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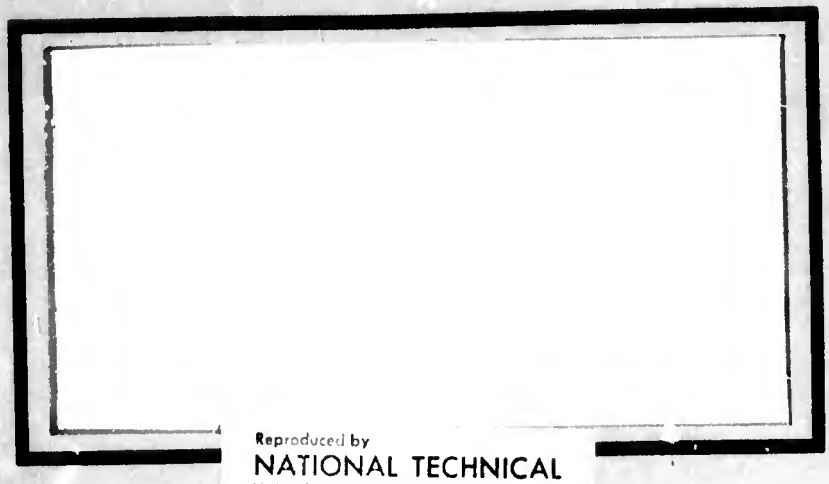
AN ANALYSIS OF THE RELATIONSHIP BETWEEN READABILITY OF AIR FORCE PROCEDURAL MANUALS AND DISCREPANCIES INVOLVING NON-COMPLIANCE WITH THE PROCEDURES

Keith H. Johnson, et al

Air Force Institute of Technology
Wright-Patterson Air Force Base, Ohio

15 September 1972



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13. ABSTRACT

Readability of Air Force logistics procedural manuals is generally too high for their readers. The readers, from different Air Force Specialties (AFS), are faced with a readability/reading ability gap when using the procedural manuals. This "gap" was found to correlate directly with the frequency of discrepancies actually found over a two year period by Air Defense Command (ADC) Headquarters Inspector General's Staff. Additionally, USAF manuals in the 66-, 67-, 70-, 75-, series were tested for readability using the Fog Count method. Mean readability was 17th grade (95% one side confidence interval) with a standard deviation of 4.5 grades (95% one sided confidence interval).

Recommendations for action to correct the problem areas found by this study are included.

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Degree of Master of Science in Logistics Management

By

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IV

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DEDICATION

This thesis is dedicated to the nameless sailors of the U.S. Navy who critiqued the technical manual for AN/BQR 16 Sonar Equipment. Their written comments are quoted at the beginning of each chapter.

Their comments show real insight into the needs and abilities of the men who use manuals of all types.

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CHAPTER I

PROBLEM

"Is there going to be a school to learn how to operate this manual?"

Problem Statement

The USAF Inspector General, in the magazine TIG Brief, makes frequent comments on management discrepancies. With few exceptions the discrepancy cited is related to a failure to comply with written policies or procedures. TIG Brief implies the non-compliance is primarily caused by human failure. Because of TIG Brief coverage, corrective actions are based on the assumptions of human failing compounded by inadequate supervision. If these assumptions are incorrect the value of the selected corrective actions is questionable.

The readability of written material is a primary determinant of understanding by the recipient. When understanding is inadequate the basis for compliance with a written directive is weakened. Is it possible then that certain USAF directives do not provide adequate understanding? If so, present assumptions are not necessarily appropriate. Further, corrective action based on these assumptions probably will not correct the problem. The question at issue

then becomes: "Is poor readability of written directives related to non-compliance?"

Background

The concept of readability was developed by education theorists. Readability is "the quality of a piece of reading matter making it understandable to those for whom it is written." (25:1) The parallel concept is "reading ability." Readability refers to the material, reading ability refers to the reader.

A reader who has reading ability of 9th Grade, can understand, at an average level, material with a readability of 9th Grade. Because of the complementary nature of readability and reading ability there must have been a time when normative data was developed. Material readability was developed by checking analytic measuring tools against the actual performance of representative students. Once this correlation was established it became possible to determine reading ability of individuals using graded material. Unfortunately no evidence can be found to show that specific readability measures and reading ability measures have been standardized on a common scale of measurement. Thus when one selects a reading ability measuring method and a complementary readability measuring method, there is no analytic basis for asserting they are directly related.

Reading ability is a composite capability. It is a function of both vocabulary and comprehension. Vocabulary

can be further subdivided into: mathematics vocabulary, science vocabulary, social science vocabulary, and general vocabulary. Even comprehension can be factored into: interpretation of meaning and following directions. These factors can be measured discreetly or collectively. The collective measure can be and is regarded as total reading ability.

Educators are concerned with readability because this is a primary measure of difficulty. It provides the scaling device to ensure reading ability in students progresses in measurable increments. It also provides the means to ensure sequential learning, i.e., one appropriate step at a time.

Many measures of readability have been devised. The better known measures are the Flesch Index, Dale-Chall Index, and Fog Count. Each uses two factors as the basis for the index. One factor is based on sentence structure/length; the other is based on word structure. Notwithstanding the different scales produced by each index, all may be converted to a school grade level equivalent (GLE). This GLE is the most meaningful measure of readability, though it is not particularly precise.

The parallel measure of reading ability also has several measuring devices. The Californian Reading Achievement Test, for one, is often referred to in research reports. The USAFI Achievement III Test is another reading ability test. This latter test is used by the USAF for measuring reading ability. Both use the grade level equivalent as the measure of reading ability.

Readability measures have been used in the USAF for at least 13 years. However, there is no evidence of appreciable and systematic application of the concept. In 1959, Mr. Donand A. Ross of the Aero Medical Laboratory conducted an evaluation of the comprehensibility of Technical Manuals. (15) Though using subjective criteria, he concluded ". . . Technical Manuals are generally deficient in design for comprehensibility. . . ." One of his five criteria embodied the Fog Index. It showed an average readability of 17th grade for the six manuals tested. This indicated the written material was appropriate for a reader at Master's or Doctor's degree level. (15:6)

Other individuals, in the Air Force Systems Command, at System Program Offices and Laboratories have applied readability concepts in their various roles. In an interview with Mr. Richard Geiselhart of Air Systems Division--Personnel Subsystems Branch, he described the efforts expended by the C-141 and C-5A SPO's to ensure Technical Manuals had readability levels appropriate to the user's reading ability. He cited a specific maintenance problem involving the C-141 aft pressure door which was caused by the poor readability of the relevant portion of the technical manual.

In 1964 a study was initiated into methods of presentation of information for maintenance. It was titled "Project PIMO (Presentation of Information for Maintenance and Operation). This study examined in detail the man/information interaction when accomplishing maintenance. Focus was on the

total man--information--action system rather than just information presentation. Job guides were developed for use in Project PIMO which embodied simply worded, highly readable instructions. Many other factors were involved in the development of job guides in Project PIMO. Some of these were: specificity of information, coherency of information for each specified task, illustrations to relate task instructions to location, and limitation of information in each job step. In the final event, the readability of job guides is about 6th grade level. Project PIMO Final Report emphasizes this by saying: "The format is relatively simple and therein lies its value. It presents the information in a clear and concise manner, at a standard level of detail." (16:4)

The nature of the maintenance information problem, as seen by the researchers in Project PIMO, was complexity. Over the years weapon systems had become more complex and so the information concerning these systems had proliferated. Originally, technical manuals had been developed when systems were relatively simple and technicians well qualified. The style of technical manuals didn't change much but the people and the systems did. Systems grew more complex and technicians more specialized but the technical manuals were still essentially reference material. The system solution developed in Project PIMO therefore involved, of necessity, more than just readability considerations. It went as far as putting task relevant information in the user's hands and expressed in a clear and intelligible manner.

One must keep in mind that the potential efficiencies of the PIMO approach can only be realized by adjustment to the total system, i.e., in training, manpower utilization, and maintenance management practices. Nevertheless, the Project PIMO findings were significant. The findings were:

a. Apprentices can perform as well as experienced specialists when both groups use PIMO Job Guides. (16:13)

b. Both experienced specialists and apprentices showed strong evidence of learning while performing with the PIMO Job Guides. (16:13)

c. There is a 100% reduction in errors by both experienced and apprentice technicians using PIMO Job Guides. (16:13)

d. When apprentices attempted to follow Technical Orders they committed numerous errors. Often they could not even complete the activity. (16:13)

e. There is a high degree of acceptance, by both apprentices and experienced technicians, of PIMO format. (16:14)

In dollar terms the implications of the PIMO approach are highly significant. Some of these implications are:

a. 38-40% increase in operational readiness of the C-141A fleet (for example) can be achieved. This is equivalent to owning 16.44 more C-141A's. (16:15)

b. Reductions in On the Job Training (OJT) for just the 431X1E technician would repay 22 times over the cost of converting C-141A Manuals to PIMO format. (16:15)

Collectively the results of studies and experience with technical manuals over the past 15 years are:

a. The general trend of technical manuals is toward poor intelligibility unless specific constraints are imposed.

b. Poor intelligibility in technical manuals is associated with reduced maintenance efficiency and effectiveness.

c. There is potential for improvement in maintenance efficiency through better communication of technical information. That is, the efficiency loss due to poor intelligibility can be recovered.

