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6 DEVELOPMENT OF A SYSTEMATIC AND QUANTITATIVE METHOD FOR EVALUATING INSTRUCTIONAL MATERIAL. INSTRUCTIONAL MATERIAL ADEQUACY GUIDE AND EVALUATION STANDARD (IMAGES),

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INTRODUCTION

Three essentials to combat readiness are manpower, materiel, and equipment manuals. Equipment manuals provide the information and communication link between the soldier and the equipment he must operate and maintain. These manuals also contribute directly to the reliability, maintainability, and operational effectiveness of the Army's weapon systems. To obtain full advantage of these systems we must provide the soldier with accurate, complete, and understandable equipment manuals.

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This ^{report} ~~presentation~~ describes a recently developed method for evaluating the technical adequacy, accuracy, and readability of Army equipment manuals. The method is entitled the Instructional Material Adequacy Guide and Evaluation Standard (IMAGES). The ~~presentation~~ ^{report} also includes a brief summary of the results of a 6-month pilot study of IMAGES at four of the Army's proving grounds.

BACKGROUND

In January 1975 an article was published in an Army Materiel Command (AMC) newsletter regarding the large number of complaints from the field about the inadequacies of the Army's technical manuals. As many as 350 complaints were received during one 3-month period.

As the developer's tester and evaluator, the US Army Test and Evaluation Command (TECOM) is responsible for verifying and evaluating the technical adequacy, accuracy, and utility of draft equipment

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manuals for all Army equipment and weapon systems submitted for development test and evaluation.

During July-August 1975, TECOM conducted an investigation of the methods employed for evaluating manuals. Based on interviews and discussions with maintenance personnel at each proving ground, it was found that: (1) there was no systematic or standard method for evaluating technical manuals, (2) the techniques employed were dependent upon the subjective judgment and experience of the particular evaluator, and (3) there was no consistent measurement standard for classifying defects or determining overall manual quality. It was also found that in some instances only those portions of manuals necessary for use in performing corrective maintenance were evaluated.

DEVELOPMENT OF IMAGES

Based on the results of the preliminary investigation, TECOM immediately initiated a methodology improvement study with the overall objective of developing a systematic and quantitative method for evaluating technical manuals.

The methodology study was conducted during the period September 1976 through September 1977. The objective of the study was to develop a systematic, quantitative method for evaluating equipment manuals which would: (1) be useable by Army maintenance evaluators, (2) provide for a complete evaluation of manuals, (3) be compatible with the present system for reporting and correcting deficiencies, (4) classify and quantify manual defects, and (5) provide a consistent measurement standard for determining overall manual quality.

IMAGES, as developed by TECOM, is based on the technical specifications to which Army equipment manuals are prepared. It contains a strategy and checklists for evaluating the adequacy of the style, technical contents, and readability of manuals. It also contains criteria for determining the comprehension level to which a manual is written and provides a quantitative measurement system for determining overall manual quality.

IMAGES consists of 11 parts. A summary of the Parts of IMAGES by Category of Equipment is shown in Figure 1. Part I contains the instructions. This part is applicable to all categories of Army equipment and to all types of equipment manuals, Operator -10 through General Support -40. The General Style and Format Requirements are also applicable to all other parts.

ACCESSION BY	DATE	BY	REMARKS
STN	07/01	00	
ORG			
EXAMINER			
ACTIVATION			
Per Basic ref.			
ASC Val III			
CLASSIFICATION/AVAILABILITY CODES			
Ext. Avail. and/or Special			
A			

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Category of Equipment*	Governing Specification	Ref Code	Part Reference
Introduction to IMAGES (Applicable to all Categories)			Part I
General Style and Format Requirements	MIL-M-38784A	A	All Parts
Mechanical and Construction Equipment, Automotive Equipment and Power Tools (Excludes Combat Vehicles)	MIL-M-63009C	B	Part II
Telecommunications Equipment (Except Teletypewriters)	MIL-M-63019	C	Part III
Radar Equipment	MIL-M-63020	D	Part IV
Teletypewriter Equipment	MIL-M-63021	E	Part V
Electronic Test Equipment	MIL-M-63025	F	Part VI
Army Aircraft Equipment	MIL-M-63026A	G	Part VII
Weapons, Combat Vehicles and Fire Control Materiel	MIL-M-63032A	H	Part VIII
Lubrication Orders	MIL-M-63004B	J	Part IX
Equipment Serviceability Criteria	MIL-M-63006B	K	Part X
Commercial Equipment	MIL-M-6298C	L	Part XI

Figure 1. Parts of IMAGES by Category of Equipment

*IMAGES is currently being expanded to include Missile System Equipment and Nonnuclear Explosive Ordnance Disposal manuals.

