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APR 77 W MIDDLETON, J GUILLIAMS, P WEBER N00167-77-M-8086

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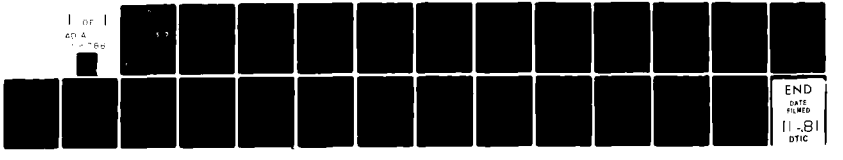

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This report presents the results of an evaluation by Westinghouse Electric Corporation of a document titled "A Guide For Selecting Formats and Media For Presenting Maintenance Information" dated November 1976. The document was prepared by BioTechnology, Inc., Falls Church Virginia, under contract with the David W. Taylor Naval Ship Research and Development Center in Bethesda, Maryland and was produced as part of the Navy Technical Information Presentation Project (NTIPP). The report also discusses the applicability of the F/M Guide to a

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20. ABSTRACT (Continued)

re-write of the Hagan ACC/FWC TM. The findings of the evaluation support the following recommendations.

(1) Develop draft writing specification encompassing the selection parameters embodied in the guide.
(2) Apply the draft specification to a rewrite of the Hagan ACC/FWC TM.
(3) Evaluate the effectiveness of both products in "real-world" environment.

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SECTION I

INTRODUCTION

1.1 PURPOSE

This report presents the results of an evaluation by Westinghouse Electric Corporation of a document titled "A Guide For Selecting Formats and Media For Presenting Maintenance Information" dated November 1976 The document was prepared by BioTechnology, Inc., Falls Church Virginia, under contract with the David W. Taylor Naval Ship Research and Development Center in Bethesda, Maryland and was produced as part of the Navy Technical Information Presentation Project (NTIPP).

1.2 APPROACH

The technical evaluation was performed to determine (based on extensive Westinghouse experience in research, development and production, of various formats of maintenance information) if the format/media guide would serve as a useful tool for logisticians in selecting formats/media used to present maintenance information.

Our approach was to determine if the F/M Guide presented a well-structured view of reality which put the complexities and possible uncertainties inherent in the selection/decision making problem into a logical framework amenable to comprehensive evaluation. The evaluation was conducted by experienced engineering writers, behavioral analysts, writing supervisors, training technicians and certified professional logisticians. Numerous reports/studies relating to the same subjects were reviewed. However, the summary information contained in this report reflects a consensus of the evaluators. Only significant and representative comments are included. No attempt was made to specifically identify typographical errors, etc.

SECTION II
SUMMARY

2.1 OVERALL APPROACH

The approach recommended by the guide for format/media selection, based on evaluation of the various system conditions, personnel qualifications and task complexities, is considered basically sound. This approach, if implemented, should result in more cost effective and significantly improved maintenance information being provided to Navy personnel. There are, however, potential problem areas associated with implementation of the guide as written, particularly with respect to selecting maintenance data for new systems and for selecting troubleshooting formats. Additionally, we feel that certain refinements in the detailed format selection process are needed to enhance the usability of the guide and to more accurately define the selection parameters used. These are summarized below and discussed in greater detail in the body of this report.

1. A key element in the selection process suggested by the guide is the requirement for detailed technical information relative to hardware designs and complexity of maintenance actions. It is doubtful that such data would be available, in the level of detail required, at the time format decisions must be made. The guide as presently written would therefore be difficult to apply in selecting data formats for newly acquired systems.
2. The rationale for separating "special case" and "remove and replace" maintenance actions in the format selection process is unclear. We feel that remove and replace MA's can and should be grouped with the "special case" MA's to simplify the format selection process. Also, the term "special case" is believed ill chosen since the maintenance actions referred to are simply routine maintenance tasks.

3. The method described in section 4 for selecting "homogenous sets" of MA's will be difficult to apply in dealing with new system acquisitions for the same reasons cited in item 1 above; i.e. information relative to functional breakdowns and equipment subordination would not be available. On existing equipment where such factors are known, selection of homogenous sets would still he highly judgemental and therefore of nebulous value. We believe that selection of homogenous sets is a complicated and unnecessary step in the selection process.

4. Cost comparisons between available presentation formats should either be deleted from the guide or else presented as general background information not directly related to format selection. Assuming that the various selection parameters pertaining to system conditions, maintenance complexities and personnel qualifications are properly applied during the selection process, the resulting maintenance data will be both adequate and automatically cost effective.