The PIMO study was initiated because of growing concern with the hazardous impact of maintenance error. The benefit of precise communication of requirements to maintenance personnel is readily apparent. Very real benefits also occur from better utilization of aircraft. Indeed, avoiding the cost of aborted missions or even accidents is a benefit that all can recognize and seek. However, the benefits of communicating precisely with supply personnel, say, are not so readily understood.

The U.S. Army was impelled into a better understanding of communicating precisely by the advent of Project

100,000. Research into the relationship between aptitude and performance had been sponsored by the U.S. Army since the early 1950's. (33:111) Starting in October 1966, however, the Department of Defense--but the U.S. Army in particular--had to train and employ significant numbers of men generally considered to be of marginal ability. This task had to be achieved without a reduction in force effectiveness.

Two research studies were thus undertaken by HumRRO (Human Resources Research Organization). These two studies designated UTILITY and REALISTIC were designed to obtain information on the performance and characteristics of "marginal" men.

As a part of these studies both high and low aptitude personnel were involved. The aspects of REALISTIC, which focused on literacy skills, produced findings which had implications in the employment of both high and low aptitude personnel. Table 1, below, summarizes the data of interest. (33:48,49)

TABLE 1

DATA ON PUBLICATION READABILITY, PERSONNEL READING ABILITY AND PUBLICATION USAGE FOR THREE MOS's

	MILITARY OCCUPATION SPECIALTY (MOS)					
	COOK		VEHICLE REPAIRMAN		SUPPLY SPECIALIST	
Mean Readability of Relevant Publications	9th Grade		14.5th Grade		16+	
Mean Reading Ability of High and Low Aptitude Men	9.5	7.5	9.5	7.5	10	8
Index of Publication Usage	83%	85%	46%	35%	55%	40%

From this data certain relationships are evident:

a. When the material to be used is difficult there is less tendency for readers, at all aptitudes, to use it. However, higher reading ability men will use them more than the less able readers. (33:50)

b. The high publication usage by Cooks appears to be the direct result of designing the publications for the user.

Specific comment was made by HumRRO as follows:

The present data on readability, reading ability, and readership across the three MOS's suggest that stimulating and increased usage of job reading materials might be accomplished both by improving literacy skills of the men and by the redesign of reading materials. Furthermore, the data for Cooks suggest that greater gains in readership might be expected from the redesign of materials than from increasing the literacy skills of men. In this regard, much research on the construction and evaluation of various job performance aids has indicated that by following a systems approach, job printed materials can be designed which greatly improve the effectiveness of job incumbents across a spectrum of aptitude. It seems likely that the provision of such aids would also increase the utilization of job printed materials. (33:50)

HumRRO's research also showed:

a. There is a high correlation between general reading ability and understanding task related reading material. (33:52)

b. The correlation between general reading ability and understanding of task related material reduces as experience within an MOS increases. Nevertheless, the correlation remains high.

The preceding discussion indicates that there is a consistent pattern of events. In the PIMO research a measurable improvement in maintenance efficiency was achieved by systematically tailoring the technical information to the user and his function. In REALISTIC, HumRRO found one case where information and user were matched (Cook). In this case there was much higher use of the information than in the poorly matched cases.

There is no evidence of research being conducted by the USAF into the efficiency of information flow between Air Force Manuals/Regulations and their users. However, some parallels between technical manuals and Air Force Manuals/Regulations may exist.

Complexity of administrative and management procedures has probably increased as much as the complexity of weapon systems. The extensive use of computers in administration and management has created a complex man/machine/information interface which parallels that in maintenance. The information concerning administration and management has also proliferated. However, just as with technical manuals, there has been no change in the traditional way of communicating that information. The authors of this study, therefore, reason as follows:

a. A relationship has been established between intelligibility of information and maintenance efficiency.

b. In the administrative/management fields the same two basic ingredients appear to exist. There appears to be poor readability of AFM's/AFR. There are problems of non-compliance.

c. Is it therefore possible that a relationship exists between poor readability of AFM's/AFR's and procedural non-compliance problems?

Scope

This study is not concerned simply with the readability of AFM's/AFR's. Even in the face of poor readability it may be that other factors adequately compensate and thus prevent problems. This study is therefore concerned with establishing whether there is a direct and measurable relationship between readability and efficiency.

There are too many manuals, regulations, and directives in the USAF to treat them collectively as a single population and sample from it effectively. Further, the variety of ways in which a problem can manifest itself makes the task of correlation extremely difficult. Therefore, a single class of problems was selected. That class of problems is confined to non-maintenance, non-training procedures, i.e., confined to administrative procedures. Also, the problems must be associated with written, published directives. That is, the correct action requirements must have been published and distributed to those required to take action.

OBJECTIVE

The objective of this thesis was to determine the relationship between discrepancies, as cited by an inspecting organization, and one possible cause--poor readability of source documents. Specific objectives are:

a. To measure the amount of readability/reading ability gap between procedural manuals/regulations and their target population.

b. To determine if a relationship exists between the readability/reading ability gap and instances of non-compliance with the procedures in the manuals/regulations.

HYPOTHESIS

To accomplish the objectives this thesis tested the following hypothesis:

There is a direct relationship between the amount of readability/reading ability gap and the frequency of non-compliance discrepancies. As the size of the gap increases, the frequency of discrepancies will also increase.

CHAPTER II

DATA COLLECTION

"To make a manual for myself it would have to be what I consider dirt farmer basic."

Required Data

Three elements of data were needed to test the hypothesis. They were:

a. A measure of the frequency of occurrence of discrepancies which were deviations from standardized, written procedures in the logistics field.

b. A measure of the readability of these written procedures.

c. A measure of the reading ability of the people required to execute these written procedures.

Sources and Method of Data Analysis

The most likely source of a comprehensive file of discrepancies is the USAF Inspector General. Enquiries were therefore initiated to determine the availability and appropriateness of data from that source. The results of those enquiries were disappointing. Discrepancy data compiled by the USAF Inspector General does not, as a rule, include a

specific document reference. This fact totally negates the value of the data file for the purposes of this thesis. Further comment will be made on this point later in the thesis.

Further enquiries produced a discrepancy file maintained by Air Defense Command (ADC) Headquarters which was suitable. This listing specifies each discrepancy, the specific document reference, the numbers of times that discrepancy was found, and the types of units on which it occurred. Because this file related to a single Command rather than the USAF as a whole the sample size was constrained. Nevertheless, it was still possible to obtain a sample of sufficient size to proceed with the enquiry.

The basis for sampling discrepancies from the ADC file was as follows:

a. The discrepancy was a deviation from standard written procedures in the fields of Supply, Transportation, Maintenance, or Procurement Management, i.e. in the Logistics areas.

b. The cited source document was either an Air Force level manual/regulation or command level manual/regulation. This restriction was imposed to eliminate supplements and lower organizational level procedures. The readability of supplements cannot be determined because of marked variations in language between the basic manual and the supplement. Manuals/regulations issued by lower organizational levels than Command HQ are directed

to a fraction of the Command population and therefore the potential for discrepancies is reduced.

c. Discrepancies at Air National Guard (ANG) units were not to be sampled. The authors have no data from which to determine literacy skills of ANG personnel.

d. Finally, the discrepancy had to involve a deviation from a procedure rather than a responsibility. Responsibility statements do not communicate specific action requirements to operative personnel. Further, responsibility statements are more related to supervisory level and this research is concerned with working level personnel.

The screening process reduced the number of acceptable discrepancies to 53. Of these, 32 were contained in the ADC file for 1970 and 21 were in the 1971 file. This sample was further reduced by the criteria imposed for determining the target population.

The next step was to determine the target population (i.e. the Air Force Specialty (AFS)) to which the procedure applied. Information concerning the type of unit, e.g. Radar, or F-106 Squadron, on which the discrepancies occurred was contained in the file. Also, the cited document itself sometimes indicated the specific AFS. Any discrepancy involving a procedure used by more than one or two AFS's was discarded from the sample. This was done because no meaningful measure

of literacy skill over a wide band of AFS's can be derived. After applying this criteria the sample was reduced to 39. Twenty-five of these are from the 1970 file and 14 from the 1971 file.

Next, the readability of each cited document was determined using the Flesch method (ANNEX A). Tables 2A and 2B list the source document of the final samples for 1970 and 1971. The readability of the cited portion of the document and the frequency of occurrence of the discrepancy are also listed.