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Parts II through XI are related to specific categories of equipment and the governing specifications. Each of these parts is complete so that the maintenance evaluator only needs to use one part of IMAGES to evaluate all manuals for a given system.

Each part of IMAGES, parts II-XI, contains the following four sections:

a. Section I contains the Introduction which covers the purpose and scope of the evaluation, applicable levels of maintenance, and step-by-step instructions for performing the evaluation.

b. Section II contains a detailed checklist of General Style and Format Requirements. In addition, it contains general technical requirements for engineering drawings, illustrations, and schematics. It also contains requirements and criteria for hazard warnings, security classification markings, and quality assurance provisions, including readability standards.

c. Section III contains a detailed checklist for Specific Technical Requirements by type of manual and covers the type -10 Operator's manual through the type -40 General Support Maintenance manual. This section also includes procedures for evaluating lubrication instructions, preventive maintenance checks and services, troubleshooting provisions, and special tools and equipment.

d. Section IV contains the required Review/Evaluation forms for classifying and recording defects and the criteria for determining the overall quality level of the manual.

IMAGES EVALUATION PROCEDURES

The general procedures which the maintenance evaluator follows in using IMAGES are as follows:

Step 1 - Determine from the Draft Equipment Publication Package the governing specification to which the manual was prepared and determine that a Maintenance Allocation Chart (MAC) is available.

Step 2 - Based on the governing specifications, determine the part of IMAGES applicable for use in the manual evaluation.

Step 3 - Following the detailed review/evaluation procedures in Section I, and using the checksheets provided, conduct a complete evaluation of the manual.

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Section I, Introduction to IMAGES, contains instructions for the classification of defects to assist the evaluator in judging the severity of a manual defect. IMAGES provides for three classes of defects as follows: (1) critical, (2) major, and (3) minor. In addition, there are three levels for each category of defect. The definitions and criteria for classifying defects are included on a Classification of Defects card as shown in Figure 2. The defect class and level are assigned code numbers for ease of recording and evaluation purposes. For example, critical defects are indicated by the numbers 1, 2, or 3 and are assigned a defect value of 100; major defects are numbered 101, 102, or 103 and are assigned a defect value of 10.0; and minor defects are numbered 201, 202, or 203 and are assigned a defect value of 0.2.

Checksheets are provided for classifying and recording defects and for determining the overall Quality Index value for the manual. Two different types of checksheets are used for each manual evaluation. The first of these is the Maintenance Requirements by Functional Group Review/Evaluation Checksheet. A sample of this checksheet is shown in Figure 3. This checksheet is used in conjunction with the detailed checklist for specific technical requirements (Section III of IMAGES) to determine the technical adequacy and accuracy of the manual.

The Review/Evaluation of Format Requirements Checksheet is used in conjunction with the General Format and Style checklist (Section II of IMAGES) to evaluate the adequacy of the manual with regard to specified style, format, illustrations, hazard warnings, and readability requirements. A sample of the Review/Evaluation Checksheet is shown in Figure 4. Each requirement in the checklist is compared with the applicable text to determine if the text material complies with the requirements.

The final step in the manual evaluation procedure is completion of the Review/Evaluation Summary Sheet, Figure 5. The total number of defects in each category is transferred from the two checksheets described above to the Summary Sheet. The total number of defects is then multiplied by the weighted value for each category to determine the total value for weighted defects. The "n" value of weighted defects per page is then determined by dividing the number of weighted defects by the number of manual pages evaluated. The overall Quality Index is then determined by entering the Table of Quality Values, which is also shown in Figure 5. The Quality Index Value is used to determine overall manual quality which may also be expressed in adjectival terms: excellent, good, fair, or unacceptable, as shown

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CLASSIFICATION OF DEFECTS

This Classification of Defects card is used to assist the evaluator in judging the severity of a manual defect. If a defect exists in the manual, it is selected and rated in accordance with the definition indicated. The defect class code number selected for entry on Form No. 1 and Form No. 2 should define the defect as nearly as possible, based upon the severity of the defect should it remain uncorrected in the manual.

