CHAPTER 8
EVALUATION OF DOCUMENTATION FORMATS

C. G. Drury, Ph.D., A. Sarac and K. Kritkausky
State University of New York at Buffalo

8.1 INTRODUCTION AND BACKGROUND: DOCUMENTATION DESIGN

Documentation errors continue to be a source of concern for airlines and regulatory bodies around the world. The Aviation Safety Reporting System (ASRS) is still finding procedure-related incidents running at about half of all incidents, with many of these involving written communications. This report details the latest of a series of projects aimed at reducing errors caused by poorly-designed documentation. The project first refines a documentation design job aid developed and tested in an earlier project, then proceeds to measure the performance of people working with the documents written using this job aid.

As has been noted throughout the FAA Office of Aviation Medicine's Human Factors in Aviation Maintenance projects, documentation plays a large and important role in aviation maintenance and inspection. Documents from an airframe manufacturer's manual, through an airline's general maintenance manual, to aircraft logbooks and inspection workcards, define what tasks must be accomplished, how to accomplish them and provide the data needed by the user. Some, such as logbooks and workcards, are also systems to ensure regulatory compliance and production control, requiring the user to have a two-way interaction with the document, both reading it and using it for recording responses. Such documents have been the focus of redesign efforts during the project, for example user-designed logbooks, and human factors guidelines for workcards.[9,11]

The importance of good document design in reducing errors was emphasized by an analysis of the paperwork errors made when a rather poorly-designed Campaign Directive (CD) was issued by an airline. It was found that *none* of the errors were made where guidelines for good human factors design were followed and *all* of the errors were made where the guidelines were not applied.

At present, the civil aviation industry is undergoing something of a documentation revolution as the information in documents is becoming available in computer-based form as well as the traditional paper-based form. This allows information to pass more easily between manufacturers, airline engineers, and document users such as Aviation Maintenance Technicians (AMTs). Standards have been promulgated (e.g. by Air Transport Association (ATA)) for formats such as Standard Generalized Markup Language (SGML) which facilitate this information interchange. But the ultimate requirement of the information remains unchanged: it must be usable by an end-user, implying that the user can comprehend the document and use it without error.

The FAA Human Factors in Aviation Maintenance Program has considered the unique needs of computer-based documentation over several years. For example, guidelines for design of workcards delivered by a portable computer were developed and tested by Patel, Pearl, Koli, Lofgren and Drury.[8] (A paper based on this work is currently in press: Drury, Patel, and Prabhu, 1998).[3] A commercial system for computer-based documentation using portable computers has grown out of the project, going well beyond the 1993 prototype demonstration of Patel, Pearl, Koli, Lofgren and Drury.[6,8] With many aviation companies moving to computer-based documentation, a unique opportunity has been presented to improve the quality of document design.

If airlines and others who produce end-user documents are to apply what is known of human factors good practice to the design of their own documents, simple tools are needed for document designers. During 1996, a Documentation Design Aid (DDA) was produced in cooperation with an airline partner to help meet this need.[4] This was either a Windows-based computer program or a paper checklist. The computer version of DDA could go beyond the guidelines presented in the paper-based version, to explain how each guideline was based on quantitative human factors research.

The Documentation Design Aid was evaluated by having engineers use it to make changes to an existing workcard. This usability test showed that even first time users could improve the quality of documentation quite rapidly using the DDA.

But neither usability of the DDA, nor even the usability ratings of documents produced using the guidelines are the ultimate test of documents designed to ensure safe aircraft maintenance.9 The true test is to measure the effect of document design changes on maintenance errors.

An analogous set of tests was performed earlier on aspects of documentation design, the use of Simplified English. Chervak, Drury and Ouelette measured the usability of workcards written in AECMA's restricted language of aviation maintenance — Simplified English.2 Using a sample of 175 AMTs from across the USA, they found that comprehension was higher for Simplified English, particularly for complex workcards and for non-native English speakers. This study was extended to count errors made in task performance, using engineering students and automobile mechanics performing maintenance tasks on a small gasoline engine.1 The Simplified English versions of the workcards produced less errors and performance hesitations than similar workcards not using Simplified English.

The current project extends this methodology to workcard design as a whole, and user errors made during actual maintenance task performance in airline operations, rather than errors made during a controlled experiment. First, however, changes were needed to the Documentation Design Aid itself based upon feedback during the usability trials and from human/computer interaction professionals.