5. Section 4 of the guide states that there are only four basic options available for presenting troubleshooting information. This, in effect, excludes all other troubleshooting formats from consideration. There are, however, other format options available, including numerous variations of the four shown in the guide. For example, the Maintenance Dependency Chart format promulgated by specification MIL-M-24100B is not considered. Also, the criteria given for choosing between the four options discussed is poorly developed.

6. As indicated in item 1 above, we feel that a basic fault in the format selection process described in the guide is the requirement for program management personnel to make format decisions at a very early stage in program development and based on limited technical information. A far more realistic approach would be to make such decisions during or after the equipment functional analysis normally performed by engineering writers engaged in the actual development of maintenance data. A reasonable way to achieve this would be to prepare a detailed writing specification incorporating those portions of the guide pertaining to format selection. This would allow format decisions to be made on a more realistic basis by the writers engaged in data development, subject to review and approval by the procuring agency.

2.2 ORGANIZATION/TAXONOMY

Overall organization and classification of material presented in the document is good.

2.3 READABILITY/COMPREHENSIBILITY

A knowledgeable MOTD engineer or technical manual writer should be able to interpret the selection principles and methodology presented. However, the intent is that all users be able to apply the techniques and principles without major variations. The document uses multiple phrase and "run-on" sentences which require study to identify the meaning. While grammatically correct, this technique leads to misinterpretation.

An accepted method of measuring readability/comprehensibility is the Flesch formula. Using this formula, many of the paragraphs measure at an equivalent grade level above college graduate. The document also contains some abstractions and

nominalizations. The combination makes for difficult reading and comprehension. The intended user could handle both the grade level and other characteristics but it is much better to insure readability/comprehensibility by eliminating the difficulties.

2.4 APPLICABILITY TO REWRITE OF HAGAN ACC/FWC MANUALS

The availability of existing maintenance data on the Hagan ACC/FWC system will allow the selection principles and procedures embodied in the guide to be applied to this effort without undue difficulty. However, since the guide is not intended as a writing specification, a considerable amount of additional information would have to be provided in order to accomplish the rewriting task. For example, the guide does not address such things as the number of volumes required, how the various types of maintenance will be grouped, how equipment operating instructions will be presented, etc. A manual outline could not be prepared using only the information contained in the guide. Also, the "fixed" parameters such as personnel turnover rates, spans of supervision, and personnel qualification standards used throughout the guide for format selection will have to be determined and provided to the writers.

2.5 CONCLUSIONS/RECOMMENDATIONS

The most logical "next step" in evaluating the format/media selection concept presented in the guide is, we believe, creation of a draft writing specification encompassing both the guide's format selection methodology and the additional information pertaining to equipment analysis, manual organization, etc. provided in any detailed writing specification. This document should then be used to prepare new maintenance manuals on the ACC/FWC systems. This will allow a realistic evaluation of the workability of the format/media guide and of the resulting maintenance data produced. This approach has two distinct

advantages, (1) it would eliminate the necessity of making firm format decisions at an inappropriate time in the program and (2) it would ensure, by virtue of a detailed equipment maintenance analysis having been performed, that adequate technical information would be available for making such decisions. In development of the draft specification, attention should be given to organization of data so as to avoid indiscriminate mixing of formats within individual sections or maintenance groups. A general outline of the format selection portion of such a specification is presented as Attachment 1 to this report.

SECTION III

DETAILED CRITIQUE

3.1 General

This section consists of a chapter-by-chapter critique of the guide. It includes further discussion of the items presented in the summary as well as miscellaneous editorial comments.

3.2 Chapter 1 - Introduction

Item 1 - Page 4, Step 1 - Gather Source Data. In this paragraph, reference is made to the Task Identification Matrix (TIM) as the basic tool for identifying system MAs. In reviewing the subsequent chapters describing detailed format selection, it is indeed apparent that the entire process is dependent upon availability of a complete and accurate TIM. We are skeptical that such a TIM could be produced at this stage. Moreover, as the guide appears to recognize, the TIM does not represent system task analysis. It conveys no information pertaining to task complexities or conditions under which any task must be performed. Since elements such as these are probably the most significant in the format selection process, it is obvious that a great deal of detailed task analysis would be required in order to make meaningful format decisions. It is doubtful that such analyses can realistically be made at this stage of the program.