DEFECT CLASS CODE NUMBER	DEFINITION
CRITICAL DEFECT Information that is omitted, incorrect, incomplete or confusing in a manual which could result in:	
1	hazardous or unsafe conditions for personnel using, maintaining or depending on the equipment described by the manual.
2	destruction or impaired performance of a major tactical end item (missile, tank, vehicle, etc.)
3	access to classified material by unauthorized personnel.
CRITICAL defect is indicated as 1, 2 or 3 and is assigned a defect value of 100.	
MAJOR DEFECT Information that is omitted, incorrect, incomplete or confusing in a manual, other than a critical defect, which could result in:	
101	immediate or ultimate failure of the equipment or component of the equipment or immediate cessation of operation.
102	reduced usability or inefficient performance of the equipment.
103	unnecessary difficulty or significant loss of time to the user of the manual in performing a particular function.
MAJOR defect is indicated as 101, 102 or 103 and is assigned a defect value of 10.0.	
MINOR DEFECT Information that is omitted, incorrect, incomplete or confusing in a manual other than a critical or major defect, which:	
201	would not affect the performance of the equipment.
202	deviates from standards having little bearing on the usability of the manual or on the equipment described.
203	does not materially reduce the usability of the manual for its intended purpose.
MINOR defect is indicated as 201, 202 or 203 and is assigned a defect value of 0.2.	

Figure 2. Classification of Defects Card.

REVIEW/EVALUATION OF MAINTENANCE REQUIREMENTS AUTHORIZED BY MAC

TM 5-222-24 EVALUATOR: **J. DOE** DATES: FROM **8-5** TO **8-25**
 SPECIFICATION: MIL-M-6302X TEST SITE: **WHITE SANDS** PROJ. NO. **222** TYPE TEST: **DT-3**
 REQUIREMENTS: VERIFIED (✓) NOT VERIFIED (✓)

GROUP NO.	FUNCTIONAL GROUP	MANUAL REFERENCE				MAINTENANCE REQUIREMENTS (SEE MAC)										ENTER EVALUATION STATUS AS APPLICABLE	REMARKS	LEGEND	MAINTENANCE CATEGORY			
		TABLE NO.	FIGURE NO.	LIST NO.	PARAGRAPH	INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL					REBUILD	SPECIAL TOOLS	EQUIPMENT
05	COOLING SYSTEM																					
0505	FAN TOWER ASSEMBLY																					
06	ELECTRICAL																					
0601	ALTERNATOR																					
0602	Voltage Regulator																					
0603	Motor Starting																					
0604	Control & Indicator Panel																					
0608	Power Supply, 3R (Driver)																					
0609	Dome Light																					
						SUBTOTALS																
						TOTALS																

NOTE: RECORD THE DATE OF ALL CRITICAL MAINTENANCE REQUIREMENTS CHECKS IN THE SUMMARY SHEET.

Figure 3. Manual Maintenance Requirements Checksheet.

REVIEW/EVALUATION OF MANUAL FORMAT REQUIREMENTS

TM 5-XXX-XX-24 EVALUATOR: J. Dec DATES: FROM 8-5 TO 8-25
 SPECIFICATION: MIL-63088 TEST SITE: WHITE SANDS PROJ. NO. XXXX TYPE TEST: DT3
 REQUIREMENTS: VERIFIED (✓) ✓ NOT VERIFIED (✓) ✓

REFERENCE CODE	MANUAL REFERENCE				ADEQUATE	NOT APPLICABLE	OMITTED	DEFICIENT	DEFECT CLASS CODE NO.	REMARKS OR RECOMMENDED CHANGES AND REASON
	PAGE NO.	PARA NO.	LINE NO.	TABLE FIGURE NO.						
<u>A1</u>					✓					
<u>THRU</u>										
<u>A1</u>					✓					
<u>A7.1</u>								✓	203	
<u>A7.2</u>						✓				
<u>A7.3</u>	<u>10</u>							✓	203	<u>Part number not spelled out</u>
<u>25</u>									*	<u>Part number not spelled out</u>
<u>A7.4</u>					✓					
<u>A7.5</u>								✓	203	
<u>A7.6</u>					✓					
<u>THRU</u>										
<u>A7.10</u>					✓		✓		103	
<u>A7.11</u>										