TABLE 2A

FREQUENCY OF DISCREPANCIES BY SOURCE DOCUMENT
AND SOURCE DOCUMENT READABILITY

TABLE 2A (1970)

Discrepancy Reference	Procedure Readability in Grade Level	Discrepancy Frequency
1. ADCM 67-3,para 10-1c	16+	29
2. ADCM 67-3,para 10-2b	16+	17
3. AFM 66-1,para 3-33I	16+	18
4. ASPR 3-607.4i	16	1
5. AFM 66-1,para 3-52f	15	5
6. ADCM 136-3,para 8-2b	15	8
7. ADCM 136-1,para 8-2d	15	7
8. AFM 66-1,para 3-54j	15	10
9. ADCM 67-3,para 10-17a	14	10
10. AFM 67-1,VII,PI,Ch 18	14	6
11. AFM 67-1,VII,PII, Ch 15,61a	14	2
12. ADCM 67-3,para 10-17f	14	27
13. ADCM 67-3,para 10-11b/1	14	10
14. ADCM 67-3,para 10-17c	14	15
15. ADCM 67-3,para 10-18	14	29
16. ADCM 67-3,para 10-10d	13	10
17. ADCM 136-3,para 5-2c	13	7
18. AFR 148-3,para 9b	12	7
19. AFR 148-3,para 9a	12	10
20. AFM 67-1,VII,PII, Ch 15,45a,b	12	13
21. AFM 66-1,para 3-47b	12	10
22. ADCM 67-3,para 8-22	11	19
23. ADCM 67-3,para 10-20c	11	10
24. ADCM 66-36,para 6-4m	11	11
25. AFM 67-1,VII,PI, Ch 15,para 49	10	11

TABLE 2B

FREQUENCY OF DISCREPANCIES BY SOURCE DOCUMENT
AND SOURCE DOCUMENT READABILITY

TABLE 2B (1971)

Discrepancy Reference	Procedure Readability in Grade Level	Discrepancy Frequency
1. AFR 70-18,para 4, b,(11)	16+	6
2. AFM 140-1,para 2-4c	16+	17
3. AFM 140-1,para 6-5	16	11
4. ASPR 3-607.4i	16	5
5. AFM 66-1,para 3-52f	15	5
6. ADCM 136-3,para 8-2b	15	6
7. ASPR 3-607.4f	14	5
8. ADCM 67-3,para 10-18	14	24
9. ADCM 67-3,para 10-17a	14	12
10. ADCM 136-3,para 5-2c	13	6
11. AFR 148-3,para 9,b	12	16
12. ADCM 67-3,para 8-22	11	13
13. ADCM 66-36,para 6-4m	11	13
14. ADCM 136-1,para 6-1b	10	5

With the target population defined by AFS it still remained to determine the reading ability of the target population. Firstly, a representative measure of population reading ability had to be defined. Using the mean value of reading ability for each AFS was considered first. This approach was discarded because the mean only represents one parameter of population reading ability. The other parameter, variance, could not readily be introduced into the analysis in conjunction with a mean value. Modes and median measures were also rejected for this reason. It was decided to select the cumulative 90% level as the one which characterizes the reading ability of each AFS. The 90% cumulative level is that reading ability which is exceeded by 90% of the target population. It is a function of both the mean value and variance and therefore embodies in a single value both distribution parameters. Selection of the 90% was quite arbitrary. It was based on the subjective notion of expressing the lower level of reading ability found in a population without going to an extreme cumulative value. However, for completeness, the reading ability of the 75% cumulative level, and the 50% cumulative level (median) were also determined.

Reading ability, expressed in Grade Level Equivalent (GLE) was determined using data from the Uniform Military Record (UMR). The UMR specifies for the years 1966-70 inclusive, the Cumulative Aptitude Index for each Air Force Specialty Code (AFSC) of the USAF's enlisted personnel. The population on which this is based is slightly above 500,000.

Annex B, which was extracted from Reference 12, provides a method for determining the reading ability of any AFSC. Using this method and the aptitude indexes provided by the UMR, the reading ability for each target population was determined. Reading ability at the 90%, 75%, and 50% cumulative level was computed for each AFS. These data are summarized in Tables 3A and 3B.

TABLE 3A

THE CITED MANUAL AND ITS TARGET POPULATION WITH THE POPULATION'S READING ABILITY AT THE CUMULATIVE 50%, 75%, 90% LEVELS (1970)

Discrepancy Reference	AFSC	Reading Ability in Grade Level Equivalent		
		50%	75%	90%
1. ADCM 67-3,para 10-1,c	645X0	12	11	9
2. ADCM 67-3,para 10-12b	645X0	12	11	9
3. AFM 66-1,para 3-33I	303X2	13	12.5	11.5
4. ASPR 3-607.4i	671X1	13.5	13	12
5. AFM 66-1,para 3-52f	434X0	14.5	13	12
6. ADCM 136-1,para 8-2b	462X0	12.5	11.5	11
7. ADCM 136-1,para 8-2d	462X0	12.5	11.5	11
8. AFM 66-1,para 3-54j	303X2	13	12.5	11.5
9. ADCM 67-3,para 10-17a	645X0	12	11	9
10. AFM 67-1,VII,PI Ch 18	645X0	12	11	9
11. AFM 67-1,VII,PII, Ch 15,61a	645X0	12	11	9
12. ADCM 67-3,para 10-17f	645X0	12	11	9
13. ADCM 67-3,para 10-11b/1	645X0	12	11	9
14. ADCM 67-3,para 10-17c	645X0	12	11	9
15. ADCM 67-3,para 10-18	645X0	12	11	9
16. ADCM 67-3,para 10-10,d	645X0	12	11	9
17. ADCM 136-3,para 5-2c	462X0	12.5	11.5	11
18. AFR 148-3,para 9,b	645X0	12	11	9
19. AFR 148-3,para 9,a	645X0	12	11	9
20. AFM 67-1,VII,PII, Ch 15,45a,b	645X0	12	11	9
21. AFM 66-1,para 3-47b	303X2	13	12.5	11.5
22. ADCM 67-3,para 8-22	645X0	12	11	9
23. ADCM 67-3,para 10-20c	645X0	12	11	9
24. ADCM 66-36,para 6-4m	303X2	13	12.5	11.5
25. AFM 67-1,VII,PII, Ch 15,para 49	647X0	10	9	8.5

TABLE 3B

THE CITED MANUAL AND ITS TARGET POPULATION WITH THE POPULATION'S READING ABILITY AT THE CUMULATIVE 50%, 75%, 90% LEVELS (1971)

Discrepancy Reference	AFSC	Reading Ability in Grade Level Equivalent		
		50%	75%	90%
1. AFR 70-18,para 4, b,(11)	671X0	13.5	13	12
2. AFM 140-1,para 2-4c	647X0	10	9	8.5
3. AFM 140-1,para 6-5	602X0	11	10.5	9
4. ASPR 3-607.4i	671X1	13.5	13	12
5. AFM 66-1,para 3-52f	434X0	14.5	13	12
6. ADCM 136-1,para 8-2b	462X0	12.5	11.5	11
7. ASPR 3-607.4f	671X3	13.5	13	12
8. ADCM 67-3,para 10-18	645X0	12	11	9
9. ADCM 67-3,para 10-17a	645X0	12	11	9
10. ADCM 136-3,para 5-2c	462X0	12.5	11.5	11
11. AFR 148-3,para 9,b	645X0	12	11	9
12. ADCM 67-3,para 8-22	303X2	13	12.5	11.5
13. ADCM 66-36,para 6-4m	303X2	13	12.5	11.5
14. ADCM 136-1,para 6-1b	462X0	12.5	11.5	11

Data Limitations

There are a number of limitations inherent in the data used for this study:

a. The USAF IG and Command IG's probably record several thousand discrepancies each year. The present sample amounts to a small portion of that total. As explained earlier the USAF IG discrepancy file could not be used. In using Command HQ files the researchers could not use combined data from several commands because of possible variations in emphasis between commands. Also, it was necessary to restrict the age of discrepancies to the past two years because manuals and regulations are subject to amendment and change. A wider time base would have caused some error in estimating document readability.

b. ADC HQ discrepancy file is only a record of problems found. The probability of finding each problem, however, is a function of the emphasis on specific areas during the inspections and the zeal, knowledge, and inclinations of each inspector. This study does not require that every problem be found. The only requirement is a uniform pattern of inspection at each unit. Given uniformity of inspection the frequency of discrepancies found should be an acceptable measure of the actual relative frequency of their

existence. Based on the knowledge that Command inspectors work to standard checklists the authors believe the pattern of command inspection meets the requirement for uniformity of inspection.

c. The scale for the grade level readability of documents is not known to be the same scale as grade level reading ability of people. Although both are stated in the same unit, grade levels, when they are added or subtracted the result is not a consistent measure. That is, interval scaling of the difference between them cannot be proven. As part of the statistical testing of the data, correlation tests between the difference (readability minus reading ability) and frequency of discrepancies was conducted. The authors therefore treated the difference in measure (Gap) as ordinal data and used non-parametric correlation tests.

Collectively, these limitations may have some effect. However, the authors have no objective basis for measuring or predicting an effect. Subjectively, the authors believe the combined effect of:

a. critical screening of the original discrepancy file,

b. limiting target populations to specific AFS's,

c. treating each year (1970 and 1971) as separate data, and

d. using non-parametric tests,

prevents any significant error arising from these limitations. Nevertheless, the relatively small sample remains a liability because the statistical tests used are sensitive to sample size.

Additional Data

The distribution of the readability of manuals/regulations in the logistics area was also determined. It is not a necessary part of this study; however, the authors wished to obtain some additional insight.

For this purpose the Fog Count (31:155) measure of readability was used. Although the Fog Count is the least accurate method available, it does have one advantage. It scores readability in grade levels from zero to infinity. Thus, the limitation of the Flesch Method of scoring every readability above 16 grade as 16^{+} grade is avoided. However, the reader is cautioned not to treat the Fog Count GLE as if it were the same as Flesch GLE.