8.2 PROJECT OBJECTIVES

For the current project, we continued to work with the same airline partner used in earlier DDA development. This ensured airline user input into re-design of the DDA for ease of integration into the partner's on-going program of electronic documentation delivery. It also ensured that the ground work for DDA evaluation would be simplified through our organizational linkages developed during earlier DDA development. Finally, a second project with the same airline partner showed members of the airlines documentation team, and maintenance management, that progress was being made towards the deployment of improved documents.

Specific objectives of the 1997-98 project were:

- Objective 1: To modify DDA as required to ensure that it can be integrated with our airline partner's current and future documentation systems
- Objective 2: To provide a direct test of the operational error rates found with DDA and original (non-DDA) documents.

8.3 METHODOLOGY

To meet these two objectives, the project had a design component and an analysis component. These are described in turn.

8.3.1 DDA Integration

The Documentation Design Aid tested at the end of the 1996-97 project provided most of the information required by technical writers to apply human factors good practice to documents such as workcards. However, it lacked a major element, Simplified English, and the DDA user interface did not meet current good practice in human/computer interaction. Additionally, from the point of view of the airline partner, it was a stand-alone system, not integrated with their on-going electronic documentation efforts. The redesign/ integration objective was designed to upgrade the DDA and help its integration into our partner's activities.

Simplified English has already proven useful in workcard design, so it should be incorporated into human factors good practice.2 C. G. Drury attended a meeting of Association Europeenne des Constructeurs de Materiel Aerospatial's (AECMA) Simplified English Committee in May, 1997 to obtain information on the latest developments in Simplified English. We were thus able to use the current version of Simplified English, and to decide on the level of Simplified English support provided in the DDA. There are a number of advanced Simplified English computer programs available which will parse a document to detect deviations from grammar and word choice for Simplified English approved. Examples are the original prototype developed by Boeing, and MAXIT developed by Smart Technologies of New York. Rather than attempt to reproduce the functionality of commercial systems (an effort well beyond the scope of this project and difficult without specialist skills in linguistics), it was decided to incorporate only a Simplified English word checker within DDA. This could be accomplished relatively easily in the Visual Basic™ language used to program DDA.

To check whether a word is part of the approved Simplified English vocabulary, the word is pasted (or typed) to a dialog box within DDA. If the word is in the approved vocabulary the user is told this. If not, the program checks for synonyms of Simplified English words and, if a match is found, suggests the approved Simplified English word. If no match is found, the program tells the user that it cannot recognize the word. The DDA will also check words in a more extensive fragment of text for their compliance with Simplified English. It will not perform grammar checks, for example, the use of passive voice or for long noun clusters.

Although the original DDA interface had proven to have good usability, the knowledge of human factors in computer interface design is expanding rapidly, so that the opportunity was taken for a thorough overhaul. Three human computer interaction specialists from Galaxy Scientific Corporation provided a detailed critique of the DDAs interface and functionality. In addition, two human factors engineers who have taught human computer interaction at the graduate level provided input. Based on these inputs, the menu structure, functions available, and options for program navigation were all re-programmed.

Most of the specific changes made were to the wording of dialog boxes, the colors used for backgrounds, and to the program logic so as to ensure consistency between function in different pairs of the program. For example, the Simplified English checker was presented as a separate dialog box.

While the modifications to the DDA were being programmed, the opportunity was taken to update the sources of human factors good practice in document design. Several more recent compilations of guidelines were located and the appropriate changes made in the DDA content. 5,6,10

An updated version of the DDA is now complete and is available through Human Factors site on Web (www.hfskyway.com) and 1998 Human Factors Guide for Aviation Maintenance CD-ROM.

8.3.2. Evaluation of DDA documents

The evaluation section is presented in some detail to serve as a model for other evaluation efforts. As human factors becomes embedded within many aviation maintenance and inspection organizations, formal statistical evaluation of interventions should become the province of the practicing airline engineer rather than the human factors researcher. Hence, a discussion of the considerations leading to choice of sample size is included. Additional material is supplied on how to measure comprehension and usability, and how to collect error data from maintenance records. Statistical analysis techniques are also presented as a model for evaluation by practitioners.

8.3.2.1. Measures

Operational Effectiveness means that the document should have high comprehension, high user acceptance, and low error rate. Comprehension by the user is measured using a short comprehension quiz on each document. User acceptance was measured by having the user complete a set of rating scales covering different aspects of document design. Both the comprehension quiz and the rating scales have been used in previous studies of document design. Error rate is the final outcome measure. Data on actual paperwork errors was collected from the Maintenance Records department by the partner airline in their regular manner and associated with each test document.

