COMPUTER AIDED AUTHORING OF PROCEDURAL TRAINING DOCUMENTS

Richard Braby
J. Peter Kincaid
and
Paul G. Scott
Training Analysis and Evaluation Group
Naval Training Equipment Center (Code 1)
Orlando, FL 32813

ABSTRACT

This paper describes the design and computer production of highly illustrated training materials to teach complex operating procedures. Procedure training is the most common type of military training and is widely perceived as needing improvement. The training materials described in this paper, and the computer routines used to create them, have been successfully field-tested in teaching selected operating procedures of the SH-3D/H aircraft. A typical page is highly illustrated and follows a strict format, including an overview of the equipment, and pictorial close-ups for action and response. Narrative description is kept to a minimum. Computer routines can control vocabulary by checking each word against carefully developed lists (including technical words, abbreviations and nomenclature). In addition to the book, the procedural training package includes a detailed line drawing or photograph of the equipment's control panel (paper mock-up); students continually refer to the paper mock-up during their learning. Formats and word lists are now incorporated into draft specifications for the Naval Technical Information Presentation Program, an automated process to produce technical information for new Navy systems.

INTRODUCTION

Training devices provide important "hands on" practice in teaching equipment operating procedures. Training on devices is usually less costly, more versatile, and safer than using actual equipment. Still, most complex training devices are expensive and students' access to them is limited. To make the best use of device time, students need preliminary training. For example, before using a Cockpit Procedure Trainer, the student pilot studies the NATOPS manual and other printed materials describing a specific procedure. We have found this kind of preliminary training to be lacking in a number of important respects.

- Printed materials (e.g., workbooks describing procedures) are mainly narrative - the operations they teach are heavily visual in nature.

- Instruction is usually in a group. However, learning to perform procedures is frequently more effective when practice is self-paced.

- Students are usually unprepared to take best advantage of their limited time with the training device. When properly prepared, available device time produces greater training gains.

This paper describes Procedure Training Aids designed to overcome these problems. It presents the instructional formats for the material, describes how students use the material before going to the trainers, and the results of one field test. Because these materials are fairly expensive to produce, we have created computer aided authoring routines to reduce cost. These routines are described along with sample materials generated. Finally, we recommend how best to use computer generated Procedure Training Aids. This paper addresses only equipment operating procedures.

This work is sponsored by the Naval Technical Information Presentation Program (NTIPP) of the David Taylor Naval Ship R & D Center. The aim of the NTIP Program is to design a state-of-the-art publishing system for producing the technical manuals, training materials and other hardware support documents needed with new Navy equipment. An NTIPP system is being designed to support writing, composing, illustrating, printing, distributing and updating these many types of documents. Computer aided authoring routines for formatting Procedure Training Aids is one element of this larger effort.

STRATEGY FOR PROCEDURE LEARNING

An operating procedure consists of a series of steps, generally performed from memory in a particular sequence, on a piece of equipment. The steps are commonly performed with the aid of a simple check list. A typical example is a pilot's preflight check of an aircraft.

The guidelines below are for designers to create procedural training materials.[1] We assume that the students have previous experience in operating similar equipment.

- Divide the procedure into small, easily learned groups of steps.

- Demonstrate each group of steps with an observable model.

- Guide the student in practicing individual steps within a group, then the group of steps. Repeat this for each group of steps, and finally guide the student in practicing the entire procedure.

- Make early training easy by providing:

  - guided and prompted responses
  - immediate and frequent feedback on results.

- Make later training like the job environment by providing only the guides, prompts, and feedback found on the job.

- Use graphics to communicate the visual components of tasks, such as:
  - recognizing, locating, and determining the status of controls and displays
  - positioning switches and other controls.
- Control vocabulary to:
  - simplify text without sacrificing accuracy
  - develop glossaries and training aids for mandatory technical words.
- Require students to chain the steps together into a smooth sequence by talking and pointing their way through the procedure:
  - pointing to a paper mock-up showing where actions take place
  - describing the operator's actions and system responses at each point
  - performing each group of steps in this manner.

