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ABSTRACT

The Department of Defense (DOD) has undertaken major research and development programs to improve the quality of their documentation, yet there continue to be major deficiencies in the quality of the manuals produced. In an attempt to identify factors in the design and development process that may be contributing to such deficiencies, this project studied five publication houses, four of which produced DOD technical manuals. Writers, managers, and illustrators were interviewed at each site to obtain information on the work flow in developing a manual; the use of specifications; the validation and verification process; and the skills and duties of writers, illustrators, and government representatives. This report presents an introductory review of the literature; a description of the research methodology; and discussions of the findings on specification use and deficiencies, cost of inadequate/inappropriate specifications, relative effort in the workflow, the government's technical manual representative, writers and their qualifications and training, writers' job duties, source materials, degree of automation, comprehensiveness, illustrations, quality assurance, validation, and verification. A final discussion of the study results and their implications, a list of 29 references, and a flow chart of a typical technical information development process conclude the report. (THC)

CDC Technical Report No. 19

Technical Manual Production: An Examination of Four Systems

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November 1985

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Abstract

The Department of Defense has undertaken major research and development programs to improve the quality of their documentation. yet there coninues to be major deficiencies in the quality of the manuals produced. Five publication houses. four of them producers of DOD technical manuals. were studied in an attempt to identify factors in the design and development process which may be contributing to manual deficiencies. Writers. managers. and illustrators were interviewed at each site. The work flow in developing a manual is described. Data on the use of specifications, the validation and verification process. and the skills and duties of writiers. illustrators. and government representative are presented.

Technical Manual Production: An Examination of Four Systems[1]

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Technical documentation has risen to a new position of recognition and even prominence in our society. The usability of the technical documentation is widely recognized as a critical factor in how well we can use the flood of new technology and it is increasingly recognized as an important variable in marketing and sales.

What has led to this new found prominence of the technical manual? We would propose that it is due to the increasing numbers of users that are novices to the equipment. Technology used to be in the hands of a few "experts" who had worked with the particular equipment or similar equipment for years. Furthermore, there was a pool of coexperts to be called upon whenever a problem arose. Thus most of the system knowledge was in the head of the user. The documentation was simply a formal, engineering oriented description of the system which could serve as a reference.

Today however, the typical user of the system is a "novice" -- a person with inadequate knowledge to effectively operate and maintain a system without the support of documentation. What happened to create this new "typical" user? First, and most obviously complex technology became affordable and applicable in our daily activities. Hence, large numbers of individuals totally naive to the particular technology became users of that technology. Personal computers are a clear example of this development of a naive user group but there are many other instances. For example, office personnel must maintain very complex reproduction equipment and bank tellers must maintain the automatic teller machines.

There is another kind of novice however. This individual is an expert in the broad

domain in which the technology is applied. but is a novice with regards to the particular equipment. While the absolute novice described above is what one typically thinks of when considering audience. we would predict that this expert who is a novice regarding the particular equipment will be (if not already) the prevalent user for which we will be designing documentation. This novice-expert (or is it an expert-novice) has resulted from the dramatic advances in technological development. In the past an individual could become an expert and maintain his or her expert status because there was little variation in the family of equipment and the technology evolved gradually. Today however the technology is changing so rapidly that it is virtually impossible to maintain expertise (in the old sense) in some areas. For example. it is assumed that the knowledge a new engineer brings to the job will only be adequate for 10 years -- at which point the technology will have evolved to a point where retraining will be required. But even before one's knowledge becomes obsolete. the variations within a family of equipment (,e.g., minicomputers, programmable controllers, reproduction equipment. etc.) makes it difficult to transfer that expertise from one equipment to another.

Whereas the expert of old may only have required system documentation. the novice and the expert-novice require quidance in carrying out particular operation and maintenance tasks. That is, they require task-oriented or functional manuals in order to perform their job. The information must be organized and presented at a level of detail and in a format that facilitates performance of the job. However, the traditional, and still prevalent, design for manuals is simply a complete system description from the engineer's perspective -- one section describes the theory of operation and successing sections describe the physical components of the equipment. The contrast between the user's needs and these traditional manuals is between an organization based on system functions rather than hardware components and a presentation oriented toward the job tasks rather than toward engineering theory (Duffy. 1985b).

While the need for user oriented manuals appears to be a relatively recent phenomenon, it has been the focus of Department of Defense research and development efforts for over 35 years (Smillie, 1985). This is because the Department of Defense has long been confronted with the problem of a large body of novice users (at least by civilian standards) of technology. A typical enlistment is for only four years During that time, the individual must be trained in the military structure as well as in a technical skill and then must make a positive contribution through the application of the technical skill in the operation or maintenance of some of the most sophisticated equipment in the world.

