore is not repeated here. The SIMMS aids have been prepared for the Coast Guard and the Navy. The Air Force has supported the development of such aids for three electronic systems. Although the Air Force evaluation of these aids was rather indecisive, it would appear that the SIMMS concept adequately meets the needs for diagrams and related information for electronic decision-type troubleshooting (Folley and Elliott, 1967). The Air Force has specifications available for SIMMS aids and will prepare them for Major Command upon request. The Navy has also developed specifications for SIMMS aids.

HumRRO Project FORECAST - These decision type aids are also described by Shriver and Trexler (1966). A controlled study concerning the effectiveness of these aids indicated that training time could be reduced from 30 week to 12 weeks for Army M-33 Fire Control Technicians (Shriver, 1960 and Shriver and Others, 1964).

Computer Generated Troubleshooting Trees

Both the Human Engineering Division of the Aerospace Medical Research Laboratories and the National Aeronautics and Space Administration have supported exploratory development for generating troubleshooting decision trees (Folley and Pieper, 1964 and Hannom and others, 1967). This work shows promise for the rapid generation of optimum troubleshooting sequences. These sequences themselves are not in a form that is readily usable by the technician. The sequenced information must be transformed into either a decision or non-decision type format for presentation. Such trees when perfected can be utilized in the development of fully proceduralized routines. The Human Engineering Division has an active in-house project on the computer generation of troubleshooting trees.

Computer Simulation of Circuit Component Variations

The Aero Propulsion Laboratory has supported exploratory development of computer programs that simulate the effects of various out-of-tolerance circuit component conditions on circuit output. The computer can generate tables of various out-of-tolerance output values (symtons) and the probably component or causes of each. This work is aimed at reducing the number of check points necessary in equipment for either fully automated test equipment or for proceduralized trouble-shooting routines. Although this method shows promise, a large amount of expansion and refinement will be required before this work can be made operational.

AN ANALYICAL COMPARISON OF AIDS

IN TERMS OF MAINTENANCE

ACTIVITIES SUPPORTED

Several advanced types of job performance aids have been discussed earlier in this summary. Questions such as the following are sometimes asked when new type aids are mentioned.

"How do these aids differ from the data found in current technical orders?"

"What' s wrong with current technical order? The Air Force has spent a large amount of money for complete data and their adequacy has been varified in the evaluation of the weapons system."

This section has been included to help answer such questions and to clarify what current Technical Orders and what each of these advanced type performance aids do to assist or aid the maintenance man. Figure 1 indicates the extent to which each type of aid supports each category or function of flight line or field shop maintenance activity. The categories or functions of maintenance activities are the same as those described on page 5 of this summary. Another set of categories have been developed to describe various levels of aiding.

Levels or Categories of Aiding

The levels of aiding were generated to describe what each aid does to help the maintenance man perform a particular maintenance activity. These categories are Information Only (I), Restructured Information (RI), Step by Step Procedures (P) - or directions, Expanded Procedures (EP) and Fully Proceduralized (FP) or non-decision aiding. Perhaps the best way to describe these levels is to list the attributes of fully proceduralized or non-decision aids and to indicate how each of the other levels fails short of these attributes.

1. Fully Proceduralized or Non-Decision Aids - Such aids may appear in various formats but they can be identified as "fully-proceduralized" or "non-decision" aids if they possess all of the following attributes.

a. Step by step directions are provided.

b. These directions are based on an action tree which if followed will demonstrate to the technician that the equipment under test is either operating normally or abnormally. If any abnormality is identified, the action tree will provide a routine which will insure that the abnormality is identified and corrected.

	Maintenance Activities ;	Current Tech Order	FORECAST (Elec)	SIMMS (Elec)	PIMO (Mech)	PIMO (Elec)	AFHRL (Elec)	Remarks
Flight Line	Checkout	P	Ground Equipment	EP	FP	FP	FP	I = Info Only
	Align, Adjust, Calibrate	P		P	FP	FP	FP	RI = Restructured Info
	Between Stage Troubleshooting	I		EP	Some SIMMS EP	Some SIMMS EP	FP	P = Step by Step Procedures
	Within Stage Troubleshooting	I		RI			FP	EP = Expanded Procedures
	Remove & Replace	I		I	FP	FP	FP	FP = Fully Proceduralized
Field Shop	Checkout	P	EP	EP	Field Shop Activities Not Included		FP	
	Align, Adjust Calibrate	P	P	P			FP	
	Between Stage Troubleshooting	I	RI	EP			FP	
	Within Stage Troubleshooting	I	RI	RI			FP	
	Remove & Replace	I	I	I			FP	

Figure 1- Comparison of Performance Aids Systems In Terms of Maintenance Activities Supported

c. At every action point in the tree, the aid furnishes <u>all</u> of the necessary information and directions for the successful accomplishment of the required action. The technician is not required to look for it in many parts of his maintenance document - it is all immediately in front of him while he is performing the required action. These information and directions include (1) a <u>picture</u> or drawing of the equipment location under consideration; (2) step by step directions of what he should do; (3) specific information as to what the normal conditions of that location should be and (4) specific directions as to what he should do next if the condition found is either in or out of tolerance.