FORMAT MODEL FOR PROCEDURE TRAINING AIDS

By incorporating the learning guidelines, our Procedure Training Aids direct the student to efficiently practice and learn complex procedures.[2-3] Typically, Procedure Training Aids have four types of pages:

. Presentation Page	Presents the acts necessary to perform a step in the procedure.
. Paraphrase Page	Exercises student in recalling the content of the previously presented Presentation Page.
. Finger Pointing Exercise Page	With guides and prompts, provides the student with an exercise in which he talks and points his way through a group of steps and learns to do this as a smooth sequence of actions.
. Paper Mock-up	Provides the student with an extension of the finger pointing exercise; this time without guides and prompts.

A fifth type of page is optional:

. Glossary	Defines acronyms, abbreviations, and mandatory technical words. (See table 1)

In all these pages, visual job task information is presented graphically. Words are used only for those messages that must be transmitted with language.

GLOSSARY

BDHI	Bearing distance heading indicator
BIM	Blade integrity meter
FWD	Forward
Nf	Free turbine speed (engine rotary rpm)
Ng	Gas generator compressor speed
Nr	Rotary wing rpm
OVSP GOV	Overspeed governor
OVSP GOV OVRD	Overspeed governor override
RFI	Radio frequency interference

Table 1. Glossary of terms showing abbreviations of nomenclature and technical terms (Taken from NATOPS Flight Manual for SH-3D/H Helicopter)

FIELD TESTS

Field tests have shown students using Procedure Training Aids perform significantly better than students using more traditional types of materials.

One field test took place at Anti-Submarine Squadron One, a training squadron at the Naval Air Station, Jacksonville, Florida.[4] Thirty-five newly designated Naval Aviators transitioning to a fleet aircraft took part in the test. Sixteen of the subjects, the control group, received training using the existing instructional workbook materials developed for learning the Normal Start Procedures. Nineteen subjects, the experimental group, received the Procedure Training Aid. Both groups used the NATOPS manual, providing the official technical description of the procedure.

Upon initial assignment to the training squadron, subjects were given either the traditional materials or the Procedure Training Aid, along with the NATOPS manual. The students studied these materials independently. After a sufficient time, the students were scheduled for a training session in the Cockpit Procedure Trainer where their trials were graded using a standard grading technique. Students were rescheduled for additional sessions until they passed the Normal Start Procedures.

Figure 1 shows the number of trials needed by the students to perform the procedure correctly. Twelve of the 19 students trained with the Procedure Training Aid performed the engine start procedure correctly on the first attempt. This compared with two students out of 16 who performed the procedure correctly the first time in the Cockpit Procedure Trainer after using the traditional materials.

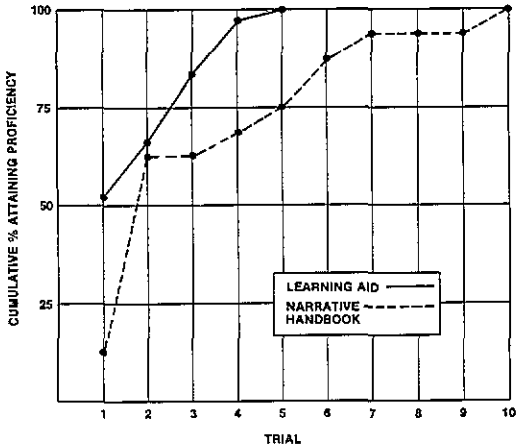


Figure 1. Results of engine-starting field test

The field test demonstrates that the Procedure Training Aid was more effective than the traditional method for preparing students for Cockpit Procedure Trainer exercises. The school also considered the Procedure Training Aid to be a practical method for this training and is continuing to use the material. Additional Procedure Training Aids for other procedures were developed by the squadron out of their own resources using guidelines we developed.

COMPUTER AIDED AUTHORING

Procedure Training Aids are relatively expensive to produce using traditional techniques due to the many complex, heavily illustrated pages required. We considered computer aided authoring techniques to be essential to make costs reasonable and production times practical. Two generations of computer routines have been developed, and a third is nearing completion.

These routines make it easy and fast for an author to enter procedure information into a computer data base using only plain English commands. The computer then automatically formats this information and prints camera ready copy of the formatted text and boxes for the graphics which must then be set in place by hand.