Item 2 - Page 4, Steps 3 and 4 - Selected Formats for Troubleshooting and Remove/Replace Actions. The rationale for separating remove/replace and "special case" maintenance actions is questionable. We believe that removal and installation procedures for a typical system

would involve maintenance actions easily applicable to one or more of the "special case" categories listed in the guide. In fact, of the five special case format samples shown, three involve remove or install tasks (figures 3, 4 and 5). Because information requirements for remove/install and special case maintenance actions are essentially the same, we see no valid reason for their separate grouping.

3.3 Chapter 2 - Gather Maintenance Action And System Condition Data.

Item 1 - Page 5, Paragraph 2.2, Review Task Identification Matrix. The inference here is that the TIM is prepared as a standard product of the Integrated Logistic System (ILS) process. Although some form of "topdown breakdown" may be available during a new system acquisition ILS development process, i.e., generic listings, part number sequence lists, etc., it is highly unlikely that a valid TIM would be prepared unless previously specified (at a significant cost impact) by the procuring agency. Furthermore, the TIM alone, unless keyed to the provisioning process and the user maintenance philosophy will not guarantee complete TM coverage. The TIM is therefore best suited to facilitate data improvement programs for "out of production" systems/equipment. A more positive approach for identification and control of maintenance functions, and one which should be considered in data/training development for new system acquisitions, is the Logistic Support Analysis (LSA) program. The LSA program is discussed in detail in MIL-STD-1388-1 and MIL-STD-1388-2.

3.4 Chapter 3 - Identify Special Case Maintenance Actions

We believe this entire step in the selection process should be eliminated and that MAs should be analyzed individually to determine presentation formats. The guidelines provided for identifying special case MAs are arbitrary and would lead to highly judgemental and, in some cases, improper format selections. For example, using only the criteria in the guide, a maintenance procedure that was both highly complex and required on a periodic basis could be presented in either of two completely different formats. Some additional shortcomings or problems associated with using this chapter in the guide are:

1. There are no significant differences in effectiveness or cost between the format suggested for SOPs (figure 3) and that suggested for complex MAs (figure 5). Why not present both in the same format?

2. The guide apparently does not recognize any distinction between operating and maintenance instructions. A potential user would be at a loss to determine the proper formats for presenting operating information. The time-critical hazardous MA sample shown in the guide (figure 6) is extracted from an aircraft operator's manual and is obviously an emergency operating rather than maintenance procedure. We believe the "time-critical hazardous" category of maintenance action should be presented in a separate section of the guide along with appropriate guidelines for selecting operating instruction formats. Incidentally, the sample shown in figure 6 does not contain supporting text nor does the guide indicate how such text should be presented.

3.5 Chapter 4 - Select Formats For Presenting Troubleshooting Information

Item 1 - Page 14, Paragraph 4.1, Available Formats. This paragraph states that there are four format options available for presenting troubleshooting information. The rationale for this conclusion is not given, however, it would have the effect of excluding all other troubleshooting formats from consideration. While it would be clearly impractical to cover every innovative troubleshooting format developed in recent years, we feel that limiting the available selection to only these four is unduly restrictive. Other options such as the Maintenance Dependancy Chart (MDC) promulgated by MIL-M-24100B should be considered as well as the numerous variations of the four options shown in the guide that are in current use.

Item 2 - Page 15, figure 9. This procedure contains a technical error in that the technician is not told when and where to connect the meter black test probe when making the measurement.

Item 3 - Page 17, Figure 11. The "simple logic" format shown in this sample can be used effectively on systems of a purely electrical or electronic nature, however, it is poorly suited to most other types of equipment. Since the guide does not address the nature of equipment in selecting troubleshooting formats, it is possible for the simple logic format shown in figure 11 to be applied to a system for which it is totally unsuitable. We feel that information relative to particular advantages of one format over another should be provided and that more consideration should be given in the selection process to the technical nature of the equipment being maintained.

Item 4 - Page 19, Paragraph 4.3, Identify Format Candidates for Homogenous Sets of Troubleshooting Actions. This step in the overall selection process is proposed as a means of reducing the total number of MAs to a "reasonable" level. While it is true that the number of MAs under consideration could be reduced in this manner, we feel that this advantage would be outweighed by the uncertainties involved in the process and the nebulosity of the results. Some basic faults in the process described in the guide for identifying homogeneous sets of MAs are:

1. It assumes that the subordination of equipment, as determined by the topdown breakdown, is a valid indicator of troubleshooting complexity. This may be a valid assumption in some cases and completely misleading in others. For example, a system consisting primarily of mechanical or pneumatic devices may have a subordination of 15 or 20 and require only visual inspections or monitoring of gages to isolate faults. Conversely, fault isolation for a sophisticated electronic system with a subordination of 5 or less could involve extensive tests and complex deductive reasoning. The point to be made here is that the single most important factor in determining adequacy of a particular format, task complexity, would be applied in a completely erroneous way.