TOTAL

NOTE: AN ASTERISK (*) IN THE DEFECT CLASS CODE NUMBER COLUMN DENOTES THAT THE DEFICIENCY HAS BEEN CLASSIFIED ELSEWHERE.
 FORM NO. 2

CRITICAL	0
MAJOR	1
MINOR	5

NOTE: TOTAL ALL CHECKSHEETS AND ENTER ON SUMMARY SHEET

Figure 4. Manual Style and Format Checksheet.

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REVIEW/EVALUATION SUMMARY

TM 5-XXXX-XX-2 TITLE Nomenclature of end item
 SPECIFICATION: MIL-M-630XX TEST SITE White Sands PROJ NO XXXX
 TYPE TEST DT-3 REQUIREMENTS VERIFIED (✓) NOT VERIFIED (✓)✓

Enter totals of all deficiencies from Review Evaluation Forms No. 1 and 2 and compute as follows:

Enter Total Number of CRITICAL (1, 2, or 3) DEFECTS: 0 × 100 = 0
 Enter Total Number of MAJOR (101, 102, or 103) DEFECTS: 4 × 10 = 40
 Enter Total Number of MINOR (201, 202, or 203) DEFECTS: 2 × 2 = 4

Total above for number of WEIGHTED DEFECTS = 40.4

Enter total number of MANUAL PAGES EVALUATED = 100

Divide total number of WEIGHTED DEFECTS by
 number of manual pages evaluated to obtain $100 \div 40.4$ "n" value
 the "n" value or WEIGHTED DEFECTS per page

Match the "n" value above with the n value in Table of Quality Values. The QI value in the adjacent column is the value to be entered here:

Quality Index = 67

TABLE OF QUALITY VALUES

QUALITY INDEX FOR n BETWEEN .30 AND 1.99																			
n	QI	n	QI	n	QI	n	QI	n	QI	n	QI	n	QI	n	QI	n	QI	n	QI
.30	100	.31	99	.32	98	.33	97	.34	96	.35	95	.36	94	.37	93	.38	92	.39	91
.40	90	.41	89	.42	88	.43	87	.44	86	.45	85	.46	84	.47	83	.48	82	.49	81
.50	80	.51	79	.52	78	.53	77	.54	76	.55	75	.56	74	.57	73	.58	72	.59	71
.60	70	.61	69	.62	68	.63	67	.64	66	.65	65	.66	64	.67	63	.68	62	.69	61
.70	60	.71	59	.72	58	.73	57	.74	56	.75	55	.76	54	.77	53	.78	52	.79	51
.80	50	.81	49	.82	48	.83	47	.84	46	.85	45	.86	44	.87	43	.88	42	.89	41
.90	40	.91	39	.92	38	.93	37	.94	36	.95	35	.96	34	.97	33	.98	32	.99	31
1.00	30	1.01	29	1.02	28	1.03	27	1.04	26	1.05	25	1.06	24	1.07	23	1.08	22	1.09	21
1.10	20	1.11	19	1.12	18	1.13	17	1.14	16	1.15	15	1.16	14	1.17	13	1.18	12	1.19	11
1.20	10	1.21	9	1.22	8	1.23	7	1.24	6	1.25	5	1.26	4	1.27	3	1.28	2	1.29	1
1.30	0	1.31	0	1.32	0	1.33	0	1.34	0	1.35	0	1.36	0	1.37	0	1.38	0	1.39	0
1.40	0	1.41	0	1.42	0	1.43	0	1.44	0	1.45	0	1.46	0	1.47	0	1.48	0	1.49	0
1.50	0	1.51	0	1.52	0	1.53	0	1.54	0	1.55	0	1.56	0	1.57	0	1.58	0	1.59	0
1.60	0	1.61	0	1.62	0	1.63	0	1.64	0	1.65	0	1.66	0	1.67	0	1.68	0	1.69	0
1.70	0	1.71	0	1.72	0	1.73	0	1.74	0	1.75	0	1.76	0	1.77	0	1.78	0	1.79	0
1.80	0	1.81	0	1.82	0	1.83	0	1.84	0	1.85	0	1.86	0	1.87	0	1.88	0	1.89	0
1.90	0	1.91	0	1.92	0	1.93	0	1.94	0	1.95	0	1.96	0	1.97	0	1.98	0	1.99	0

QI Manual Quality
 90 - 100 Excellent
 80 - 89 Good
 70 - 79 Fair
 below 70 Unacceptable

FORM NO. 3

J. DOE
 Evaluator Name

8-25
 Date

Figure 5. Review Evaluation Summary Sheet.