Freeman, Hubler, and Monroe (1980) interviewed a random sample of 32 men who were working in aircraft maintenance (aviation mechanics, structural and hydraulic) and provided the following profile. The typical mechanic is 24 years old, has a high school diploma, never enjoyed reading, had a ninth grade reading ability upon graduation from high school but through non-use reads well-organized test at almost the seventh grade level, does not use the traditional technical manuals for much of his work preferring to use proceduralized, task specific, maintenance repair cards, and gives no indication that he understands how or why the system works. Furthermore the average score on the general classification test (a measure of general ability where the mean is 50 and the standard deviation is 10) was approximately 49%.

Given this profile and the short period of employment it is obviously essential that the job guidence (i e , the technical documentation) be easy to use and understand. Shriver and Hart (1975), used the research data on document design strategies to estimate the cost savings to the U.S. Army possible through effective document design. They estimated that $830 million would be saved due to reduced maintenance time and a reduced number of false removals of functioning parts. A further $900 million in reduced training time would be saved if the manuals were fully proceduralized.

Recognizing the need for more effective manuals, the Department of Defense has developed rules, guidelines, task analysis procedures, validation and verification procedures, and a host of specific user or task oriented organizations and formats in a continuing effort to improve the usability of the manuals (Hatterick and Price, 1981; Duffy, 1985a; Kern, 1985; Smillie, 1985; Little and Smith, 1983). Hatterick and Price (1981) describe over one hundred user oriented design techniques that have been developed since the 1950's. Experimental evaluation of these strategies has indicated very significant time savings and improved accuracy when these job-oriented manuals are used (see, e.g., Potter and Thomas, 1976; Elliott and Joyce, 1968)

Given all of the above it is rather astonishing to find that the technical manuals prepared for the Department of Defense seem to be little improved. There are still horror stories of the inadequacies of the manuals and of the rejection of the manuals by maintenance prersonnel (Duffy, 1985a,b; Smillie, 1985; General Accounting Office, 1979; Kern, 1985; Sulit and Fuller, 1976). The General Accounting Office (1979) describes one radar manual where the technician had to refer to 165 pages in eight documents and look in 41 different places in those documents to repair one particular malfunction. Clearly, the manual is not task oriented.

Above and beyond the design issues, the manuals are notorious for the complexity of the writing. They are jargon ridden above and beyond the shorthand jargon the technician would normally use, the sentences have a bureaucratic complexity, and even the non-jargon vocabulary is overly complex and abstract. (Kniffin, et. al., Kincaid, Fishburne, Rogers, and Chisssom, 1975, Duffy, 1985a). The problem is such that the Department of Defense has begun to impose readability standards and controlled vocabulary lists and is moving toward automated authoring techniques (Frase, McDonald, and Keenan, 1985, Braby and Kincaid, 1981; Kincaid, Aagard, O'Hara, and Cottrell, 1981

These comprehendibility problems persist in the technical manuals in spite of the fact that the solution involves following the basic tenants of clear writing that have been known for centuries. The development of a rhetoric of explanatory text has a long history (Conners, 1985). There are innumerable style guides and virtually all trumpet the need to consider the audience and condemn the overly complex syntax and vocabulary. Furthermore, the writers of the military technical manuals are classified as professional writers and have been trained or have extensive experience in writing.

In sum, we have a case where there is extensive research and guidance on the design of technical manuals and the manuals are being developed by professional writers, yet there remain significant problems in the quality of the manuals. Our objective in this study was to begin an analysis of the technical manual production process to identify those factors contributing to the difficulties in producing a manual. We did this through interviews with writers, illustrators, managers, and other personnel at five publication houses. While there has been extensive research on the individual writing process, there is little data on the publication system and how the writer fits into that system. Our basic assumption is that the poor manuals arise from some set of inadequacies in the publication process and that if there is to be an improvement in the quality of the manuals that improvement will only arise from a modification in the production system.

We are not denying the critical importance of the time and financial constraints placed on publication groups. Document development is notoriously underfunded, especially if the hardware development group controls the budget (Jordan, Kleinman and Shimberg, 1981, Duffy, 1985b) The start of a manual production effort is too frequently delayed until the product is almost developed and then a rush job is required to meet the delivery deadline Those time and money constraints, like all other constraints, have specific effects on the publication process. We need to understand the publication process and the factors within that process that contribute to inadequacies in the manuals. We must understand the

process and the inadequacies of the process if we are to improve the system -- regardless of whether or not the time and money constraints persist. We might also note that time and money just may not be the major factors hindering the development of quality manuals (see. e.g., Duffy, Curran, and Sass, 1983; Wright, 1985; Flower and Hayes, 1981).