The distribution was obtained by sampling from the manuals/regulations of the 66-, 67-, 70-, 75 series. These are the series which document procedures for the logistics functions of Maintenance, Supply, Transportation, and Procurement Management. A sample of 28 manuals was selected at random from the total population of 212 manuals/regulations, i.e. a 12.5% sample.

Each of the manuals/regulations in the sample were sampled further. From each, five separate samples, each of

100 words or more were taken at random. These five samples were aggregated and the average Fog Count for the manual obtained. In taking the five samples from each manual, complete paragraphs were always used. In the final event the total sample for each manual was at least 747 words. Table 4 summarizes the data obtained from this procedure.

TABLE 4

PRESENTATION OF DATA USED TO DETERMINE DISTRIBUTION OF READABILITY OF USAF MANUALS CONTAINING LOGISTICS PROCEDURES

Publication	Word Count	Number of Sentences	Average Fog Count	GLE
	66 SERIES			
1. AFR 66-25	797	19	42	21
2. AFR 66-30	758	20	37.9	19
3. AFR 66-38	775	24	32.3	16
4. AFR 66-43	779	28	27.8	14
5. AFM 66-1	776	23	33.7	17
6. AFM 66-12	747	25	29.9	15
7. AFM 66-17	790	25	31.6	16
	67 SERIES			
1. AFR 67-7	798	28	28.5	14
2. AFR 67-28	824	20	41.2	20
3. AFR 67-34	1106	30	38.7	19
4. AFR 67-41	785	23	34.2	17
5. AFR 67-87	768	32	24	12
6. AFR 67-140	777	22	35.3	17
7. AFR 67-144	795	19	41.8	21
8. AFM 67-1, Vol III, p. 5	807	28	28.8	14
9. AFM 67-1, Vol V	1540	47	38	19
10. AFM 67-1, Vol VI	801	19	41	21
11. AFM 67-5	867	21	41.2	20
12. AFM 67-6	768	31	24.8	12
	70 SERIES			
1. AFR 70-11	946	21	45	22
2. AFR 70-22	790	17	46.5	23
	75 SERIES			
1. AFR 75-8	783	15	52	26
2. AFR 75-30	824	25	33	16
3. AFR 75-36	786	23	34.1	17
4. AFR 75-48	791	20	39.6	20
5. AFR 75-88	788	17	46.4	23
6. AFM 75-1	811	21	38.6	19
7. AFM 75-6	761	16	47.5	24

The sample was tested for goodness of fit to a normal distribution using the Lilliefors Test (1:302). The operational statement of the hypothesis, which was also the null hypothesis was:

H_o: Readability is normally distributed with unspecified mean and variance.

The alternate hypothesis was:

H_1: Readability is not normally distributed.

(A significance level (α) of 0.20 was selected.)

The Lilliefors Test did not reject the null hypothesis at $\alpha = 0.20$. Indeed, results indicate an α of 0.40 is needed to cause H_o to be rejected. The sample mean was 18.36 and the standard deviation was 3.48. A lower confidence limit of mean readability for the specified population was then calculated. A one-sided confidence interval of 95% was selected. The t (or Student) distribution was used for this calculation. The upper confidence limit of the standard deviation was also calculated. Once again a one-sided interval of 95% was used together with the Chi-Square distribution.

On the basis of these tests the authors conclude as follows:

a. The readability of manuals/regulations in the 66-, 67-, 70-, 75- series is normally distributed.

b. The mean readability of 66-, 67-, 70-, 75- series manuals is not less than 17.25 grade levels (at 95% confidence). Basically, this statistic infers there is only one chance in 20 that the <u>true</u> mean

is less than 17.25.

c. The standard deviation of the readability of these manuals is not greater than 4.5 grade levels (at 95% confidence). This too infers there is only one chance in 20 that the true standard deviation is greater than 4.5.

After making some subjective allowance for the crudity of the Fog Count the authors believe the following inferences can safely be drawn:

a. The average readability of logistics procedural manuals is at least in the upper half of college level.

b. Eighty-five per cent of these manuals have a readability of college level or higher.

CHAPTER III

STATISTICAL ANALYSIS

"I'm so snowed I can't think of anything to say."

Hypothesis

The single hypothesis proposed in Chapter I was: There is a direct relationship between the amount of readability/reading ability gap and the frequency of non-compliance discrepancies. As the size of the gap increases, the frequency of discrepancies will also increase.

Before the statistical analysis was conducted this hypothesis was converted into operational form as follows:

Primary Hypothesis

H_o (Null Hypothesis): The amount of the gap is not directly related to frequency of occurrence of non-compliance discrepancies in the logistics field. (One tailed test)

H_1 (Operational Hypothesis): The amount of the gap is directly related to the frequency of occurrence of non-compliance discrepancies in the logistics field.

The authors found as they proceeded with this study that other statistical tests were both possible and desirable. In each case the results of these additional tests do not

provide direct evidence to support or reject the primary hypothesis. They do, however, provide additional insight into relationships. They also provide some inferences. Accordingly, for clarity and completeness, the following additional operational statements are included.

Secondary Hypothesis

H_o (Null Hypothesis): The level of readability of manuals is not directly related to frequency of occurrence of discrepancies in the logistics field. (One tailed test)

H_1 (Operational Hypothesis): The level of readability of manuals is directly related to frequency of occurrence of discrepancies in the logistics field.

Tertiary Hypothesis

H_o (Null Hypothesis): The level of reading ability in target populations is not inversely related to the frequency of occurrence of discrepancies in the logistics field. (One tailed test)

H_1 (Operational Hypothesis): The level of reading ability in target populations is inversely related to the frequency of occurrence of discrepancies in the logistics field.

Classification of Data

The identifier for each data point is the document reference and year. Thus given the information: "AF Manual 66-1, paragraph 3-33I, and 1970" one can determine from Tables 2A and 3A:

a. Number of discrepancies

b. Target population

c. Percentile reading ability of target population

d. Readability of cited manual

A number of statistical tests were conducted. Therefore, the raw data was first rearranged into tables which aggregated all relevant data. Further tables were then developed for specific tests. These tables are:

a. Table 5A-1970:--Cited documents and their readability, frequency of citation, and target population reading ability at the cumulative 50, 75, 90 percentiles.

b. Table 5B-1971:--Cited documents and their readability, frequency of citation, and target population reading ability at the cumulative 50, 75, 90 percentiles.

c. Table 6A-1970:--Cited documents and their readability, and frequency of citation.

d. Table 6B-1971:--Cited documents and their readability, and frequency of citation.

e. Table 7A-1970:--Cited documents and their target population's reading ability at 50, 75, 90 percentiles, and frequency of citation.

f. Table 7B-1971:--Cited documents and their target population's reading ability at 50, 75, 90 percentiles, and frequency of citation.

g. Table 8A-1970:--Cited documents and the gap at 50, 75, 90 percentiles and frequency of citations.

h. Table 8B-1971:--Cited documents and the gap at 50, 75, 90 percentiles, and frequency of citation.

TABLE 5A

1970: CITED DOCUMENTS AND THEIR READABILITY; FREQUENCY OF CITATION; AND TARGET POPULATION READING ABILITY AT THE CUMULATIVE 50, 75, 90 PERCENTILES

Document	Readability	Number of Citations	Tgt Population's Reading Ability		
			50%	75%	90%
1. ADCM 67-3, para 10-1,c	16+	29	12	11	9
2. ADCM 67-3, para 10-12b	16+	17	12	11	9
3. AFM 66-1, para 3-33I	16+	18	13	12.5	11.5
4. ASPR 3-607.4i	16	1	13.5	13	12
5. AFM 66-1, para 3-52f	15	5	14.5	13	12
6. ADCM 136-3, para 8-2b	15	8	12.5	11.5	11
7. ADCM 136-3, para 8-2d	15	7	12.5	11.5	11
8. AFM 66-1, para 3-54j	15	10	13	12.5	11.5
9. ADCM 67-3, para 10-17a	14	10	12	11	9
10. AFM 67-1,VII,PI, Ch 18	14	6	12	11	9
11. AFM 67-1.VII,PII, Ch 15,61a	14	2	12	11	9
12. ADCM 61-3, para 10-17f	14	27	12	11	9
13. ADCM 67-3, para 10-11b/1	14	10	12	11	9
14. ADCM 67-3, para 10-17c	14	15	12	11	9
15. ADCM 67-3, para 10-18	14	29	12	11	9
16. ADCM 67-3, para 10-10,d	13	10	12	11	9
17. ADCM 136-3, para 5-2c	13	7	12.5	11.5	11
18. AFR 148-3,para 9,b	12	7	12	11	9
19. AFR 148-3,para 9,a	12	10	12	11	9
20. AFM 67-1,VII,PII, Ch 15,45a,b	12	13	12	11	9
21. AFM 66-1, para 3-47b	12	10	13	12.5	11.5

TABLE 5A--Continued

Document	Readability	Number of Citations	Tgt Population's Reading Ability		
			50%	75%	90%
22. ADCM 67-3, para 8-22	11	19	12	11	9
23. ADCM 67-3, para 10-20c	11	10	12	11	9
24. ADCM 66-36, para 6-4m	11	11	13	12.5	11.5
25. AFM 67-1,VII,PII, Ch 15,para 49	10	11	10	9	8.5