2. <u>Procedures (P) or Directions</u> - Most Technical Orders provide step by step guidance for checkout procedures and for align, adjust and calibrate procedures if the technician can find them. An examination of this guidance will soon indicate that it does not meet the criteria for fully proceduralized aids. He must be familiar with the layout of his equipment or look for a pictorial in another part of the technical order. In some cases tolerances are provided in another part of the document and in others the technician must make a guess or judgment as to what they should be.

3. <u>Expanded Procedures (EP) or Directions</u> - Some of the more advanced job performance aid systems do contain an integrated action tree, for at least part of the maintenance actions, for example, the Maintenance Dependency Charts of SIMMS. These charts utilize much more abstract symbols than the actual picture of the location under consideration. As in the case of current technical orders, the technician must be familiar with the physical layout of his equipment or look for a pictorial in another part of the document.

4. <u>Information Only (I)</u> - For some maintenance activities such as for between stage troubleshooting, for within stage troubleshooting and for remove and replace activities, some of the job performance aid systems provide information. For example, all technical maintenance orders for electronic equipment include a schematic diagram which provides a great deal of information in a very abstract and symbolic form for both between stage and within stage troubleshooting. The technician must, however, develop his action trees as he goes. He usually does this each time he is confronted with an equipment which is operating abnormally.

5. <u>Restructured Information (RI)</u> - Some of the job performance aids systems have provided improved presentations of symbolic and abstract information. For example, SIMMS and FORECAST have blocked the schematic information to aid the technician in his analyses of the schematic operation.

Comparison of Job Performance Aid Systems

An inspection of Figure 1 will indicate that each of the systems is an improvement over the aids found in traditional technical orders.

1. Advanced Type Decision Aids - Aids such as SIMMS and FORECAST provide improved checkout procedures. SIMMS provides a symbolic action tree which if followed provides guidance for between stage and systems troubleshooting. It leads the technician to the right "ball park" rapidly provided he can interpret the Maintenance Dependency Chart. Once he is there he must provide his own within stage troubleshooting procedures and locate his own support information. Both SIMMS and FORECAST provide blocked schematics for within stage troubleshooting.

2. Fully Proceduralized or Non-Decision Aid Systems - Both the PIMO project and the AFHRL exploratory development efforts have produced fully proceduralized aids. The PIMO project has provided such aids for checkout activities; align, adjust and calibrate activities; and for remove and replace activities for a great many flight line maintenance tasks for the C-141 aircraft. But for between stage troubleshooting, it has fallen back onto SIMMS aids. This project was limited to flight line maintenance and did not include the actual engine maintenance and field shop maintenance of electronic equipments. As a result, little trouble analysis was required for the spectrum of maintenance tasks included in the project. Between stage and within stage trouble analysis are the most difficult maintenance tasks for maintenance technicians to accomplish using conventional aids. They also have been the most difficult activities for which to provide fully proceduralized aids. Our exploratory development program has addressed itself to this task of providing fully proceduralized procedures for between and within stage troubleshooting for electronic equipment and has successfully produced such aids.

TRAINING IMPLICATIONS

1. When current maintenance jobs are completely restructured by well designed job performance aids great savings in training time have been demonstrated. HumRRO Project FORECAST using well designed decision type performance aids reduced training time from 30 weeks to 12 weeks for Army M-33 Fire Control Technicians. (Shriver, 1960 and Shriver and others, 1964).

The AFHRL research has demonstrated that high school students of both medium and high electronic aptitude can troubleshoot after very short training periods using fully proceduralized aids (Elliott, 1967c). The PIMO experiment has demonstrated that both maintenance apprentices and personnel with no previous training using fully proceduralized aids could perform C-141 flight line maintenance tasks as well as the experienced certified technicians (Goff, 1969).