We already have data describing the workflow in the development of a technical manual. Deardorff, Hagemen, Hehs, and Norton (1979) completed a quality assurance study which included the determination of the typical technical information development process. These findings, presented in Figure 1, indicated 30 distinct work activities shown as blocks in the figure. Within the 30 work activities there are four key events: preparation of the draft manual (blocks 1-10), validation (block 11), verification (block 21), and printing and distribution (blocks 29 and 30). In addition to the internal workflow, there is also the interaction with the government specification and the government representative monitoring and approving the work.

Insert Figure 1 about here

We used the Deardorff, et. al., flow chart to guide our own interview process. We wanted to validate their findings and extend the findings to consider what management, writer, illustrator, and government activities during each event may be contributing to the problems of manual usability. We interviewed personnel at four publication houses that focus on Defense publications. We attempted to get a representative sampling of the publication houses and therefore looked for both small specialty houses as well as large corporations where the focus is on producing manuals for equipment they are developing. We also looked at houses developing new manuals and houses involved in updates and revisions. Finally, we included one publication house that did not develop government manuals but rather they produced manuals for products developed inhouse or by sister companies. We

suspected government requirements may be a major factor in the manual development problems and therefore thought the inclusion of this nongovernmentcompany might suggest alternative publication strategies.

Method

The basic approach involved conducting open-ended structured interviews with management and line personnel at the production houses.

Subjects.

Personnel from five production houses were interviewed. Four of the production houses prepared military TMs and one prepared civilian TMs. The houses preparing military TMs differed in size: one was small. two were of intermediate size. and one was large. The civilian production house was large.

The production houses were in three locations in the Middle Atlantic states and on the West Coast. The work of the single small production house typically involved writing TMs from vendor's literature, updating technical drawings, and producing illustrated parts breakdowns. The primary work of one of the medium-sized companies was in rewriting military TMs that had been found to be deficient. The other medium-sized company and the large companies prepared TMs for equipment/systems which they or other companies had under development.

Interviews were held with a variety of personnel at each site. The positions held by interviewees ranged from top level management to new writers and illustrators. At each production house persons interviewed included at least one first-level manager. a lead writer or a writer, and an illustrator, or a person knowledgeable about the illustration area. The specific individuals to be interviewed were selected by the company. At each company. the number of personnel from which responses were gathered ranged from three to 20

Interview Form

A structured interview form was developed and used to guide the interview sessions

The items were selected based on experience of project personnel, discussions with the subject matter experts, and the findings of other relevant projects. There were 26 questions covering six areas: relative effort within the workflow, management, writers, illustrators, validation, and quality assurance (QA).

Interview Sessions

The interview was open-ended to allow coverage of topics not anticipated in the questionnaire. Items from the questionnaire were posed and the respondents answered at whatever length and depth they wished, including discussion of topics not on the questionnaire. The questionnaire was used as a checklist by the interviewer so that all topics listed on it would be covered and would form a common basis across all interviews. The order of the discussion was not believed to be important and it varied from person to person.

There were three types of interview situations. In the first, discussions were held with a group of interviewees; the second type began with a group and led to individual interviews; and the third type involved a series of individual interviews. The different approaches were required because of availability of personnel and production house preferences.

Results

The interview data from each subject was summarized into key points and issues relevant to either describing the production process or identifying key factors that affect the quality of the technical manual. The subjects comments could be sorted into eight topic areas: (1) specifications, (2) workflow, (3) government's TM representative, (4) writers (5) illustrators, (6) quality assurance (7) validation, and (8) verification. The findings for each topic area are presented below.

Specifications

It is the contractor who develops the TM, but Government actions during pre-contract

award period have important implications to TM comprehensibility. It is during this period that the Government chooses the specifications which help drive the design and cost of the final product. The discussion below covers interviewee comments on the specifications.

Specifications used. When asked what specifications appear most frequently in the RFPS and contracts, all interviewees answered that MIL-M-38784 was the major and most frequently seen specification. For Naval Sea Systems Command, **MIL-M-15071G (SHIPS), Military Specification: Manuals, Equipment, and Systems**, is frequently a companion document to MIL-M-38784 These specifications are for the development of standard, topic oriented, technical documents. The subjects also indicated several specifications for nontraditional manuals which they have had to write to: **MIL-M-24100B, Functionally Oriented Maintenance Manual (FOMM)**; MIL-M-81701, MIL-M-81919, MIL-M-81927, or MIL-M-81928 for Work Packages; and MIL-M-63038, Army's "New Look" Skill Performance Aids. These specifications are for functional and user oriented documents and contain significantly more information on what content is to be included and how that content is to be organized and formatted. There has been research evaluating the effectiveness of each of these specifications and in each case designing to the specification led to a significant improvement in performance (Hatterick and Price, 1981; Duffy, 1985b).