TABLE 5B

1971: CITED DOCUMENTS AND THEIR READABILITY; FREQUENCY OF CITATION; AND TARGET POPULATION READING ABILITY AT THE CUMULATIVE 50, 75, 90 PERCENTILES

Document	Readability	Number of Citations	Tgt Population's Reading Ability		
			50%	75%	90%
1. AFR 70-18, para 4,b,(11)	16+	6	13.5	13	12
2. AFM 140-1, para 2-4c	16+	17	10	9	8.5
3. AFM 140-1, para 6-5	16	11	11	10.5	9
4. ASPR 3-607.4i	16	5	13.5	13	12
5. AFM 66-1, para 3-52f	15	5	14.5	13	12
6. ADCM 136-3, para 8-2b	15	6	12.5	11.5	11
7. ASPR 3-604.4f	14	5	13.5	13	12
8. ADCM 67-3, para 10-18	14	24	12	11	9
9. ADCM 67-3, para 10-17a	14	12	12	11	9
10. ADCM 136-3, para 5-2c	13	6	12.5	11.5	11
11. AFR 148-3, para 9,b	12	16	12	11	9
12. ADCM 67-3, para 8-22	11	13	12	11	9
13. ADCM 66-36, para 6-4m	11	13	13	12.5	11.5
14. ADCM 136-1, para 6-1b	10	5	12.5	11.5	11

TABLE 6A

1970: CITED DOCUMENTS, THEIR READABILITY AND FREQUENCY OF CITATION

Document	Readability	No. of Citations
1. ADCM 67-3,para 10-1c	16+	29
2. ADCM 67-3,para 10-12b	16+	17
3. AFM 66-1,para 3-33I	16+	18
4. ASPR 3-607.4i	16	1
5. AFM 66-1,para 3-52f	15	5
6. ADCM 136-3,para 8-2b	15	8
7. ADCM 136-3,para 8-2d	15	7
8. AFM 66-1,para 3-54j	15	10
9. ADCM 67-3,para 10-17a	14	10
10. AFM 67-1,VII,PI,Ch 18	14	6
11. AFM 67-1,VII,PII, Ch 15,61a	14	2
12. ADCM 67-3,para 10-17f	14	27
13. ADCM 67-3,para 10-11b/1	14	10
14. ADCM 67-3,para 10-17c	14	15
15. ADCM 67-3,para 10-18	14	29
16. ADCM 67-3,para 10-10,d	13	10
17. ADCM 136-3,para 5-2c	13	7
18. AFR 148-3,para 9,b	12	7
19. AFR 148-3,para 9,a	12	10
20. AFM 67-1,VII,PII, Ch 15, 45a & b	12	13
21. AFM 66-1,para 3-47b	12	10
22. ADCM 67-3,para 8-22	11	19
23. ADCM 67-3,para 10-20c	11	10
24. ADCM 66-36,para 6-4m	11	11
25. AFM 67-1,VII,PI, Ch 15, para 49	10	11

TABLE 6B

1971: CITED DOCUMENTS; THEIR READABILITY AND FREQUENCY OF CITATION

Document	Readability	No. of Citations
1. AFR 70-18,para 4,b,(11)	16+	6
2. AFM 140-1,para 2-4c	16+	17
3. AFM 140-1,para 6-5	16	11
4. ASPR 3-607.4i	16	5
5. AFM 66-1,para 3-52f	15	5
6. ADCM 136-3,para 8-2b	15	6
7. ASPR 3-604.4f	14	5
8. ADCM 67-3,para 10-18	14	24
9. ADCM 67-3,para 10-17a	14	12
10. ADCM 136-3,para 5-2c	13	6
11. AFR 148-3,para 9,b	12	16
12. ADCM 67-3,para 8-22	11	13
13. ADCM 66-36,para 6-4m	11	13
14. ADCM 136-1,para 6-1b	10	5

TABLE 7A

1970: CITED DOCUMENTS AND THEIR TARGET POPULATION'S READING ABILITY AT 50, 75, 90 PERCENTILES, AND FREQUENCY OF CITATION

Document	Tgt Population's Reading Ability			No. of Citations
	50%	75%	90%	
1. ADCM 67-3,para 10-1c	12	11	9	29
2. ADCM 67-3,para 10-12b	12	11	9	17
3. AFM 66-1,para 3-33I	13	12.5	11.5	18
4. ASPR 3-607.4i	13.5	13	12	1
5. AFM 66-1,para 3-52f	14.5	13	12	5
6. ADCM 136-3,para 8-2b	12.5	11.5	11	8
7. ADCM 136-3,para 8-2d	12.5	11.5	11	7
8. AFM 66-1,para 3-54j	13	12.5	11.5	10
9. ADCM 67-3,para 10-17a	12	11	9	10
10. AFM 67-1,VII,PI,Ch 18	12	11	9	6
11. AFM 67-1,VII,PII,Ch 15, 61a	12	11	9	2
12. ADCM 67-3,para 10-17f	12	11	9	27
13. ADCM 67-3,para 10-11b/1	12	11	9	10
14. ADCM 67-3,para 10-17c	12	11	9	15
15. ADCM 67-3,para 10-18	12	11	9	29
16. ADCM 67-3,para 10-10d	12	11	9	10
17. ADCM 136-3,para 5-2c	12.5	11.5	11	7
18. AFR 148-3,para 9b	12	11	9	7
19. AFR 148-3,para 9a	12	11	9	10
20. AFM 67-1,VII,PII, Ch 15,49a & b	12	11	9	13
21. AFM 66-1,para 3-47b	13	12.5	11.5	10
22. ADCM 67-3,para 8-22	12	11	9	19
23. ADCM 67-3,para 10-20c	12	11	9	10
24. ADCM 66-36,para 6-4m	13	12.5	11.5	11
25. AFM 67-1,VII,PII, Ch 15,para 49	10	9	8.5	11

TABLE 7B

1971: CITED DOCUMENTS AND THEIR TARGET POPULATION'S READING ABILITY AT 50, 75, 90 PERCENTILES, AND FREQUENCY OF CITATION

Document	Tgt Population's Reading Ability			No. of Citations
	50%	75%	90%	
1. AFR 70-18,para 4,b,(11)	13.5	13	12	6
2. AFM 140-1,para 2-4c	10	9	85	17
3. AFM 140-1,para 6-5	11	10.5	9	11
4. ASPR 3-607.4i	13.5	13	12	5
5. AFM 66-1,para 3-52f	14.5	13	12	5
6. ADCM 66-1,para 8-2b	12.5	11.5	11	6
7. ASPR 3-604.4f	13.5	13	12	5
8. ADCM 67-3,para 10-18	12	11	9	24
9. ADCM 67-3,para 10-17a	12	11	9	12
10. ADCM 136-3,para 5-2c	12.5	11.5	11	6
11. AFR 148-3,para 9,b	12	11	9	16
12. ADCM 67-3,para 8-22	12	11	9	13
13. ADCM 66-36,para 6-4m	13	12.5	11.5	13
14. ADCM 136-1,para 6-1b	12.5	11.5	11	5

TABLE 8A

1970: CITED DOCUMENTS AND THE GAP AT 50, 75, 90 PERCENTILES; AND FREQUENCY OF CITATIONS

Document	Gap 50%	Gap 75%	Gap 90%	No. of Citations
1. ADCM 67-3,para 10-1c	4+	5+	7+	29
2. ADCM 67-3,para 10-12b	4+	5+	7+	17
3. AFM 66-1,para 3-33I	3+	3.5+	4.5+	18
4. ASPR 3-607.4i	2.5	3	4	1
5. AFM 66-1,para 3-52f	.5	2	3	5
6. ADCM 136-3,para 8-2b	2.5	3.5	4	8
7. ADCM 136-3,para 8-2d	2.5	3.5	4	7
8. AFM 66-1,para 3-54j	2	2.5	3.5	10
9. ADCM 67-3,para 10-17a	2	3	5	10
10. AFM 67-1,VII,PI, Ch 18	2	3	5	6
11. AFM 67-1,VII,PII, Ch 15,61a	2	3	5	2
12. ADCM 67-3,para 10-17f	2	3	5	27
13. ADCM 67-3,para 10-11b/1	2	3	5	10
14. ADCM 67-3,para 10-17c	2	3	5	15
15. ADCM 67-3,para 10-18	2	3	5	29
16. ADCM 67-3,para 10-10d	1	2	4	10
17. ADCM 136-3,para 5-2c	.5	1.5	2	7
18. AFR 148-3,para 9b	0	1	3	7
19. AFR 148-3,para 9,a	0	1	3	10
20. AFM 67-1,VII,PII, Ch 15,49 a & b	0	1	3	13
21. AFM 66-1,para 3-47b	-1.0	- .5	.5	10
22. ADCM 67-3,para 8-22	-1	0	2	19
23. ADCM 67-3,para 10-20c	-1	0	2	10
24. ADCM 66-36,para 6-4m	-2	-1.5	- .5	11
25. AFM 67-1,VII,PII, Ch 15,para 49	0	1	1.5	11