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at the bottom of the Summary Sheet. The Acceptable Quality Level for manuals is a Quality Index score of 70 or above. Any score below 70 is considered unacceptable and the manual is considered deficient. The responsible developer is informed of all manual defects, as well as the overall acceptability of the manual. Deficient draft manuals must be corrected before the manuals are considered acceptable for final publication.

PILOT STUDY OF IMAGES

A 6-month pilot study of IMAGES was conducted at US Army Aberdeen Proving Ground, Maryland; US Army Yuma Proving Ground, Arizona; US Army Electronic Proving Ground, Arizona; and US Army White Sands Missile Range, New Mexico, during the period October 1976 through March 1977. The primary objective of this study was to determine the adequacy and usability of IMAGES for evaluating equipment manuals.

Prior to the initiation of the study, a training course in the use of IMAGES was given to maintenance evaluation personnel at each of the participating proving grounds. A total of 24 maintenance personnel, 14 military and 10 civilian, participated in a 5-day training program.

The equipment manuals selected for evaluation at each of the proving grounds were those available at the time of the study. There was no preselection of candidate manuals.

A total of 20 different equipment manuals was evaluated during the study. Of the 20 manuals evaluated, 7 were rated acceptable, with scores of 70 or better, while 13 were rated unacceptable with scores less than 70. A summary of the results of the IMAGES evaluation of the 20 manuals in terms of Quality Index score and overall quality rating is shown in Tables 1 and 2. The data in Table 1 show the results of the evaluation of the seven manuals rated acceptable. The results for the 13 manuals rated unacceptable are shown in Table 2. The types of manuals were varied and representative ranging from the type -12 Operator/Organizational through the type -34 Direct/General Support level. Those manuals designated "P" also included Repair Parts and Special Tool Lists.

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TABLE 1

MANUALS RATED ACCEPTABLE
(Total of 20 Manuals Rated)

Manual Title	Manual Type	Quality Index Score*	Quality Rating
Airborne Laser Tracker	-34	98	Excellent
Tank, Fabric Collapsible, 50,000 gal	-12	97	Excellent
Tractor, Universal Engineer, Crawler	-34P	96	Excellent
TD 1065, High Speed Data Buffer	-12	79	Fair
Laser Rangefinder, AN/GVS-5	-34	79	Fair
TD 1069, Digital Multiplexer	-34	76	Fair
Target Designator, Laser, AN/PAQ-1	0	70	Fair

*A score of 70 or above is acceptable.

TABLE 2

MANUALS RATED UNACCEPTABLE
(Total of 20 Manuals Rated)

Manual Title	Manual Type	Quality Index Score*	Quality Rating
Laser, Rangefinder, AN/GVS-5	-20	67	Unacceptable
Radio Set, AN/ARN 123	-24	66	Unacceptable
MICV, XM723	-20, -34	40, 31	Unacceptable
Doppler Navigation Set	-20	55	Unacceptable
Tractor, Universal Engineer, Crawler	-12P	45	Unacceptable
105MM Gun, M48A5, Turret	-20/1, -20/2	41, 28	Unacceptable
Howitzer, Medium, Towed: 155MM, XM198	-20, -34	40, 29	Unacceptable
TD 1065, High Speed Data Buffer	-12	38	Unacceptable
TD 1069, Digital Multiplexer	-12	29	Unacceptable
Pneumatic Tool & Compressor 250CFM	-14	17	Unacceptable

*A score of 70 or above is acceptable.

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A summary of the results of the evaluation of the same 20 manuals set out by classification and category of defect is shown in Table 3. There were 495 defects of format and style and 239 defects of specific technical requirements for a total of 734 defects in the 20 manuals, or an average of 36.7 defects per manual. The number of critical and major defects was fairly evenly distributed between format and style and technical requirements. However, there were substantially more minor defects of format and style, as expected by the nature of the requirements.