The publication house producing nonmilitary documents is also guided by specifications. There are two primary specifications: one for the development of "standard" manuals and one for the development of highly graphic, procedural manuals.

Specification Deficiencies. The civilian and military publication houses stand in sharp contrast in terms of their evaluation of the specifications. Subjects at the civilian house had very few complaints about the specifications. There are at least two reasons for this acceptance of the specification. First, there is little variation in the kind of manuals that are developed. Thus the specification can be specific to the particular type of equipment and

job -- it does not have to be applied to a wide variety of equipment types. Second, new writers attend a "school" in which they are trained to write to the specification.

The publishers of military manuals, in contrast, indicated that the specifications, as they are used, are seriously deficient and contribute to both the cost and the difficulty in using the TMs. According to interviewees, the deficiencies include: (1) an indiscriminate application of the specifications to all types of technology (equipment), (2) no interpretation of the specifications, (3) an indiscriminate application of the specifications over all maintenance levels, and (4) inadequate specifications for new technologies.

Regarding the indiscriminate applications of specifications, production house personnel complained that there was no attempt on the part of the Government's TM representative to determine the portions of a specification which were applicable to the item under question. The Government's TM representative always invoked the entire specification instead of tailoring the specification to the item under consideration. For example, even the standard specification calls for a functional orientation in the maintenance section where the operation of the equipment is described. Most electronic systems lend themselves to this type of presentation, e.g., the laser rangefinder on a tank can be described in functional terms. However, for many mechanical systems, this approach is not appropriate.

For the second deficiency, no specification interpretation, the respondents indicated that while the specifications tell production houses what is needed, they do not specify or direct how to do it. Production house personnel believe that the Government should know the technology and the TM user well enough to interpret the specifications for them or to supply them with a "Book Plan" on how to implement the specifications. The Book Plan would identify the specifications that are applicable, define how the specifications are to be used for this particular TM, and demonstrate how the TM is to be organized and consolidated. In essence, the writers, illustrators, and managers all have difficulty

interpreting how a general guideline (the specification) applies in particular circumstances. There is one specification (Joyce, Chenzoff, Mulligan, and Mallory, 1973) where there are companion reports providing just such strategy guidance for both managers and writers. There is no evidence that such guidance improved the use of the specification.

The third RFP deficiency was that specifications are applied indiscriminately across all levels of maintenance. In the military, there are three levels of maintenance: organizational, intermediate, and depot. These levels reflect a progression in the difficulty of the maintenance task and the expertise of the personnel typically assigned to the tasks. The compiaint is that a specification which calls for a particular level of detail is typically invoked for all maintenance tasks. Yet the level of detail is only appropriate for a particular level of maintenance. For example, in an electronics system; organizational personnel focus on the function of components or boxes and the interrelationship between them. They do not need detailed descriptions of what is occurring inside a box. In contrast, the detailed information is of central concern to the depot personnel, while detailed descriptions of the interrelationships of the boxes is of little use. Specifications calling for different levels of description discussions are needed for different maintenance levels. The respondents believe that the existing mismatch between the user's need and the requirements of the specification significantly decreases the usability and the comprehendibility of the TMs.

The fourth deficiency proposed by the writers was that the current specifications are not adequate for new technologies. For example, most specifications call for functional presentation. Yet many of the new built-in-test equipments (BITE) do not test the system equipment by function. Rather, BITE may test by card or by communication paths. New specifications need to be developed on how best to present this technical information.

Cost of inadequate/inappropriate specifications. There is a relationship between cost and non-applicable portions of specifications. The production house cost estimates are

based on the contents of the specification. When an entire specification is applied to a system, the production house must base its costs on the assumption that the Government will insist the TM include all items required by the specifications, irrespective of whether that documentation is really needed. A production house proposal could point out non-applicable portions of the specifications, but this action runs the risk of being considered non-responsive.

Relative Effort in the Workflow.

Subjects were shown the production workflow chart in Figure 1 and asked to describe how their production deviated from that flow. They were also asked to discuss how the work load is distributed across the flow chart. We allowed the subjects to impose their own structure on the workflow when they were discussing the proportion of the workload. Thus different groups segmented the flow chart differently. However, we did require them to impose actual percentage estimates when they spoke in generalities, e.g., if a subject said, "most of the work occurs during stages 1 to 6" we required him or her to estimate the percentage.