TABLE 8B

1971: CITED DOCUMENTS AND THE GAP AT 50, 75, 90 PERCENTILES; AND FREQUENCY OF CITATIONS

Document	Gap			No. of Citations
	50%	75%	90%	
1. AFR 70-18,para 4,b,(11)	2.5+	3+	4+	6
2. AFM 140-1,para 2-4c	6+	7+	7.5+	17
3. AFM 140-1,para 6-5	5	5.5	6	11
4. ASPR 3-607.4i	2.5	3	4	5
5. AFM 66-1,para 3-52f	.5	2	3	5
6. ADCM 136-3,para 8-2b	2.5	3.5	4	6
7. ASPR 3-604.4f	.5	1	2	5
8. ADCM 67-3,para 10-18	2	3	5	24
9. ADCM 67-3,para 10-17a	2	3	5	12
10. ADCM 136-3,para 5-2c	.5	1.5	2	6
11. AFR 148-3,para 9,b	0	1	3	16
12. ADCM 67-3,para 8-22	-1	0	2	13
13. ADCM 60-36,para 6-4m	-2	-1.5	- .5	13
14. ADCM 136-1,para 6-1b	-2.5	-1.5	-1	5

Statistical Technique Employed

The Spearman Rank Correlation Test (26:202) was used for all statistical tests. This test is a measure of association between two variables X and Y. The test statistics is r_s, the correlation coefficient. r_s may take on values between -1 and +1. When r_s is both large, relative to sample size, and positive, a direct relationship between X and Y exists. That is, as X increases so does Y. Conversely, when r_s is large (absolute value) and negative, an inverse relationship between X and Y exists. That is, as X increases, Y decreases.

The statistic r_s can be converted to a t (Student) distribution statistic. Comprehensive tables for t distribution critical values were available to the authors. Therefore, for greater accuracy in calculating significance, all r_s values derived in the tests were converted to t values.

A total of 21 Spearman Rank Correlation tests were conducted. Table 9 is a matrix showing the X random variable and Y random variable for each of the 21 tests.

The matrix shows:

a. The test number

b. The relationship tested, i.e. direct relationship or inverse relationship

c. The variables used in each test

TABLE 9

MATRIX OF SPEARMAN RANK TESTS CONDUCTED SHOWING X VARIABLE, Y VARIABLE, TEST NUMBER, AND RELATIONSHIP TESTED IN EACH CASE

X \ Y		Frequency of Cited Discrepancies 1970	Frequency of Cited Discrepancies 1971	Frequency of Cited Discrepancies 1970 + 1971
Readability of Cited Manual (in grade level equivalent units)		Test 1 Direct	Test 2 Direct	Test 3 Direct
Reading Ability of Target Population at Stated Percentiles (in grade level equivalent units)	90%	Test 4 Inverse	Test 7 Inverse	Test 10 Inverse
	75%	Test 5 Inverse	Test 8 Inverse	Test 11 Inverse
	50%	Test 6 Inverse	Test 9 Inverse	Test 12 Inverse
Gap at Stated Percentiles (in grade level equivalent units)	90%	Test 13 Direct	Test 16 Direct	Test 19 Direct
	75%	Test 14 Direct	Test 17 Direct	Test 20 Direct
	50%	Test 15 Direct	Test 18 Direct	Test 21 Direct

Annex C details the definitions, equations, and procedure for conducting a Spearman Rank Correlation test. A sample calculation is included. The sample calculation is, in fact, Test 7 from Table 9.

Seven of the 21 tests involved combined data from 1970 and 1971. This was done to obtain a large sample. The data was simply pooled. That is, the 25 citations of the 1970 sample were pooled with the 14 citations of the 1971 sample. The resultant pool was 39 citations. There were 8 citations common to both years. These were treated as if they were not common. This pooling technique could appear invalid. However, each citation in this enlarged sample represents the number of discrepancies found during one inspection year. If the common citations had been added together the frequency would have been distorted with respect to a reference cited in only one year. Common citations could have been reduced to a one year base by averaging. This technique, however, would have reduced random effects for common citations and destroyed homogeneity of the total sample. The authors could not find any objective test for the validity of their pooling approach. Subjective, but critical evaluation of this pooling failed to show any weakness which could affect the value of the statistical tests.

Results of Statistical Tests

The results of the statistical tests fall into three groups. These groups are collected in separate tables as

follows:

a. Table 10: Results of tests for the relationship between readability of cited documents and frequency of citation.

b. Table 11: Results of tests for the relationship between reading ability of the target population and frequency of citation.

c. Table 12: Results of tests for the relationship between readability/reading ability gap and frequency of citation.

TABLE 10

RESULTS OF TESTS FOR SHOWING RELATIONSHIP BETWEEN READABILITY OF CITED DOCUMENTS AND FREQUENCY OF CITATION

Test Identification	r_s	t_{comp}	Significance level at which H_o is Rejectable ($^o\alpha$)
Test #1 (1970)	-0.047	-.226	> .50
Test #2 (1971)	0.047	.163	.40
Test #3 (1970-71)	-0.074	-.451	> .50

TABLE 11

RESULTS OF TESTS FOR THE RELATIONSHIP BETWEEN READING ABILITY OF THE TARGET POPULATION AND FREQUENCY OF CITATIONS

Test Identification Test No. (Yr/Percentile)	r_s	t_{comp}	Significance level at which H_o is Rejectable ($^o\alpha$)
Test #4 (70/90%)	0.372	1.922	0.035
Test #5 (70/75%)	0.372	1.922	0.035
Test #6 (70/50%)	0.370	1.910	0.036
Test #7 (71/90%)	0.793	4.510	0.0005
Test #8 (71/75%)	0.753	3.964	0.002
Test #9 (71/50%)	0.756	3.985	0.002
Test #10 (70 + 71/90%)	0.572	4.240	0.0005
Test #11 (70 + 71/75%)	0.562	4.133	0.0005
Test #12 (70 + 71/50%)	0.562	4.133	0.0005

TABLE 12

RESULTS OF TESTS FOR THE RELATIONSHIP BETWEEN READABILITY/READING ABILITY GAP AND FREQUENCY OF CITATION

Test Identification Test No. (Yr/Percentile)	r_s	t_{comp}	Significance level at which H_o is Rejectable ($^o\alpha$)
Test #13 (70/90%)	0.199	0.974	0.18
Test #14 (70/75%)	0.092	0.443	0.33
Test #15 (70/50%)	0.048	0.230	.40
Test #16 (71/90%)	0.400	1.510	0.08
Test #17 (71/75%)	0.160	0.560	0.30
Test #18 (71/50%)	0.110	0.383	0.36
Test #19 (70 + 71/90%)	0.299	1.910	0.035
Test #20 (70 + 71/75%)	0.125	0.766	0.23
Test #21 (70 + 71/50%)	0.067	0.408	0.35

CHAPTER IV

ANALYSIS OF RESULTS AND TEST OF HYPOTHESIS

"Sailors don't read so gud so keep the explanations short and in easy to understand terms."

General

The inclusion of cumulative 50% and 75% reading ability, or gaps, in the statistical tests was for completeness. The weakness in these figures lies in their characteristic of convergence. As one moves closer to the median value (cumulative 50%) the differences between AFS's tends to reduce. For this reason the authors did not use the results of cumulative 50% and 75% tests in their analysis.

Readability

Tests 1, 2, and 3 were tests of the relationship between readability and frequency of discrepancies. None of these tests produced significant results. Indeed, on the basis of tests one may only conclude there is no relationship, either direct or inverse. From these data we conclude there is no relationship between readability of documents and frequency of discrepancies.

Reading Ability

Tests 4, 7, and 10 were tests of the relationship between target population's reading ability (at 90% cumulative) and frequency of discrepancies. All tests showed the relationship to be significant. Alpha's of 0.035, 0.0005, and 0.0005 were obtained. These results are extremely significant.

On the basis of these tests alone one could be tempted to conclude reading ability is the major factor influencing discrepancies. However, the influence of other tests needs to be considered. The distribution of readability of logistics manuals is high. Specifically, 85% of manuals are written at college level or higher. On the other hand reading ability for target populations never exceeds 12th grade at the cumulative 90% level.

Thus the general material each AFS confronts is well above its reading ability. Project REALISTIC (33,72) showed personnel used written material most when the gap was least (see Table 1). One can foresee, therefore, that as reading ability increases, and readability is high there are several effects. Firstly, the better readers use written material more. By this use they gain better understanding of their tasks. In turn this understanding results in fewer errors. However, as shown in Project REALISTIC, a reduction in the reading difficulty of manuals would have the same effect.

In our tests of GAP versus discrepancies we dealt with specific parts of manuals. However, a person's use of

manuals is related to how difficult they appear to him--in general. Thus even though a particular paragraph is written at, say, 10th grade, the potential for it to be read is a function of the general difficulty (gap) perceived by the user. This perception leads to some non-use of the procedure with exactly the same consequences of not understanding it--errors.

The authors, therefore, conclude as follows:

a. Reading ability is inversely related to frequency of discrepancies.

b. Reading ability, therefore, influences the frequency of discrepancies, but via the intervening effect of written material which is consistently perceived as "difficult."

c. The combination of readability and reading ability is, of course--the gap. One can therefore expect a correlation between gap and frequency of discrepancies. However, because our tests involving gap dealt with specific paragraphs, the effects of general difficulty of the manuals will be masked. Nevertheless, this effect can reasonably be inferred from the reading ability versus discrepancy tests.