The first generation routine is called PLA for Computer Automated Page Layout for Text-Graphic Materials.(5) It runs on the WANG 2200 MVP minicomputer. The basic steps in the use of this routine are:

The author enters procedure data which include:

- steps in the procedure
- dimensions of pictures for each step
- text for labels
- picture-label relationships
- page headers and footers.

- The computer:
  - selects optimum page layouts
  - draws boxes for pictures and lines for labels
  - puts text in label boxes
  - types headers and footers.
- To complete the process, the author:
  - resolves layout problems that cannot be solved by the PLA routines
  - places pictures in designated boxes
  - places adhesive-backed darts connecting text boxes with their points of action on the graphics
  - ensures that the material is camera ready.

Figure 2 shows a page automatically composed and printed, and figure 3 shows the same page after the graphics and darts have been added.

A second generation routine is called MicroPLA and is similar to PLA except it runs on a microcomputer, the Commodore 8032, the workstation used in one of the Navy's Instructional Program Development Centers. A large number of default values have been added for picture sizes and coordinates within pictures. This reduces the time required to enter data into the system.(6)

The third generation routine is a more powerful and considerably improved system called PowerPLA. Earlier versions (PLA and MicroPLA) require the author to keep track of each page as it is composed. If the computer cannot format the information, the writer must remove some of the overflow information designated for that page. This overflow information must then be added to the next page, changing the content of this and perhaps other follow-on pages.

When completed, PowerPLA will overcome this and other problems. Included within PowerPLA is a page splitting algorithm which automatically resolves page overflow situations and makes it possible for the routine to format an entire document of text-graphic pages without human intervention after the initial entry is made of information to be formatted. PowerPLA is being designed to run on a WANG VS100 computer.(7)

In its final form, PowerPLA will produce glossaries and control vocabulary. These features are now part of the Computer Readability Edition System (CRES). CRES was also originally developed on the WANG 2200 MVP minicomputer.(8-10) The best version of CRES runs on the WANG VS100 and has additional features to aid authors in simplifying sentences and calculating readability grade level. The system includes a 4,000-word common word list and a number of technical word lists (e.g., "navigation and communication"). Uncommon words (not found by the computer) will be flagged so the author can change them or add them to a glossary.