All production house personnel reported that their in-house workflow was very similar to that described in the Deardorff et al. report (1979), as shown in Figure 1. Regarding the relative efforts expended during the workflow, the large production house that generates military TMs estimated that about 60 percent of total man-hours are expended in blocks 1-5 (preparing the draft text), and another 15-20 percent is expended in block 6 (preparing the draft art work). The medium-sized production houses estimated that about 75 percent of their man-hours are expended in blocks 1-10 for electronics systems, but only 55-60 percent for mechanical systems. This is because mechanical systems require larger validation efforts than electronic systems. The remaining 25-40 percent of effort is spread out over blocks 11-30 (validation to customer distribution).

Personnel at the small production house estimated that 50 percent of the effort goes

toward writing and 50 percent toward all other activities (such as art preparation. diagrams. artwork, and typing) to produce a camera-ready copy when applicable. Ten percent of the total effort is dedicated to revisions according to customer verification and comments.

The civilian production house produces two major types of TMs. one primarily text and the other primarily diagrammatic work instructions. Regarding the effort expended in collecting source data. it was estimated that 15 percent is required for the text TM an 20 percent for the diagrammatic work instructions. It was further estimated that for generating the initial draft an additional 40 percent of the effort is required for the text TM and 30 percent for the diagrammatic TM. A field test consumes 10 percent of the effort for the text TM and about 20 percent of the effort for the diagrammatic TM. While the percentages vary from project to project. it was estimated that. in general, 65 percent for text TM and 80 percent for diagrammatic TM of the work effort has been expended by the end of block 11. The remaining effort percent is distributed across blocks 12 through 30.

Government's TM Representative.

The production of the TMs is done under contract even at the publication house producing civilian manuals. At that house the contract is with subdivisions within the corporation. In spite of this contractual relationship, there was virtually no mention of a contract monitor or a progress review by the subdivision letting the contract. The publication house seems to assume responsibility for quality and progress reviews, maintaining the time and cost schedule. and establishing contact with the appropriate subject matter experts.

In contrast, when the contract is with the government. an individual or group within the government is assigned responsibility for developing the request for proposals (including the specification) for the TM. reviewing and evaluating proposals. and monitoring the contractors work in developing the TM.

When asked how the TM representative's performance could be improved. production

house personnel responded that he should: 1.) review the developing product more often; 2.) perform more front-end analysis on the specification; 3.) be more technically qualified and less format-oriented; and 4.) know and understand the user better.

The subjects indicated that after contract award, the government representative meets with them in an initial planning session and then at periodic in-process reviews. These reviews are infrequent, typically linked to a percentage of the work completed, e.g, when 25, 50, 75, and 90 percent of the draft work has been completed.

Some subjects estimated contact as occurring only once every three or four months They indicated that this infrequent contact often had a negative affect on the quality and the efficiency of the production effort. More frequent monitoring would reduce needless effort by the production house on a product that was not going to be acceptable.

The request for more front-end analyses relates to their earlier complaint that specifications are indiscriminately and inaccurately applied over different types of technologies, activities, and users. Production house personnel believe they could provide a better manual if some of the requirements' uncertainty were eliminated from the RFP through front-end analysis.

The subjects indicated a belief that in most cases the government representative does not understand the equipment for which the manual is being written and is unfamiliar with the skills of the personnel and the circumstances under which they work. They suggested that the inadequate training and knowledge of the government representative is at the base of many of the problems. A better-trained TM representative would contribute to better TMs.

Writers

Generally, writers are organized into writing groups headed by a lead writer The lead writer is responsible for coordinating the group's activities, seeing that schedules are met, serving as a quality assurance point, and training the less experienced writers. The most

frequent comments were made about the writer and the writing process covering the following seven topics.

Qualifications/Training. The production houses specializing in military work do not formally certify writers. Writers are hired on the basis of their technological expertise. They are predominantly ex-military technicians or college graduates in engineering, particularly electronic or electrical engineering. With the technological advances that are being made, the trend has been to hire fewer ex-military personnel and more engineers, and also to hire them immediately after graduation. Currently, the writer mix between ex-military and engineers was estimated to be between 50/50 and 40/60. The reason given for the trend toward engineers is that ex-military personnel do not possess the skills and knowledge applicable to advanced technology. The exception to the above trend occurs in those production houses that rewrite existing manuals. Their writers tend to be mostly ex-military personnel who have usually had experience with the item under rewrite.

All training is on-the-job for the military production house writers. There is no formal program for in-house or out-of-house training. Normally, the lead writer is responsible for on-the-job training.

Writer qualifications and in-house training courses are used at the civilian production house. These writers must have a Bachelor of Science degree in Engineering Technology (BSET). In past years when there was a shortage of qualified personnel, individuals with two-year technical school degrees were hired and then sent to school to obtain the BSET degree. Today, writers must possess the BSET degree to be considered for employment. In-house training for the civilian production house includes courses on task analyses, formatting, standards, and software to aid the editing process.