8.3.2.2. Overview of Studies

Two studies have been run: one to count paperwork errors and a separate study to measure comprehension and user acceptance. Campaign Directives (CD) were chosen as the test documents because they typically require immediate compliance. Two versions of each were tested, an original and one produced using DDA. A number of Campaign Directives were used, with each version of a particular Campaign Directive having effectivity for a specific set of tail numbers in the fleet. Total sample size was designed to be in the range of 400-800 completed Campaign Directives for counting paperwork errors. Comprehension and user ratings were analyzed to compare the two Campaign Directive versions in a separate study with a sample size of 100-200.

8.3.2.3. Evaluation Materials

A number of different Campaign Directives were used, to cover a range of length and complexity. Each Campaign Directive were produced in an original version, as supplied by the airline partner and a DDA version produced by the SUNY Buffalo team. The two versions were identical in content, differing only in documentation format and layout. For example, all the DDA versions used Simplified English and the formatting conventions approved by the DDA team at the partner airline in 1996. The two studies used the same set of Campaign Directives where appropriate, supplemented by Engineering Orders where needed. Two versions of one Campaign Directive are attached as examples. These have had the identity of the airline partner removed for publication.

An overview explaining the two studies was presented as a news item in the airline partner's house magazine in November 1997. This is good practice in any human factors study to ensure that potential participants are informed of research efforts which may affect their jobs.

8.3.2.4. Evaluation Subjects

The subject pool consisted of AMTs and/or inspectors at each station who normally perform Campaign Directives. Subjects were not chosen specially, and did not have any identifiers associated with their responses. (Age, gender, years of experience and other demographics were collected for the comprehension/ usability study.) All subjects were told in the magazine item that their responses are confidential, i.e., we are evaluating the document, not the user.

8.3.2.5. Sample sizes

Sample size depends upon the size of effect we want to measure, what the original value was, and how certain we need to be that we have found a real effect rather than chance variation. If we take error rates as our main criterion, then we can eventually compile a table counting the Campaign Directives with and without errors for each version. A Chi-Square statistical test applied to such a table will show the significance of the data, i.e. the probability of finding such an extreme result by chance. Thus if we used 300 original and 300 DDA Campaign Directives, with an original error rate of 6%, and found a 50% reduction in errors with the DDA version, we would have results shown in Table 8.1.

Table 8.1. Hypothetical Results for Sample Size 600, Original Error Rate of 6%, and 50% Error Reduction

	Number with Errors	Number without Errors	Total Number
Original version of CD	**18**	**282**	**300**
DDA version of CD	**9**	**291**	**300**

Performing the statistical test on this data gives a chance of 0.08, or odds of 92 to 8 (11.5 to 1), of finding such a result from chance variation in the data. Typically, a chance of 0.05 or less is the criterion for a statistically significant effect, but readers can draw their own conclusions given the odds. We calculated the probabilities for different original percentage errors and sample sizes, with the results shown in Table 8.2. Combinations, which would lead to a significant outcome, are shaded. Note that this table is based on a conservative estimate from the Chi-Square test. There are slightly more powerful tests but these depend on the actual distribution of errors. Thus, if anything, the sample sizes in Table 8.2 are somewhat overestimated, and represent a worst case for planning.

Table 8.2. Probability of a 50% Reduction in Error Rates being Found Significant by Chance for Different Sample Sizes and Original Error Rates

Percentage Errors in Original	N = 400	N = 600	N = 800
2%	0.41	0.31	0.25
4%	0.24	0.15	0.10

6%	0.14	0.08	0.04
8%	0.09	0.04	0.02
10%	0.06	0.02	0.01

Table 8.2 shows that we really needed about 400 samples to be reasonably sure of a significant result, always assuming that the DDA is an improvement. These 400 samples could come from a number of Campaign Directives spread over a period of time.

Results from the comprehension quiz and the rating scales should show significance with smaller sample sizes. For example, both measures showed significant results on a test of Simplified English using 175 AMTs in a 1995 study. It was planned to use a total sample size of 100-200 for the comprehension/usability study.

8.3.2.6. Procedure

Study 1: Paperwork errors

The evaluation was set up at several stations, using the larger fleets for simplicity. The team communicated with the AMTs and supervision/ management to define the evaluation, how the station would benefit, and what the expectations were for the study. As each suitable Campaign Directive was sent to SUNY Buffalo, a DDA version was produced. Production time, including retyping, for average length Campaign Directives was 2-3 hours. Packages were produced and sent back to the partner airline for a final check for accuracy by the engineer who wrote the CD, and then distribution in the normal manner. Three Campaign Directives were finally distributed in both versions.