2. At the present time, more immediate training savings can be made in some career fields than in others. For example, a study of Table 1 indicates that there are 5691 personnel authorized with AFSC's C-43131E and C-43151E for C-141 flight line maintenance. It can be estimated that on an average approximately 1000 of these people have to be trained each year. Their present training requires 16 weeks of residence training at Sheppard AFB and at least 12 weeks OJT or a total of 28 weeks. The results of PIMO indicate that if PIMO aids were applied to the flight line tasks for entire C-141 fleet, this training could be accomplished in at most 4 weeks or a reduction of 24 weeks. This would add 6 months of effective usage of each of these 1000 men. Based on a cost of $25,000 (LeMay 1964) per man for a four year enlistment with normal job utilization of only one year, a savings of at least $8000 would be made per man or a total of $8,000,000 per year on only this one AFSC. Of course, applying this concept to the C-135 and C5A would greatly increase these savings.

3. The introduction of miniturization, microcircuitry, and integrated circuits will reduce the requirement for within stage troubleshooting schemes. This should shift training emphasis from knowledge of individual circuit operation and faulty piece part identification to the practice of solving between stage troubleshooting problems (systems analysis) and practice in following checkout procedures. The technician will still be required to operate his test equipment at a high level of competence to gather equipment information, to align and adjust equipment and in some cases to use his handtools to replace defective equipment stages or functional units.

TABLE 1

PERSONNEL INFORMATION CONCERNING C-141

AFSC	No. of Air-Craft	No. of C-141 Subsystems	No. of Subsystems on Other Aircraft	No. of Personnel Authorized	No. of C-141 Personnel Auth.
431X1E	3[1]	All	Unk	7522	5691
432X0	5	Unk	Unk	2382	1200
424X0	6	"	"	274	-
432X0	6	"	"	820	284
421X2	6	"	"	724	327
422X1	6	"	"	604	284
531X0	6	"	"	141	-
532X0	6	"	"	137	-
534X0	6	"	"	739	358
535X0	6	"	"	126	-
325X1	6	"	"	439	-
301X0	6	1	3	742	194
301X0	6	1	4	943	263
301X4	6	3	5	331	119
325X0	6	1	4	433	146

1. C-141, C-135, C5A

4. The introduction of automatic and semi-automatic test equipment will reduce both between stage and within stage troubleshooting tasks to proceduralized tasks reducing or eliminating the requirement for training on circuit (stage) and systems analysis.

CURRENT AND FUTURE AFHRL JOB PERFORMANCE AIDS EFFORTS

The Training Research Division of the Air Force Human Resources Laboratory is developing fully proceduralized aids for the doppler radar AN/APN-147 and its associated computer AN/ASN-35 under contract using $135K of exploratory development funds. It will be noted that this system is only one of eight systems that is the responsibility of AFSC' s 30451 and 30471. Personnel of this career field are responsible for both the flight line and field shop maintenance. The equipment requires both between stage and within stage troubleshooting. It is one of the career fields which includes electronic fundamentals in its training program.

The exploratory development program of the AFHRL in job proficiency measurement is an independent effort from this job performance aid effort but the job task performance tests are being developed for the AN/APN-147 and AN/ASN-35 system. These tests can therefore be used to evaluate the effectiveness of proposed job performance advanced development program.

The Training Research Division AFHRL has prepared a proposed advanced development plan. The proposed project is structured for an entire career field rather than for an entire weapons system. This would be a four year program to demonstrate and evaluate the technology for training for electronic maintenance jobs that have been restructured using both decision type and fully proceduralized job performance aids is proposed. The effort will require the development of fully proceduralized job performance aids for an electronic career field; the development of applicable training programs to accompany both types of aids; and the accomplishment of a controlled experiment to evaluate the relative maintenance effectiveness and transfer effectiveness of current procedures, decision type job performance aid procedures, and fully proceduralized aids procedures. The development of the aids for the AN/APN-147 - AN/ASN-35 system is but an important preliminary effort.

The evaluations will be made on the basis of various criteria, such as cost of preparation, timeliness of up-dating, reliability of maintenance, spare-part consumption, manpower requirements, training costs, and transfer effectiveness of training and experience. It is estimated that this advanced development program will require $1,000,000.

RECOMMENDATIONS

In keeping with the recommendation of the meeting of performance aids researchers (Folley and Elliott, 1967) our primary efforts should be aimed at getting the results of previous exploratory and advanced developments utilized effectively in the operational Air Force. The following actions are recommended:

1. The PIMO aids developed for the C-141A aircraft should be up-dated and expanded to the entire C-141 fleet. Since most of the developmental work has been already accomplished, great improvements in the quality of flight line maintenance and reduction in personnel costs can be realized with a relatively small additional expenditure.