Job Duties. Major job duties for the writer include the gathering of source data, learning about the system, generating the text, updating the text as the design changes.

coordination with team members and ensuring that the text is validated. The writers for military TMs report that their most important, most difficult, and most time-consuming task is to learn about the system. The difficulty of the learning task and the subsequent writing task is directly related to the technology involved and the extent and accuracy of the source materials. This statement does not apply to those writers (probably ex-military) who are already familiar with the item or system.

Source Material. The writer's source materials include drawings, test specifications, engineering reports, and, when available, Logistic Support Analysis (LSA) data. The LSA is data identifying the maintenance and other requirements for keeping the system operational. While the LSA data is supposed to be generated during the product design, it is frequently the case that the data is not developed until the manual is under development. Using these various data sources, the writer attempts to infer how the system works. The writer may also rely to some extent on assistance from peers and design engineers. In some cases, he may have access to the equipment itself. At times, however, writers must learn how the system works without ever seeing it. When the actual equipment is not available, more errors occur in the TM because of faulty inferences, because the source material does not reflect final design changes, and because of lack of validation opportunities.

When asked about LSA product deficiencies, subjects stated that the data does not attend to the traditional human factors issues relevant to the design of technical documentation. These issues include criticality of the task, head/book tradeoff, frequency of the task, environment in which operation/maintenance would be performed, and the skill and knowledge requirements of assigned personnel.

The civilian production house writers report that obtaining source material is their most difficult task. The second most difficult task is trying to understand the system. The source materials to aid them in understanding the system include drawings, test

specifications, an engineer assigned to the writing group, design engineers, and, in some cases, prior documentation. The civilian production house writers also report that some of their work includes correcting and updating existing manuals. The hardware for these manuals is being used in the field and personnel experienced with the system act as an additional data source.

Writing. Typically, one lead writer supervises several other, less experienced writers. Writing and assignments are done by functions of the equipment not by maintenance or other tasks. One or more functions are selected from the system and assigned to a group. It is the responsibility of the writer or group to understand and then write about the assigned function. Responsibility is for the entire function, whether the writing is in one manual or is in chapters across several manuals.

When asked what model they write to, the writers indicated that they use the production house's most current TM that met the specifications listed in the contract.

The writer leads in print media and the illustrator follows. The more the manual relies on text-graphic format, the more the writer and illustrator work together. When illustrations are called for, it is the writer who first roughs out the picture for the illustrator. The writer is responsible for seeing that both text and illustrations are correct.

Degree of Automation. All interviewees indicated that they make some use of word processors in generating text. All indicated that they were trying to automate the writing process as much as possible and as quickly as possible. One of the medium-sized companies and the large military production house had their word processors programmed for computing reading grade levels. The civilian production house was the most fully automated. Writing was done at the word processors with computer-aided editing, the text was electronically stored, and the final draft was put on a paper medium via a computer-controlled phototypesetting process. A video display terminal for the preparation of graphic

presentations was also used.

Comprehendibility

The military production houses indicated that they only attended to issues of ease of comprehension if specific requirements were called out in the specification. Thus, if a specification required that the text meet a particular readability standard and that passive voice not be used, then the writers would meet those specification requirements. In essence, the specification and a previous text meeting that specification are what guides the writers activities. Some of the more experienced writers, especially ex-military writers, were concerned that the focus on meeting the specification along with the increasing tendency to hire engineers fresh out of school could lead to a loss of perspective on the users needs.

Writers and managers at the civilian production house quite uniformly indicated they consciously attended to the user's needs. Writers indicated they review their drafts with the question in mind, "Can the person use it?" This is quite different from the "Does it meet the specification?" attitude expressed by the writers of military TMs As an example of this sensitivity to the needs of their TM users, writers at the civilian production house referred to their preparation of feature documents, TM products whose format was developed after an intensive survey of user preferences.

Illustrators.

None of the military production houses have a formal certification process for illustrators. They are hired based on their expertise and credentials. The writer, not the illustrator provides the first rough draft of a drawing. Working from the rough draft, the illustrator prepares the graphic in accordance with the appropriate specification (for example, in drawing the electrical wiring equipment symbols for ships' plans, drawings must conform to MIL-STD-15-2) Illustrators usually obtain their training at junior colleges, community colleges, or private institutions.

The illustrators for the civilian production house must be former draftsmen or have an art background. All graphics for the TM are prepared by the illustrator using an interactive graphics terminal, a CRT with a lightpen and a keyboard. The illustrations are stored in memory and put into paper form by a computer-controlled phototypesetting process. In-house training on this system is required.

Quality Assurance (QA).

Quality assurance is the quality review which occurs during the development of the TM. Most specifications require a quality assurance plan indicating at what stages reviews will occur and what factors will be considered in the reviews.