When the Campaign Directive was distributed at each station, the originals were submitted and collected in the usual manner. When these were eventually received by Maintenance Records, the errors were counted in the usual way by the Records clerks. SUNY Buffalo did not interfere in any on-going processes of error investigation and discipline associated with the Campaign Directives.

Study 2: Comprehension and usability

A comprehension test, a usability evaluation page, and a short demographic questionnaire were produced for each CD chosen. The examples in Appendix A show old and new versions of a typical CD, with these attachments. Multiple copies of each version (DDA, original) were produced and used for the study. The experiments followed the same protocol used in the Simplified English study in 1995, by visiting each station and administrating the material individually to AMTs and inspectors.

Each individual was given the package, timed for completion of the comprehension test, and then asked to complete the rating scales of the usability evaluation, and the demographic data. The comprehension test has ten questions. Five questions were on the content of the CD, for example, “What do you do if a delamination is found?” The other five questions asked where (CD step number) the answer to the content question could be found. Packages were collected and the comprehension test scored as percent correct.

8.4 RESULTS

The results are in two parts to correspond to the design and evaluation objectives. Under evaluation, the main results are from Study 2 with results collected by the end of the project for Study 1. It is the airline partner’s intention to complete Study 1 and provide SUNY Buffalo with the data for later analysis.

8.4.1 DDA Integration

Now that the DDA has been rewritten and tested, it is being integrated into the partner airline's operations. This is not as straightforward as it would appear because (a) the airline has existing standards which may conflict with DDA recommendations and (b) there is an on-going program of moving from paper-based to electronic publishing. Because both of these reasons are replicated at other airlines, they are worth consideration here.

All airlines have documentation standards, typically based on an ATA standard or guideline, and referenced in legal documents such as the general maintenance manual. Any change, even one which improves documentation, must pass through an approval process both at the airline and with the local representatives of regulatory authorities. Close cooperation is required between airline personnel and regulators (e.g., MIs in the USA) to ensure that this proceeds smoothly. A single person who wants to see the changes made should be given responsibility for implementing this aspect of change. Any change can be seen as a threat by some of those it affects, so there are natural tendencies to assign on such changes a low priority. Having a single committed change agent can speed the overall process.

Most airlines are moving towards electronic publishing of many maintenance-related materials, which provides a unique opportunity to incorporate good human factors practice into the final documents. However, most of the participants in electronic publishing are not trained in human factors, so that their main concerns are for electronic compatibility rather than user/document compatibility. Too often, human factors can be seen as just another restriction on "getting the job done." To take advantage of the opportunity inherent in this change, those responsible for human factors in airlines (and other maintenance organizations) will need to actively seek out electronic publishing initiations and ensure that human factors considerations are brought into the process early.

8.4.2 Evaluation of DDA Documents

As data was collected in the two studies, it was entered into a statistical data analysis package, MINITAB™. This allowed tabulation of results and performance of statistical significance tests on the data.

Study 1: Operational Effectiveness

For Study 1, counts of numbers of documents with and without errors for each CD were tabulated, similar to Table 8.1. When the maximum number of data points in the project period had been collected, a statistical analysis was performed to determine whether the improvements were beyond the chance level.

Three CDs were used in this study, differing in length and complexity. As shown in Table 8.3, the DDA versions had more steps, more words and a lower Fleish-Kincaid reading score. The DDA produces more explicit information, leading to more steps and words, but ensures that the document is easier to read, leading to the lower Fleish-Kincaid score.

Results collected so far (end of March 1998) are shown in Table 8.3. Note that overall, two errors were detected out of the 38 original versions and zero errors out of the 11 DDA versions. The error rate for the original version (5%) was in line with the historically-expected value, but the numbers are too low for statistical analysis using the Chi-square test. Our partner airline has agreed to continue making data available to SUNY Buffalo for analysis as all CDs are completed. This would give a sample size of well over 100 instead of the current sample size of 49, but may still not be large enough to provide an adequate test (see Section 8.3.2.5). Over three times as many original versions were issued as DDA versions, because the original versions were released earlier from the Engineering Department.

It is interesting to consider the types of errors made in the study, and also to analyze confusions as well as actual errors. Both errors were in one CD (coded "21") which required both part number and serial number to be recorded for left and right water separators. One error was that both numbers were incorrect, the other that the part number was incorrect. Both CDs were sent back to the station to be completed correctly.