2. In addition, immediate attention should be given to the reduction or elimination of formal training for personnel being trained for AFSC-C-43131E which is systems specific to the C-141. The training curriculum personnel no longer required for this training should be trained to develop and up-date the fully proceduralized aids for the C-141.

3. The proposed advanced development program of the Air Force Human Resources Laboratory should be accomplished in order that the benefits of fully proceduralized aids can be applied to the now most difficult maintenance activities - between and within stage troubleshooting of electronic equipment.

4. The procedures of the PIMO project should be applied to the flight line maintenance activities of the C5A. The procedures should not be applied to the field shop maintenance until the fully proceduralized aids being "polished" by the Air Force Human Resources Laboratory are available to include all the field shop maintenance activities. This includes between stage and within stage troubleshooting. Study should be made of the cost of applying these procedures to the flight line activities of the C-135. This would cover the entire AFSC 431X1E in MAC with fully proceduralized aids for the flight line.

5. The Human Resources Laboratory should initiate a study of the weapons systems development process, so that optimal job performance aids trade-offs can be obtained during systems development.

6. After the above recommendations have been completed, the Laboratory should consider the preparation of a proposed advanced development plan for restructuring the personnel classification and

assignment systems around weapons systems. If the same type of fully proceduralized aids were developed for all electronic subsystems and mechanical subsystems, it may be possible for a person with one AFSC to maintain a large number of subsystems. For example, one type of repairman could possibly be trained to maintain all of the electronic subsystems of one weapons system thus increasing manpower effectiveness. It is also possible that such a repairman could be trained in the field rather than in a resident training center.

7. As an extension of the study proposed in paragraph 6, the progress of fully automated checkout equipment and infrared scanning devices should be studied to determine their possible impact on training, on the personnel classification and assignment system, and on manpower requirements.

8. Micro electronic developments should be studied since they too may require an advanced development program to optimize their effectiveness.

DIFFICULTIES ENCOUNTERED IN APPLYING EXPLORATORY DEVELOPMENT FINDINGS

1. The development of advanced type aids currently cost more to produce than the traditional maintenance data. Savings in both improved systems effectiveness or in training time to offset added production cost have been demonstrated, but it may be difficult to obtain the added money needed for these new type aids.

2. Advanced development projects cost more than exploratory development. In an advanced development demonstration aids must be developed for an entire weapons system or an entire career field. Even though one modern aircraft may cost more than $1,000,000 it is difficult to get money of $1,000,000 magnitude for a project that would result in great savings in operation of many such aircraft.

3. To demonstrate systems effectiveness an experiment must be structured to include an entire weapons system. But weapons systems are maintained by personnel from many career fields. In some cases personnel from these career fields maintain many other weapons systems. To demonstrate training savings an experiment must be structured to include an entire career field.

4. If the jobs of an entire career field are restructured using the same type of advanced type of aids and training is structured around such aids, maximum training savings will be effected. Such personnel can be easily cross-trained into career fields using similiar aids. Graduates must be assigned to the specific jobs for which they are trained or to jobs similiarly restructured. Therefore, the personnel training and assignment procedures must insure precise and timely job assignments.

5. The content of training for restructured jobs is considerably different than traditional training. Instructors would have to learn how to teach the new materials. The instructors would have to believe in the effectiveness of these new materials (the performance aids). This would require a considerable attitude change on the part of many instructors who firmly believe that no one should be allowed to perform maintenance without an extensive exposure to electronic theory.

6. A very similar problem exists in the field concerning the attitudes of maintenance superintendents and supervisors. Many also believe that no one should be permitted to perform maintenance without an extensive knowledge of traditional theory. In fact, some even give their new people their own theory examination before allowing them to learn to maintain their equipment. It should be remembered that current training procedures have been in being for over 30 years. All personnel currently in the field have received such theory training.

7. Many graduates of these programs probably could not "pass" the current paper and pencil (SKT) required for upgrading their AFSC's. They could, however, pass a performance test on between and within stage troubleshooting on their equipment and a performance test on the use of test equipment. The upgrading examinations for the effective career fields would have to be greatly restructured.

8. Job-Task Performance Test procedures together with appropriate scoring schemes must be developed to measure both training effectiveness and job effectiveness of personnel. Gross systems effectiveness measures such as down time and turn around were used in a current weapons systems job performance aids experiment. Such measures are not precise enough to determine individual effectiveness.

9. Even though new procedures are successfully demonstrated, there is always a resistance to change on the part of effected personnel.

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