Gap

Tests 13, 16, and 19 were tests of the relationship between the gap (at the cumulative 90%) and frequency of

discrepancies. The significance levels (alpha) observed were 0.18, 0.08, and 0.035.

Although the alpha value of .18 is not very significant the other two values are. Of these three tests, Test 19 is the most valuable because of the sample size. In general, we conclude a significant relationship does exist. More specifically, we conclude there is a direct relationship between the gap and frequency of discrepancies.

Other Relationships

The tests dealt with relationships between stated variables. However, the possibility remains that the variables used are closely related to some other characteristic of, say, a target population. For example, target population reading ability was determined from aptitude scores. Therefore, changes in reading ability scores simply follow changes in aptitude scores.

From these considerations it may be inferred the tests only reflect the intuitively obvious proposition that job performance is related to job aptitude. However, we noted that readability of documents varies. Thus in any AFS the user is confronted with manuals and procedures at all readability levels. The tests showed a correlation between gap and discrepancies, across all AFS's in the sample. Aptitude is certainly a factor in performance; however, this situation is so only to the extent that a high aptitude is necessary for the job. High reading aptitude is necessary at

present ONLY because the readability of existing manuals requires high literacy skill to understand their procedure content. On the basis of this reasoning we conclude aptitude alone is not the key factor. The key factor is the combination of "aptitude" and "the demands placed on that aptitude," i.e. the gap.

Other possibilities exist. Is it possible motivation and reading ability directly correlate and motivation is the key factor? Similar reasoning to that above suggests otherwise.

Despite these considerations the authors are conscious of some weaknesses in their data. Reading ability was not directly measured by appropriate special tests. Observations of discrepancies were not conducted in a controlled situation. However, the actions needed to avoid these weaknesses were simply beyond the resources available to the authors.

Although we can suggest conclusions from our tests and analysis we cannot sustain them on the basis of faultless research. We can, and will, suggest later in this thesis further research which can resolve arguable conclusions.

Summary of Analysis

The analysis of results, on the basis of tests, logical inference, and existing theory is portrayed in Table 13. On the basis of this analysis we can make conclusions concerning the primary hypothesis. Table 13 shows conclusion 3 is the most probable on the basis of available evidence.

TABLE 13

MATRIX OF POSSIBLE CONCLUSIONS

Effect of Evidence	Possible Conclusions			
	1 Readability & Discrepancies Directly Related	2 Reading Ability & Discrepancies Inversely Related	3 Gap & Discrepancies Directly Related	4 Other Possibilities
Directly Supports		B	C	
Indirectly Supports	F	A,F	A, B+E+D, F	A
Neutral				F
Indirectly Refutes		E		E,B,C
Directly Refutes	A			

EVIDENCE

A - Tests of Readability vs. Discrepancies

B - Tests of Reading Ability vs. Discrepancies

C - Tests of Gap vs. Discrepancies

D - Test of Readability Distribution in Logistics Manuals

E - Project REALISTIC Results (Table 1)

F - Existing Theory

Test of Hypothesis

Our primary hypothesis is considered proven on the basis of our analysis:

There is a direct relationship between readability/reading ability gap and the frequency of non-compliance discrepancies.

Interpretation of Results

The implications of our findings are these:

a. Errors in job performance can be reduced. A reduction in the gap would achieve such a reduction.

b. The gap can be reduced in three ways: firstly, by increasing the reading ability of personnel; secondly, by reducing the readability of procedural manuals; finally, by a combination of the previous two methods.

While it is impossible to define the cost of gap-induced errors some general points can be made. Gap-induced errors increase supervisory workload. Large gaps increase the time needed for personnel to attain satisfactory proficiency in their duties. Implementation of Air Force policy is impeded by large gaps. Coordination of tasks becomes more difficult when, due to a gap, there is not a substantive and common basis of understanding in those affected.

One other general liability of the gap lies in its motivational impact. An unbridgeable gap can cause personnel

to reason: "If management is really concerned with me doing the job right they would tell me clearly. They have not told me clearly; therefore, they do not really care. If they do not really care, why should I?" Furthermore, as indicated in our problem statement, any time the Inspector General cites a unit for a discrepancy the cause tends to be inferred as inadequate supervision. The supervisor, in turn, blames the individual who committed the discrepancy. Can you imagine the feelings of an individual who did the best job he could, but was unable to complete the task satisfactorily because he did not understand the manual that specified the task? Is it any wonder then that frustration, underconfidence, and equivocation are also developed, in addition to the direct loss due to the gap?

In total, the effects of the gap are considered to be significant. The authors believe a 40% (approximately) reduction in errors could be achieved by eliminating the gap. This estimate is based solely on judgement.

The task of improving readability of procedural manuals Air Force-wide is, of course, gigantic. The authors recognize in this case the cost of erasing past errors would be prohibitive. However, the cost of perpetuating past errors could be even more prohibitive as administrative and logistic systems' complexity grows. It seems appropriate therefore, at this time, to establish and implement the controls necessary to ensure all future manuals are written for their users.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

"Trouble shooting equipment operation is difficult enough as it is without complicating matters more, by a difficult equipment manual."

Conclusions

On the basis of the research conducted in this thesis the following conclusions are made:

a. The number of errors which occur when procedural tasks are performed is directly related to the gap. The gap is the difference between the readability of the procedural document and the reading ability of the user.

b. Air Force manuals in the logistics fields (Maintenance, Supply, Transportation, and Procurement) are poorly written. These manuals are written at a level which consistently overtaxes the literacy skills of typical users.

c. Action to prevent present unsatisfactory levels of manual readability being perpetuated is both feasible and desirable.

Recommended Actions

The two elements necessary for effective corrective action are:

a. a realistic standard, and

b. consistent enforcement.

A realistic standard of readability of manuals is quite easily devised. The Uniform Military Record (UMR) provides detailed data on the aptitudes of all enlistees, by AFS, and by year of enlistment. However, the UMR does not specify reading ability of personnel directly. Therefore as an interim measure literacy skill, by AFS, at the 90% cumulative level can be obtained from existing data in the UMR. Long term it is desirable that a specific literacy skill test be developed and administered. In time the results of this test would be accumulated in the UMR and be the basis of the readability standard.

It is not necessary to state a single readability standard for USAF publications. To do so would make the writing of complex procedures even more difficult. Each manual should be written for its users. If 90% of the users have a reading ability of 12th grade, say, then 9th grade level as a standard is unnecessarily restrictive. Air Force pamphlet 10-1 suggests 9th grade is an appropriate standard Air Force-wide. General readability standards of this nature only confuse the issue. The issue is, and remains, the tailoring of manuals to the user.

Enforcement of the standard is a different question. Establishing a new staff agency at each organizational level to check and approve manual readability is not a realistic approach. This approach would further complicate the already complex coordination process. Also, it would further increase the staff overhead costs.

Fortunately there is an organization in the USAF whose responsibilities are relevant to the need for ensuring standards are met. The organization is, of course, the Inspector General Staff. The authors believe the Inspector General's Staff could, through appropriate emphasis during regular inspections, ensure all staff agencies were continuously aware of the need to meet approved standards of readability. Further, the Inspector General's Staff could use their present computer facilities to determine those manuals causing widespread errors. This information would indicate where manual rewrite could be most profitably undertaken. Inspector General inspection data appears not to have been used for this purpose, to date.

Recommended Research

The authors are convinced of the validity of their results. However, further insight into the problem can be gained, particularly concerning the costs. The following further research is therefore recommended.

Firstly, a controlled experiment would be appropriate. The experiment should be directed to finding the:

a. percentage change in error rate as the gap increases,

b. the threshold value of gap at which "satisfactory" compliance ceases,

c. the gap value at which further reduction of readability does not reduce errors, and

d. the likely cost of the errors as a function of the gap.

Secondly and finally, research into alternate communication techniques would be valuable. What techniques for presenting procedures are least reliant on the literacy skill of the user? Can algorithm flow charts, for example, be used to present complex procedures that defy intelligible, written description?

The answers to these questions may well provide the basis for communicating to personnel at all reading ability levels without depending on their literacy skill. Until these questions are answered, however, the USAF should be conscious of the users' literacy skill and prepare its manuals for those users.