In fact, there were two serial numbers on each part, one assigned by the manufacturer and one assigned by the airline. Neither version was specific on which was to be recorded. The original said:

"..... record manufacturer's part number and serial number....."

while the DDA version said:

".....find the manufacturer's part number on the data plate on the side of left water separator and record it. Then find serial number on the data plate or within close proximity to the data plate on the right side of the water separator and record it....."

Thus although in the original version "manufacturer's serial number" is implied, it is not stated. In the DDA version, the description above leads the user to the airline's serial number. All six DDA-version users recorded the airline's serial number, whereas only 13 of the 22 original-version users did this. The others recorded either the manufacturer's serial number, or both, or differed between the right and left sides. While all are technically correct, the DDA version provided the uniformity which is so desirable in airline maintenance record-keeping. On the same CD, the original version had three other problems with specifying the replacement of the water separators, although none were considered errors of the records clerks.

For the CD coded "36" no errors were found but some difficulties were seen in the records. In the DDA version, one inspector did not stamp a block where he had written "N/A", and also had two digits transposed in the part number, but both were corrected. For the original version two inspectors had stamps which the team found illegible, although the records clerks could read them; one inspector had written N/A in spaces he should have left blank, and one recorded the airlines part number for the replacement part instead of the manufacturer's part number.

In summary, Study 1 was not continued long enough to produce statistically significant results. However, both of the two errors recorded and most of the problems encountered occurred in the original version and not the DDA version.

Table 8.3. Details of the Three CDs Issued, with Numbers of Errors

CD Code	Version	CD Steps	CD Words	Fleish-Kincaid Score	# without Errors	# with Errors	Total
36	**Original**	**5**	**134**	**11.4**	**11**	**0**	**11**
	DDA	**7**	**259**	**10.1**	**5**	**0**	**5**
21	**Original**	**3**	**122**	**10.4**	**20**	**2**	**22**
	DDA	**6**	**294**	**9.7**	**6**	**0**	**6**
25	**Original**	8	379	8.2	5	0	5
	DDA	11	442	7.1	0	0	0

Study 2: Comprehension and Usability

The comprehension and usability study was performed on a total of 101 AMTs at seven stations of our partner airline. All AMTs were line maintenance personnel who regularly perform the work required of CDs. The two versions of the three CDs were distributed randomly, giving the following total number of AMTs:

Table 8.4. Number of AMTs Tested

	CD1	CD2	CD3	Total
Original	17	18	17	52
DDA	19	14	16	49
Total	36	32	33	101

Age and experience distributions of the sample are shown in Figures 8.1 and 8.2. Median age and experience were compared to the population data collected by the Bureau of Labor Statistics (1988) using a Wilcoxon test. Both age and experience were different from the population values ($t = 3918$, $P < 0.001$; $t = 4286$, $P < 0.001$) showing that our sample was somewhat older and more experienced of the national population of AMTs was in 1988.

Analyses of variance were performed on the comprehension measures of Number Correct and Time Taken. (The model used was a two factor fixed effects ANOVA.) A significant effect of version (Original versus DDA) was found for Time Taken ($F(1, 91) = 12.59$, $p = 0.001$). Also, the effect of CD was significant for Time Taken ($F(2, 91) = 6.58$, $p = 0.002$). No interactions were significant.

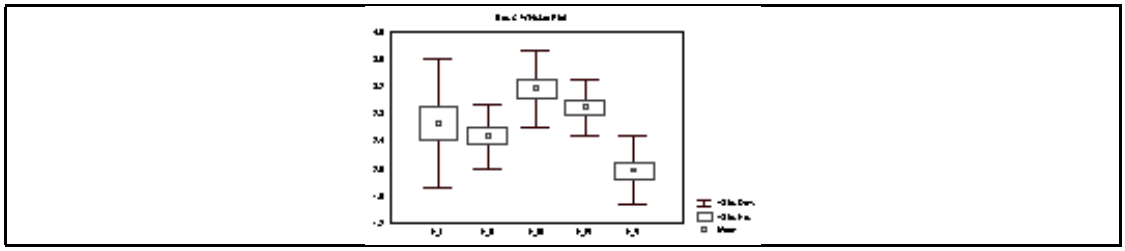

Figure 8.1. Age Distribution of AMT Sample

For Number Correct, two covariates gave significant effects, AMT age ($t = -3.08$, $p = 0.003$) and AMT experience ($t = -2.13$, $p = 0.036$). When either covariate was included in the analysis, Version became significant (Age: $F = 3.76$, $p = 0.056$, Experience: $F = 4.29$, $p = 0.041$). In both cases, the number correct decreased with the covariate, showing that older and more experienced AMTs had less correct answers. The regression equations were:

Number correct = 11.15 - 0.045 X age

Number correct = 9.82 - 0.03 X Experience

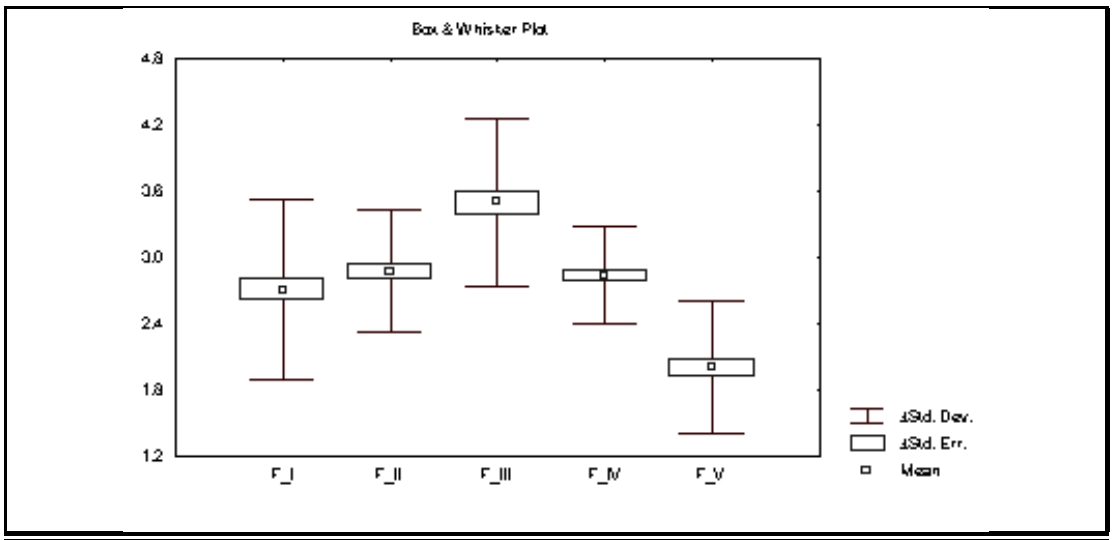

Figure 8.2. Experience of Distribution of AMT

The effects of version on the two performance measures are shown in Figure 8.3 and 8.4. Note that for consistency with previous studies Percent Errors is used in place of Number Correct where:

$$PercentErrors = \frac{NumberCorrect}{10} X \quad 100\%$$

Compared to the original CDs, the DDA version reduced the error rate by about 40% and increased the time taken by about a quarter. This is direct evidence that DDA -designed documents impact the major variable of interest to airlines, regulators and the public, i.e., error free performance. DDA-designed documents achieve this effectiveness at a modest cost in time to read, comprehend, and answer the ten questions, adding about two minutes to this total time.