All of the publication houses indicated that the quality assurance seldom includes a requirement for an independent group of engineers or writers to evaluate a writer's work. Some houses use an independent editorial QA group which checks such things as paragraph subordination, split infinitives, and syntax. They do not check the technical content or usability. QA for technical correctness of content is achieved through validation.

Validation.

Validation is the review of the final draft of the manual for technical accuracy and completeness. Production house employees said that they are fairly free to conduct validation in any way they wish. Typically, the contractor is required only to certify that the TM has been validated and is accurate.

Validation is generally the responsibility of the writer. It can range from table-top validation in which someone reads through the manual to an informal process in which each writer validates his drafts using peer engineers/technicians (familiar with the system but not with the item under test) to perform the tasks while the writer observes and supervises.

Interviewees reported that actual TM users are rarely used during validation because of the increased time and cost. The only occasions in which actual TM users participate in

validation is when the RFP calls for it (and it rarely does) or when validation and verification are combined.

All interviewees believe that the contractor decides how to conduct validation, including the type of subjects to use if any. Interviewees also reported that formal tests of usability, accessibility, and comprehensibility are not part of the validation process.

Verification.

Verification is the assessment of whether the intended audience of the manual can in fact use it to carry out operation and maintenance tasks. While validation is the responsibility of the contractor, verification is meant to be the final assessment by the government of the adequacy of the product (manual) they are buying.

Personnel at the companies producing government manuals indicated that there are few true verifications by the Government. That is, there are few times when the contractor does not provide any assistance and only Government personnel are used; it was estimated that this occurs no more than 5 percent of the time. The concern of the contractor is for the accuracy of the material. When the contractor is present and the TM user raises a question, the contractor is anxious to answer the question and to show the user how that information can be gotten from the TM. While the intentions of the contractor are good, providing that type of aid masks comprehensibility and usability deficiencies in the TM.

Validation and verification are intended to be independent events. In many cases, however, the validation and verification events are held concurrently to save time and money. In practice this means that the contractor is more active in validation/verification than would be the case if verification were held separately, and the Government relies more on the contractor under these circumstances than it otherwise would.

Discussion

The reserch findings are based on interviews with publication house personnel and as

such they are subject to a variety of reporting biases. We hope future research will attempt to validate the findings through observation and assessment of the actual publication process. We think such efforts are critical to validating our findings and to developing an objective understanding and analysis of the process. Given the restrictions, the data nonetheless suggest three factors contribute to the difficulties in producing effective technical manuals: the adversary role with the government, the qualifications of writers, and the quality assurance and validation process. Only the last factor is strongly influenced by time and money. Thus the typical explanation of time and money as the culprits in the development of effective manuals is, at best, only partially warranted.

Both the government monitor and the specification system appear to be at the base of the governments contribution to ineffective manuals. The specification is the primary vehicle for controlling the design and the production of the manual. Both the production houses and the government use the specification as the primary tool for evaluation. One of the primary complaints about the specifications is that they are inappropriately applied to equipment types and maintenance requirements. That is, the claim is that different equipments (e.g., electronic vs hydraulic; replaceble modules vs no such modules) require different guidelines for the organization and presentation of information. Furthermore, personnel performing basic maintenance tasks require a different level of detail than personnel totally overhauling the equipment.

The military has recognized this need to target particular needs and has developed a variety of alternative specifications. Indeed, the Defense Logistics Analysis Agency (1977) identified 480 different specifications, standards, and instructions for the creation of manuals. In a further attempt to target specifications to particular needs, the Navy has just created a data base management system for specifications so that all specifications are readily accessible and appropriate parts of existing specs can be combined to create the appropriate match of the spec to the equipment and task.

Our findings would suggest that the Navy approach will only lead to the further proliferation of specifications and will have little effect on the quality of the manuals. There are already over 100 specifications for the design of user oriented manuals (Hatterick and Price, 1981). Some of those specifications are extremely detailed (Joyce, et.al., 1973). The problem does not appear to rest in finding the appropriate specification but rather in the fact that the specifications tend to be the only expert design knowledge available in the production of technical manuals. The specification approach is simply inadequate to serve as the sole or even the primary mechanism for controlling the quality and usability of manuals.

Specifications attempt to identify in an objective manner the surface characteristics (writing style, level of detail, organization, format, etc.) of an effective manual. The presumption is that if the writers and designers simply replicate those characteristics the new manual will also be effective. However, the specifications only address the manual as a product: it does not describe how to produce that product, i.e., the process of writing and designing, nor does it provide a rationale for the particular design strategies to guide the writer in adapting the particular requirements to specific writing and design situations.