TABLE 3

CLASSIFICATION OF MANUAL DEFECTS
(20 Draft Equipment Manuals)

	Manual Defects - IMAGES											
	Format & Style				Specific Reqmts				Total Defects			
	Crit	Maj	Min	Total	Crit	Maj	Min	Total	Crit	Maj	Min	Total
Defects	18	132	345	495	14	121	104	239	32	253	449	734
Avg Per Manual	0.9	6.6	17.3	24.8	0.7	6.0	5.2	11.9	1.6	12.6	22.5	36.7

Critical defects were primarily related to system safety considerations such as the omission of required instruction for grounding of electrical systems, hazard warnings omitted, and the entire safety precautions paragraph omitted from the manual. Examples of major defects include failure to list tools required to perform a job, troubleshooting diagrams which differed from the equipment, and the omission of electrical schematics.

Sixteen of the 20 manuals evaluated using IMAGES had been previously evaluated using the then current method. A comparison of the total number of defects found in these 16 manuals using IMAGES, with those previously reported on DA Form 2028 (Recommended Changes to Publications and Blank Forms) under the existing system, is shown in Table 4.

TABLE 4

COMPARISON OF IMAGES AND CURRENT METHOD
(16 Draft Equipment Manuals)

	Number of Manual Defects					
	IMAGES				Current (2028's)	
	Critical	Major	Minor	Total	Total	Difference
Number of Defects	24	229	345	598	342	(256)
Average Per Manual	1.5	14.3	21.6	37.4	21.4	(16)

In terms of total defects, there were 256 or 43% more defects found using IMAGES than found when using the current method. While the current method did not classify the defects, analysis of the results showed about the same distribution of critical, major, and minor type defects using both methods.

A summary of questionnaire results obtained from 19 of the 20 evaluators who participated in the pilot study is shown in Table 5. One military evaluator was transferred prior to administration of the questionnaire. The responses to question 1 show that there was a reasonably balanced distribution between less experienced and highly experienced maintenance personnel who participated in the study. The responses to questions 2 and 3 show that a substantial majority of the evaluators gave IMAGES a higher rating than the present procedure. The responses to question 4 show that a majority of the evaluators felt that IMAGES required more time than the present method. This response was expected since, with the exception of EPG, the present method did not include a 100% evaluation of each manual. It is noted that at EPG, where the present method included a 100% evaluation of most manuals, all 4 evaluators responded that IMAGES required less time than the present method.

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TABLE 5

IMAGES QUESTIONNAIRE RESPONSES
(19 Maintenance Evaluators)

Questions	Responses	APG	YPG	EPG	WSMR	Total
1. Previous manual evaluation experience?	-1 yr	2	1	2	1	6
	1-2 yrs	1	1	1	1	4
	+2 yrs	3	2	1	3	9
2. Rate present procedure for insuring adequacy and accuracy of manuals?	Good	1	2	4	1	8
	Fair	4	2	0	4	10
	Poor	1	0	0	0	1
3. Rate IMAGES for insuring adequacy and accuracy of manuals?	Good	5	3	4	5	17
	Fair	1	1	0	0	2
	Poor	0	0	0	0	0
4. Time required for IMAGES?	Less	0	1	4	0	5
	Same	1	1	0	0	2
	More	5	2	0	5	12

IMAGES is designed to be used in conjunction with "hands-on" performance of actual or simulated maintenance tasks or used strictly for a desk audit of equipment manuals. The "hands-on" experience is of particular value in the evaluation of schematics, illustrations, and troubleshooting procedures. Both techniques were used successfully during the pilot study.

SUMMARY

The results of the pilot study and subsequent use by TECOM in evaluating manuals for a variety of Army systems currently under development have demonstrated the value and utility of IMAGES. IMAGES has been adopted by TECOM as a standard Test Operating Procedure and its use should result in a substantial improvement in the accuracy, readability, and understandability of Army equipment manuals to be sent to the field in the future.

IMAGES is currently being expanded for use in evaluating the Army's "new look" manuals prepared in accordance with Integrated Technical Documentation and Training (ITDT) specifications.