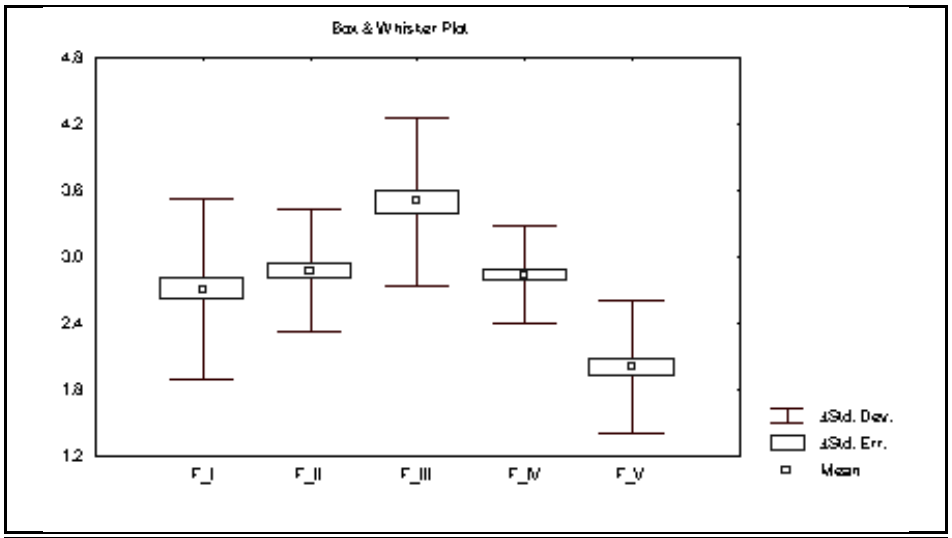

Figure 8.3. Number Correct for the Two CD Versions

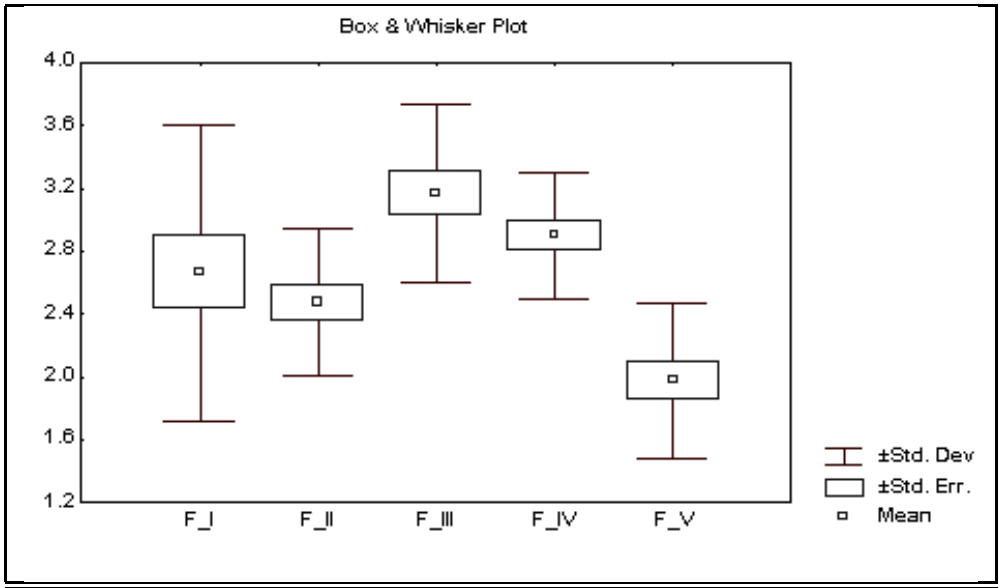

Figure 8.4. Time Taken for the Two CD Versions

It was expected that the time taken would be different for the three CDs used, and indeed it was. One CD was completed more rapidly than the other two. This was the one with the fewest steps and fewest words. Figure 8.5 shows the correlation between time taken and total number of steps in the CD. Note that the DDA format, by making all steps explicit, gives more steps and thus increases reading time. However, the accuracy, i.e. number correct, was not predicted by the number of steps or similar measures such as number of pages or words. Thus while the DDA version took longer to read, because of its greater length, its accuracy was greater as noted earlier.

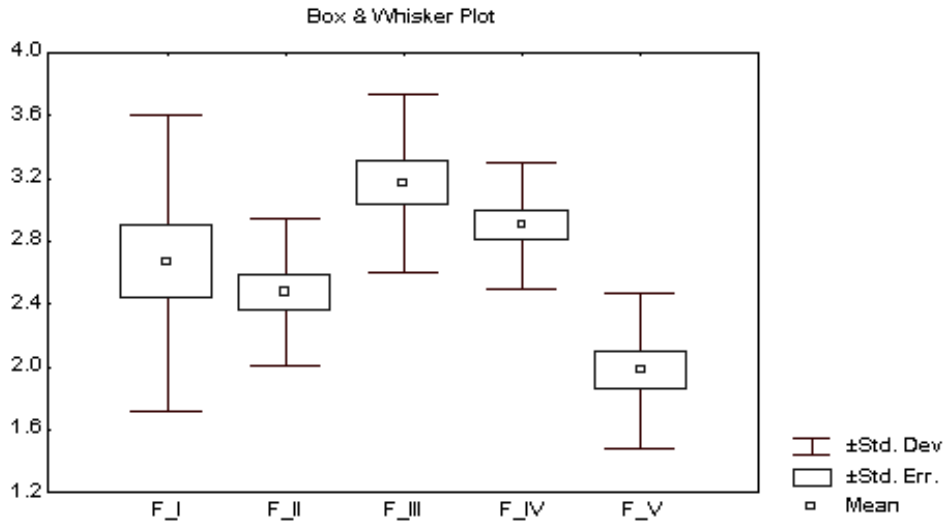

Figure 8.5. Effect of Number of Steps in the CD on Time Taken

A final finding concerning comprehension was that very few of the demographic measures affected either comprehension time or number correct. One-way ANOVA's were conducted for each of the fifteen variables measured, such as which station the AMTs were based at, which aircraft types they worked on, and their native language. Only two of these thirty statistical tests were significant at $p < 0.05$; by chance 1.5 would be expected to be significant at this level, so that little credence can be placed in these demographic results. For the record, number correct was related to whether or not the AMTs worked on Fokker products ($F(1, 99) = 4.20$, $p = 0.043$) and whether or not English was their first language ($F(1, 99) = 4.46$, $p = 0.038$). The latter finding reflects earlier work on Simplified English (Chervak, Drury and Oullette, 1996) which showed that native English speakers had higher comprehension performance. In the current study there were only four AMTs out of 101 who did not have English as their first language, again suggesting caution in interpreting these particular results.