page 1

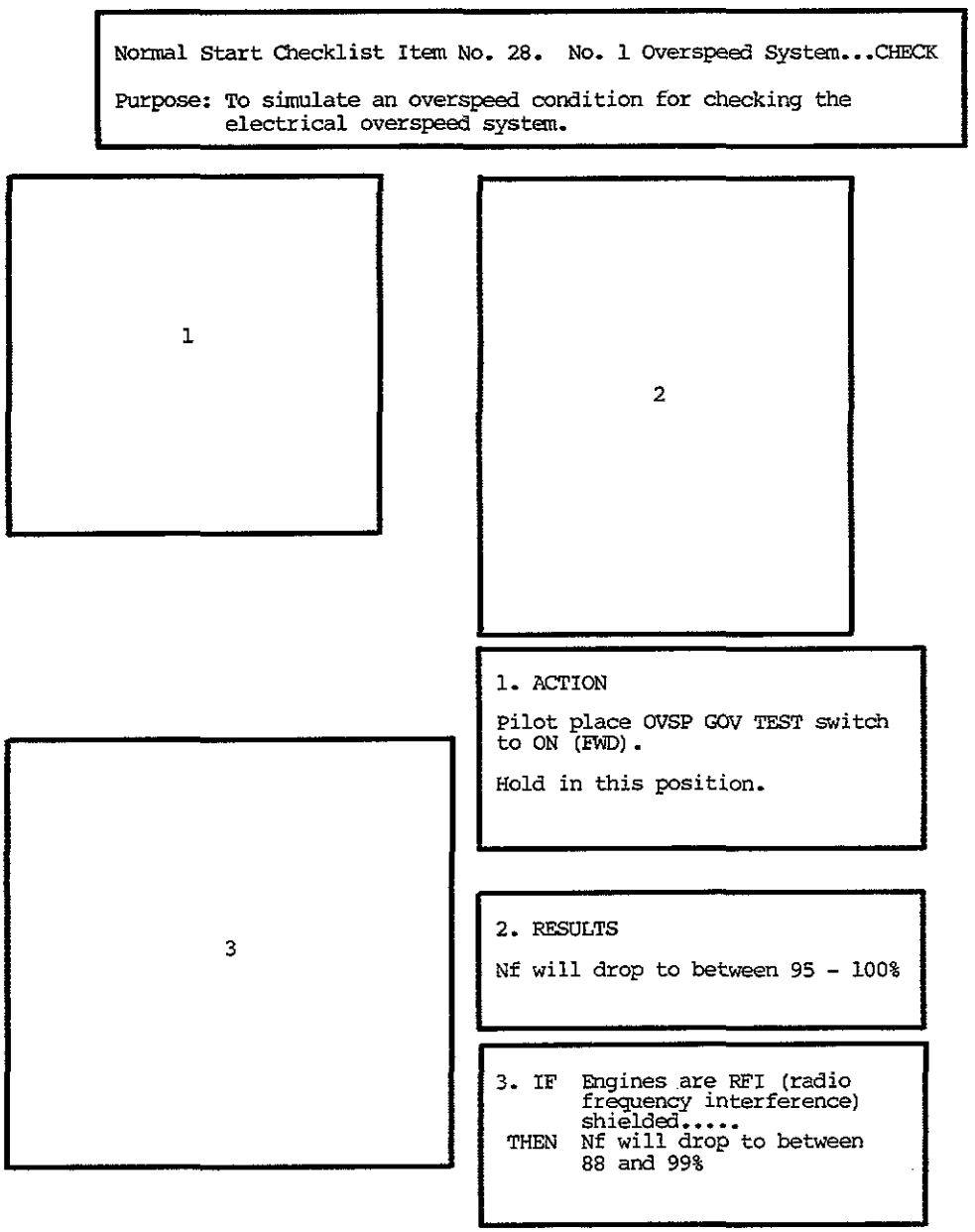
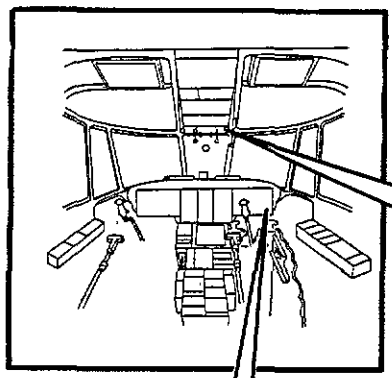
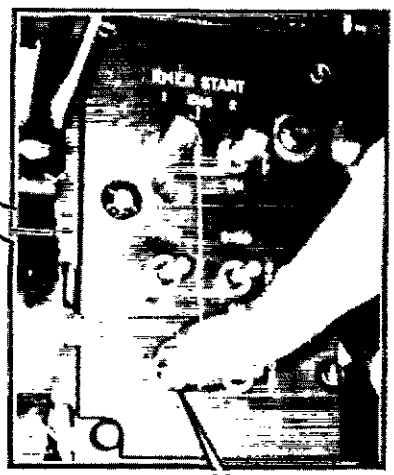


Figure 2. Presentation page produced by MicroPLA as it comes from the printer

Normal Start Checklist Item No. 28. No. 1 Overspeed System...CHECK

Purpose: To simulate an overspeed condition for checking the electrical overspeed system.

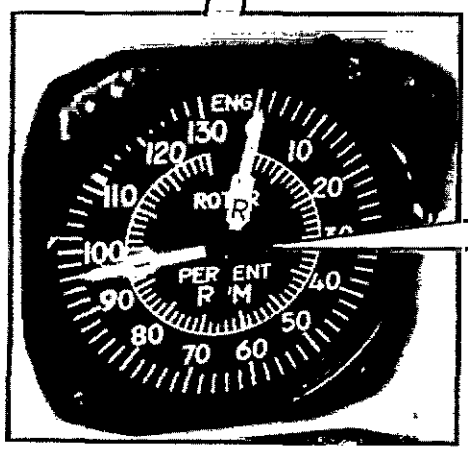




1. ACTION

Pilot place OVSP GOV TEST switch to ON (FWD).

Hold in this position.