2. Several of the selection parameters listed in figure 13 of the guide could not be applied as shown without further breakdown of the equipment. For example, the guide lists "diagnostic technique" as a selection parameter and indicates (on page 6) that it occurs in

either of two states, external or internal. The external or internal condition is then used as a determining factor in identifying homogeneous sets of MAs. We believe that the troubleshooting required in most systems or subsystems, including those shown in figure 13 of the guide, would involve both the internal and external technique. It would therefore be difficult, if not impossible, to define functional systems where the diagnostic technique could be classified as all internal or all external. We believe the solution to this problem is to assess each troubleshooting task individually.

3.5 Chapter 5 - Select Formats For Presenting Remove and Replace Information

As indicated in the comments pertaining to Chapter 2, we see no valid reasons for separating remove and replace tasks from the special case MAs described in Chapter 3. We feel that the format selection criteria presented in both chapters should be combined.

3.6 Chapter 6 - Establish TM Support Requirements

In general, we find no significant faults with the information or selection criteria presented in this chapter. Assuming that detailed technical information was available, the information provided in the guide could be used effectively in selecting formats for access requirements and recording media.

Attachment 1

GENERAL OUTLINE OF SUGGESTED FORMAT SELECTION PROCESS

1.0 FORMAT SELECTION.

NOTE

Equipment analysis, as outlined in the following paragraphs, is a standard requirement in the preparation of most maintenance data and may therefore be covered elsewhere in the specification. If not, it should be included here as a prerequisite to format selection.

1.1 Equipment Analysis. The basic purpose and products to be derived from equipment analysis should be described in detail in this section. Four of the principal products that will be required for format selection are: (1) Equipment Breakdown by Systems (2) Task Identification Matrix (3) Definitization of Functional Groups and (4) Task Analysis.

1.1.1 Equipment Breakdown. Instructions for equipment breakdown into major systems and for preparation of equipment breakdown lists should be provided in this paragraph. A sample equipment breakdown list should be included depicting subordination of replaceable components for a typical system or equipment group.

1.1.2 Task Identification Matrix (TIM). This paragraph should provide complete instructions, with an illustrated sample for preparing a TIM. Definitions of all maintenance terms and maintenance level codes should be included. The TIM should contain a "troubleshoot" column for identification of components or assemblies for which troubleshooting is required. Equipment functional groupings and subordination of components will be obtained from the equipment breakdown lists.

1.1.3 Functional Analysis. This paragraph should describe the basic purpose and processes involved in functional analysis; i.e., it is required as a first step in development of troubleshooting data and involves dividing each equipment group into successively smaller functional groups. Each functional group should consist

of a unique collection of parts or assemblies which, together, perform a clearly identifiable function. All replaceable assemblies, subassemblies or parts should be accounted for; i.e., allocated to one or more functional groups.

1.1.4 Task Analysis. Task analysis is required for each maintenance action identified in the TIM. The most significant items of information to be obtained from task analysis, insofar as format selection is concerned, are task complexities, extent of specialized skill or knowledge required, and criticality of the task in relation to system performance. Adequate evaluation of these factors will require that the following basic information be obtained for each task:

a. Equipment access requirements
b. Identification of any special tools or test equipment involved
c. Basic work skills required
d. Will marginal or improper performance of the task create a potential hazard to personnel or cause damage to equipment.

1.2 Establish User Capabilities and Conditions. A typical user profile should be established by the procuring agency and provided to the contractor. This user profile should contain the following elements:

a. Technical skill levels; i.e., prior training or military experience in the maintenance specialties involved.
b. Personnel turnover rates
c. Typical span of supervision (ratio of supervisor to worker)

1.3 Classification of Maintenance Tasks. The various tasks identified in the TIM should be grouped into three separate categories as follows:

a. Operation - Those tasks associated with equipment operation, including turn-on, normal, and emergency modes of operation should be grouped into this category.
b. Maintenance - This task category should include removal, installation, calibration, adjustment and servicing of all system components required on a scheduled or unscheduled basis.
c. Troubleshooting - Troubleshooting tasks identified for each functional group at each maintenance level should be grouped in this category.

1.4 Select Formats for Operating Procedures. Because of the similarity of available formats for presenting operating instructions, no format decisions should be required by the specification user in this area. This paragraph should therefore provide a description, including illustrated samples, of the format to be used. The following basic approach is recommended:

a. Provide a tabular listing, keyed to an accompanying illustration, of all equipment controls and indicators.

b. Provide general description of equipment capabilitites and available modes of operation.

c. Provide step-by-step instructions, keyed to accompanying illustrations, for operating the equipment in all its operating modes, including emergency modes, if any.