There is a significant body of research and a long history of experience indicating that this product oriented approach of providing rules and guidelines (as in a specification, style guide, or format guide) is an inadequate means of controlling the quality of the product (Duffy, 1981; Flower and Hayes, 1981; Hayes, Flower, Shriver, Stratman, and Carey, 1985). 1985) Rather than focusing on products this research suggests that the focus must be on the expertise of the writer and on the process of writing. This is because writing is an ill defined problem: it is a task that is never replicated. The context of writing -- the constraints in the information available, the particular communication goal, and the text already written and to be written -- is constantly changing. Because of this changing context, rules and procedures cannot be rigidly applied. Rather the writing must be guided by less rigid design heuristics and by an understanding and analysis of how the information will be

used.

The specification must contain a clear description of the goal of the overall design and a description of how each of the details of the specification contributes to that goal. Some of the details might simply be exemplars of a variety of strategies for achieving a particular goal, e.g., syntactic requirements to achieve readability. Other requirements may require rigid application to achieve consistency across a family of manuals, e.g., particular strategies for showing a more detailed view of a portion of a line drawing. The writers and designers can then adapt the requirements as necessary to achieve the particular goal.

Of course meeting the goals of the specification requires expertise from both the government monitor and the writers and designers (Smillie, 1985). The interview data suggest that little expertise is available. The manager is typically not a trained writer nor a technician. Therefore his or her review focuses on compliance with the objective statements in the specification. Furthermore, the reviews tend to occur later in the production effort, when there are drafts to evaluate, rather than in the early planning stages when the strategies are developed.

The writers tend to come from an engineering background. It was only at the civilian publication house that there was any indication that writing and design skill was an issue in the hiring of technical writers. Indeed, technical knowledge was considered the most important selection criterion, more important then even knowledge of the job context. A manager at one military publication house indicated that he recognized that the "writers" were very poor writers. However, he described their job as getting the technical data down -- the editor is the one who makes sense of it. This again reflects the product oriented view of writing as simply matching grammar, format, and style requirements.

The focus of the writers we interviewed was on interpreting the specification. They indicated that writing would not be a problem if only the specification clearly told them what

to do. However, as Smillie (1985) has argued, it is unreasonable to expect a person not trained or experienced in writing and designing user oriented texts, to be able to make intelligent decisions regarding the level of detail, the amount of explanation, etc. The writer cannot comply with a specification if he or she does not understand that the intent of the specification is to meet the needs of the user. And only one of the four military publication houses indicated any attempt to interview intended users of the documentation or assess the job context in which the manual would be used.

In contrast to the military publication houses the civilian house focused less on technical expertise and more on writing skill. Their approach would seem to reflect a growing trend in the hiring of writers outside of the military context. Computer firms, especially are more frequently hiring writing experts and sending them to school, if necessary, to learn about the particular equipment.

Finally, the data indicated little attention to quality assurance either during the development of the manual or in the final evaluation. Accuracy and completeness were the issue rather than ability to use the document. However, accuracy and completeness were typically assessed through an expert review. There are a growing number of studies to indicate that such a table top review, even by writing and design experts, does not seem to be adequate to insure that the necessary information is presented in a usable manner. Duffy, Curran, and Sass (1983) found that expert redesign of technical manuals did not improve the ability to locate or use the information in the manual -- even when there was no cost or time constraint on the revision effort. Similarly, Swaney, Janik, Bond, and Hayes (1981) found that expert review and revision by a writing expert was an inadequate means for assessing the usability of the information in a document. When they asked expert writers to revise consumer contracts only one of four contracts was improved. They found improvements in the usability of the documents only when the review and revision was based on actual testing of the ability of users to use the document. This user testing, or protocol

aided revision, is being increasingly recognized as a critical step in the production of usable documents (Soderston, 1985; Shriver. 1984).

In summary, the focus in the design of technical manuals must shift from the product to the process of developing the manuals and to the goals of the design process. Specifications should include goal statements and interpret design requirements in terms of those goals. Furthermore writers and managers must have design expertise to interpret the specifications. This may be achieved through selection or through a training and certification process. Further research will be required, however, to determine the specific training requirements or selection criteria. This writing environment clearly presents new and interesting issues in the teaching of writing (or the selection of writers). It is a highly cooperative writing environment, an issue just beginning to receive attention in composition research. In addition it requires a writer to accomodate demands for a high level of expertise in three domains: the technical area, the job context, and in writing and design skills. Again, we are only beginning to consider the role of subject matter knowledge in writing and revising. We would anticipate that a proper training program would lead to greater attention to the user and job context in both planning and testing a manual. However, it might well be that more cost efficient user testing procedures will be required.

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Figure Captions

Figure 1 - Typical Technical Information Development Process (from Deardorff et al., 1979)