ANNEXES

ANNEX A

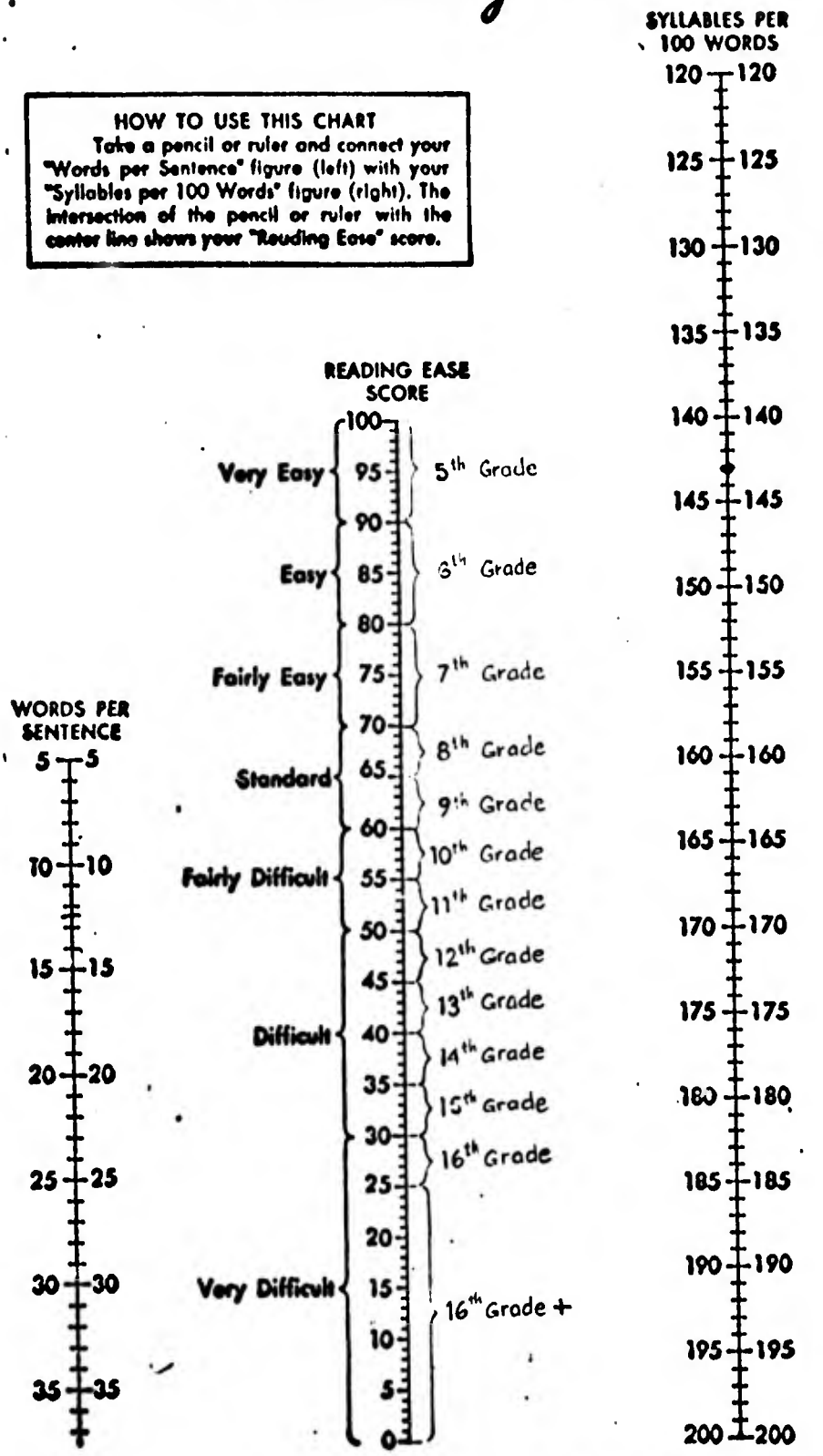
NOMOGRAM OF FLESCH READING SCALE

ANNEX A

How Easy?

HOW TO USE THIS CHART

Take a pencil or ruler and connect your "Words per Sentence" figure (left) with your "Syllables per 100 Words" figure (right). The intersection of the pencil or ruler with the center line shows your "Reading Ease" score.



ANNEX B

Relationships between General Aptitude Index and Grade Equivalent for all Enlisted Personnel

General AI	Grade Equivalent
95	15.0
90	14.5
85	14.0
80	13.0
75	12.5
70	12.0
65	11.5
60	11.0
55	10.0
50	9.5
45	9.0
40	8.5
35	8.0
30	7.5
25	7.0
20	6.5
15 & Below	6.0

FORMULA for Predicting Reading Grade Level Utilizing the General Aptitude Index and the Selector Aptitude Index

Career Fields for which the selector AI is Administrative

RGL = .0437 Gen AI + .0501 Admin AI + 5.0730

Career Fields for which the selector AI is Mechanical

RGL = .0991 Gen AI + .0085 Mech AI + 5.0459

Career Fields for which the selector AI is Electronics

RGL = .0743 Gen AI + .0222 Elect AI + 4.6088

ANNEX C

Procedures for Conducting Spearman-Rank Correlation Test

The following definitions and equations were used in obtaining values displayed in the tables of Chapter III:

r_s = Spearman-Rank Correlation Coefficient

X_i = A random variable as defined for each test listed in Table 9.

n = The total number of values of X_i for a test in Table 9. It equals the sample size.

Y_i = A random variable as defined for each test listed in Table 9.

R_x = Rank placement of the X_i score in the entire listing of X scores from lowest to highest.

R_y = Rank placement of the Y_i score in the entire listing of Y scores from lowest to highest; except in Tests 4 through 12 from Table 9 where the Y_i score was ranked from highest to lowest.

d_i = Difference between R_x and R_y value for an ith value.

d_i^2 = Square of the d_i term.

Σd_i^2 = Algebraic sum of all d_i^2 values.

t_x = Number of X_i values involved in tied scores at a given rank.

t_y = Number of Y_i values involved in tied scores at a given rank.

$T_{x,i} = \frac{t_x^3 - t_x}{12}$ = tied correction factor for x.

$T_{y,i} = \frac{t_y^3 - t_y}{12}$ = tied correction factor for y.

$\sum R_x^2 = \frac{N^3 - N}{12} - \sum_i T_x$ = corrected sum of the squares of the x ranking.

$\sum R_y^2 = \frac{N^3 - N}{12} - \sum_i T_y$ = corrected sum of the squares of the y ranking.

$$r_s = \frac{\sum R_x^2 + \sum R_y^2 - \sum d_i^2}{2\sqrt{\sum R_x^2 \sum R_y^2}}$$ = Spearman-Rank Correlation Coefficient--Corrected for ties

$$t_{computed} = t_{n-2} = r_s \sqrt{\frac{N-2}{1-r_s^2}} = t \text{ statistic}$$

$t_{critical}$ = Critical value of t statistic from the student t distribution where there are n-2 degrees of freedom and alpha as specified.

These values were obtained from Page 610 of the Chemical Rubber Company's 19th edition, Standard Mathematical Tables.

The null hypotheses were tested using the above equations. r_s, t critical, and t computed were found for each test in Table 9.

The data and calculations for test 7 of Table 9 are given as an example of how the results of Tables 10, 11, and 12 were computed.

Reference	X_i	R_x	Y_i	R_y	d_i	d_i^2
ASPR 3-607.4f	12	12.5	5	12.5	0	0
ASPR 3-607.4i	12	12.5	5	12.5	0	0
AFM 140-1, para 6-5	9	4	11	- 7	-3	9
AFM 140-1, para 2-4c	8.5	1	17	- 2	-1	1
AFR 70-18, para 41b/11	12	12.5	6	9.5	3.5	12.25
AFR 148-3, para 9b	9	4	16	3	3	1
AFM 66-1, para 3-52f	12	12.5	5	12.5	0	0
ADCM 67-3, para 8-22	9	4	13	4.5	- .5	.25
ADCM 67-3, para 10-18	9	4	24	1	3	9
ADCM 66-36, para 6-4m	11.5	10	13	4.5	5.5	30.25
ADCM 136-1, para 8-2b	11	8	6	9	-1	1
ADCM 136-1, para 6-1b	11	8	5	12.5	-4.5	20.25
ADCM 136-3, para 5-2c	11	8	6	9	-1	1
ADCM 67-3, para 10-17a	9	4	12	6	-2	4

$\Sigma d_i^2 = 89$

Correction for Ties

X			Y		
8.5		$t_x,9 = \frac{(5)^3-5}{12} = 10.0$	24		
9	5		17		$t_y,13 = \frac{(2)^3-2}{12} = .5$
9			16		
9		$t_x,11 = \frac{(3)^3-3}{12} = 2$	13	2	
9			13		$t_y,6 = \frac{(3)^3-3}{12} = 2$
11	3		11		
11		$t_x,12 = \frac{(4)^3-4}{12} = 5$	12		
11			6	3	
11.5		$\Sigma t_x = 17$	6		$t_y,5 = \frac{(4)^3-4}{12} = 5$
12	4		6		
12			5	4	$\Sigma t_y = 7.5$
12			5		
12			5		

Corrected Sum of Squares for X and Y Rankings

$$\Sigma R_x = \frac{(14)^3-14}{12} - 17 = 210.5$$

$$\Sigma R_y = \frac{(14)^3-14}{12} - 7.5 = 220$$

Calculation of Spearman-Rank Correlation Coefficient (r_s)

$$r_s = \frac{210.5 + 220 - 89}{2\sqrt{210.5 + 220}} = \frac{341.5}{2\sqrt{4.631 \times 10^4}} = 0.793$$

$$t \text{ computed} = r_s \sqrt{\frac{N-2}{1-r_s^2}} = 0.793 \sqrt{\frac{14-2}{1-.793^2}}$$

$$= 4.51$$

TABLE C2

COMPARISON OF CORRELATION COEFFICIENT, t STATISTICS AND t (CRIT) VALUE FOR TEST 7 OF TABLE 9

Year	Percentile Group	Computed r_s	"t" computed	Significance Level at which H_o Rejectable (x)
1971	90%	0.793	4.51	0.0005

On completion of the analysis required for Table C2, the basis for accepting/rejecting the research hypothesis is established.

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