2. RESULTS

Nf will drop to between 95 - 100%

3. IF Engines are RFI (radio frequency interference) shielded.....
THEN Nf will drop to between 88 and 99%

Figure 3. Same presentation on page with artwork added by hand

These lists are already developed. A number of large aerospace companies are now using CRES as part of their production of technical documents.(11-12)

USING PROCEDURE TRAINING AIDS WITH TRAINING DEVICES

The Procedure Training Aids are effective and the use of these aids is most appropriate when the procedure (1) must be performed from memory, (2) is performed on expensive or scarce equipment, or (3) must be performed correctly because of safety. Although field tests to date have dealt with procedures taught early in a training program, the aids should be effective over a broad range of training situations.

However, Procedure Training Aids should not be used when technicians are to perform the job with fully proceduralized job performance aids or other detailed technical documentation. The memory exercises within the Procedure Training Aid are unnecessary if the procedure is performed with job aids. Also Procedure Training Aids should not be used when the task to be learned involves complex decisions as found in trouble-shooting. This type of task calls for the evaluation of alternative actions, a function not supported by Procedure Training Aids.

CONCLUSIONS

Procedure Training Aids are a particularly effective means of preparing students to practice complex procedures on training devices. Their use shortens the pipeline from unskilled to trained performer; they are effective with low aptitude readers, and their use reduces hands-on practice time by properly preparing the student to make the best use of available time on the training device.

REFERENCES

1. Aagard, J. A., and Braby, R. Learning Guidelines and Algorithms for Types of Training Objectives. TAEG Technical Report 23. Orlando, FL: Training Analysis and Evaluation Group, 1976.

2. Scott, P. G., McDaniel, W. C., and Braby, R. Improved Procedures Training Through Use of Aids Developed From Learning Guidelines. TAEG Technical Report 113. Orlando, FL: Training Analysis and Evaluation Group, 1982.

3. Braby, R., Hamel, C. J., and Smode, A. F. Handbook of Format Models for Designers of Technical Training Materials. TAEG Technical Report 129. Orlando, FL: Training Analysis and Evaluation Group, 1982.

4. Braby, R., Kincaid. J. P., Scott, P., and McDaniel, W. C. Illustrated formats to teach procedures. IEEE Transactions on Professional Communications, 1982, 25(2), 61-66.

5. Terrell, W. R., Ewell, R. C., Scott, P., and Braby, R. The Design and Production of a Procedure Training Aid Using the Procedure Learning Format and the Computer Automated Page Layout (PLA) Routine. TAEG Technical Note 12-83. Orlando, FL: Training Analysis and Evaluation Group, 1983.

6. MicroPLA - A Computer Routine for the Auto-mated Layout of Text-Graphic Pages. TAEG Report, in preparation.

7. Sylla, G. and Babu, A. J. G. Computer Aided Layout of Procedure Information for Training and Job Aiding. TAEG Technical Note 11-83. Orlando, FL: Training Analysis and Evaluation Group, 1983.

8. Kincaid, J. P., Aagard J. A., and O'Hara, J. A Computer Readability Editing System (CRES). TAEG Technical Report 83. Orlando, FL: Training Analysis and Evaluation Group, 1980.

9. Kincaid, J. P., Aagard, J. A., O'Hara, J., and Cottrell, L. Computer Readability Editing System. IEEE Transactions on Professional Communications, 1981, 24(1), 1-4.

10. Braby, R. and Kincaid, J. P. Computer aided authoring and editing. Journal of Educational Technology Systems, 1981-82, 10(2), 109-124.

11. "Software augments manual readability." Aviation Week & Space Technology. January 11, 1982.

12. "Computer readability editing system developed." Domestic Technology Transfer FACT SHEET, 9(4), April 1984.

ABOUT THE AUTHORS

RICHARD BRABY, J. PETER KINCAID, and PAUL G. SCOTT are each team leaders with the Naval Training Equipment Center's Training Analysis and Evaluation Group. Dr. Braby, an educational specialist with an Ed.D. from Columbia University directs projects dealing with formats for training materials and computer aids for their production. Dr. Kincaid, a psychologist with a Ph.D. from Ohio State University, has overseen the development of the Computer Readability Editing System and its use by government agencies and defense contractors. Mr. Scott, an education specialist with a B.S. from Duquesne University, directs projects dealing with the training effectiveness of aircraft simulators. Each has published widely in the areas of educational technology and human factors.