1.5 Select Formats For Maintenance Procedures. This paragraph should briefly describe the general approach to be used in selecting maintenance procedure formats. The selection process will involve the following basic functions:

a. Assessment of task complexity, job skils required, and task criticality.

b. Establish user profile and system conditions

c. Determine task degree of difficulty based on the factors derived from a. and b. above.

d. Select appropriate format.

1.5.1 Available Formats. A brief description, with illustrated samples, of the three available presentation formats should be provided in this paragraph. The samples shown in figures 18, 19 and 20 of the guide could be used as examples of fully proceduralized, partly proceduralized and component description formats, respectively.

1.5.2 Determine Task Degree of Difficulty. A numerical value ranging from 1 to 10 should be assigned to each maintenance task to denote its relative degree of difficulty. The more difficult tasks should be assigned the highest numerical values. This number should represent the comparative difficulty anticipated in accomplishing the task after all factors pertinent to its accomplishment have been considered. Its value will be the determining factor in selecting the task

presentation format. The numerical degree of difficulty of each maintenance task should be established as follows:

Step 1 - Determine Initial Value

The initial value or starting point in determining task degree of difficulty should be based on such factors as its relative complexity compared to other required tasks, the degree of specialized knowledge or skill required and it's criticality; i.e., the potential effect of improper performance. The general guidelines listed below should be considered in assigning the initial degree of difficulty value.

a. Establish a reference point for comparison by assigning the number 10 to the most complex, critical and skill demanding task identified in the TIM.

b. Compare succeeding tasks, in terms of complexity, criticality and skill levels required, with the most difficult task and assign values accordingly.

c. Very simple tasks such as opening hatches or removal/installation of standard rackmounted "black boxes" require no further evaluation after assignment of the initial degree of difficulty value. Such tasks will be presented in the most simple of the available formats.

d. Excessive task length does not necessarily indicate complexity. Tasks which should be considered complex or difficult are those requiring sophisticated tools or test equipment, those which involve measuring or maintaining close physical or electrical tolerances, or those where equipment access is difficult or not readily apparent.

e. In assessing task criticality, the probability of an improperly performed task going undetected until it presents a personnel or equipment hazard should be carefully considered. For example, a misadjusted aircraft landing gear locking mechanism may not be detected until the aircraft is about to land and thus would constitute a hazardous condition. Adjustment of the landing gear lock would therefore be considered a critical task. Conversely, an improperly installed radar receiver, while rendering the system inoperative, would likely be detected during a system operational checkout and would not pose a hazard or create significant maintenance problems.

Step 2 - Determine Final Value

In this step, the various user capabilities and working conditions are evaluated for their effect on task performance and the initial degree of difficulty value is reduced accordingly. Those factors tending to reduce the degree of difficulty are:

a. Experience Level - If the typical user is skilled in the performance of similar tasks using the same types of tools or test equipment, the initial degree of difficulty factor should be reduced by 1.

b. Prior On-Equipment Training - If the typical user has received previous maintenance training on the specific equipment, the initial degree of difficulty factor should be further reduced by 1.

c. Personnel Turnover Rate - If the yearly personnel turnover rate in the organization where the maintenance is being performed is less than 50 percent, reduce the degree of difficulty factor by 0.5.

d. Span of Supervision - If the ratio of supervisor to worker is less than 10, reduce the degree of difficulty factor by 0.5.

Step 3 - Select Format

Final format selection is based on the adjusted degree of difficulty value obtained in steps 1 and 2 above. Formats should be assigned to the individual maintenance tasks in accordance with the following table:

Degree of Difficulty	Format
7 to 10	Fully proceduralized
4 to 6	Partially proceduralized
3 or less	Component Description

1.6 Troubleshooting Formats. Selection of troubleshooting formats should be made by the procuring agency, based on the various parameters described in the format media guide. This portion of the specification should contain a detailed description of the format to be used or provide a reference to a separate specification for troubleshooting. Unlike the maintenance procedure fromats discussed previously, which would be essentially "tailored" for individual maintenance tasks, a single troubleshooting format must be selected for all systems developed during functional analysis. Because some troubleshooting formats are poorly suited to certain types of equipment, e.g. the "combined logic" format does not work well with a purely mechanical system, particular

attention should be given to the type of equipment involved when selecting trouble-shooting formats.


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