Rating scale data to measure usability showed very few significant differences for either CD or for version. No effects of version were significant and only four ratings of CD:

Readability $F(2, 69) = 3.64$, $p = 0.031$

Ease of relating figures $F(2, 69) = 3.44$, $p = 0.038$

Ease of readability of attachments $F(2, 69) = 3.20$, $p = 0.047$

Relating graphics to aircraft structure $F(2, 69) = 3.14$, $p = 0.050$

Overall, ratings on single direction scales (0 = bad, 8 = good) were high, with averages ranging from 5.1 to 6.1. All median were significantly greater than the neutral value (4) and significantly below perfect (8) using the Wilcoxon test. On double-ended scales (0 = too little, 4 = just enough, 8 = too much), the ratings were all close to the center, ranging from 4.0 to 4.9. The conclusion is that AMTs found the DDA-designed CDs no different from the original versions, and rated both versions as highly usable.

Where possible, the actual errors made were tabulated in both studies. This allowed us to classify the errors and to determine where users were having difficulty with documents. For example, some errors were found to be system errors, such as stores supplying an incorrect part for fitting, rather than documentation errors.

In the comprehension study, the errors were tabulated for the five content questions and the five questions asking where in the CD the answer could be found. The total errors were as follows:

	Original	**DDA**
Content questions	19	6

The difference between the original and the DDA versions is significant for content questions (X^2 (1) = 6.76, $p < 0.01$) but not for location questions (X^2 (1) = 1.00, $p > 0.50$). Thus the main effect of the DDA is to reduce content comprehension errors. In fact, the errors using the DDA version are reduced by two thirds from the original. Content errors are much more operationally important than errors in specifying where the relevant content can be found. This analysis of the types of errors made makes an even stronger case for the DDA versions of the CDs than did the earlier analysis based on overall error rates.

8.5 DISCUSSION AND CONCLUSIONS

We now have a documentation design aid completed and ready for use. It was designed to incorporate the results of previous quantitative studies which define good human factors practice in documentation design. But no tool should be accepted until the design has been validated. The original DDA was tested for usability in 1996-97 and found to be effective even for first time users. Using DDA, document writers were able to find many improvements in an existing document, and all rate the usability as good.

This year we have re-written the DDA and tested it in a practical quantitative manner. The rewritten version is better human-engineered and now incorporates a Simplified English checker. Although the operational trials were few in number, they and the comprehension study fully vindicate the DDA. Documents designed using the DDA produced fewer errors than their original, and quite well-designed, counterparts.

In the operational study, only two errors were found, but both were for the original versions of the CDs. In addition, the DDA versions had less problems and confusions than the original versions. In the comprehension study, comprehension error rate was reduced by about 40%. Content comprehension errors, which have the greatest operational relevance, were reduced by about 70%. The time taken to read and comprehend the documents increased by about 25%, mainly due to the increased number of steps in the more explicit format of DDA-designed documents. Any system which reduces errors by 40% (or 70%) for a two-minute increase in task time represents an operationally- significant improvement. The DDA is also measurably easy to use (from the 1996-97 data) and produces documents which receive high ratings for usability (from the 1997-98 rating data).

This project has also been designed to provide a model for evaluation of human factors changes. The issues of sampling and testing have been explicit so that those with human factors responsibility in airlines and other repair organizations can perform their own quantitative evaluations of the changes they develop. As human factors functions in airlines become established, rapid quantitative evaluations will become an increasingly important aspect of their work.

8.6 REFERENCES

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8.7 APPENDICES

8.7.1 Appendix A – Original Campaign Directive

SUNY Airways CAMPAIGN DIRECTIVE **CD No. ABCD1234**

TITLE: AIR CONDITIONING - Record Serial Number of Left and Right Water Separators to Begin Tracking

WORK INSTRUCTIONS (continued) **| Accomplished By | Checked By**

SUNY Airways CAMPAIGN DIRECTIVE **CD No. ABCD1234**

ATA

DATE:

AIRCRAFT/ENGINE TYPE TITLE:

SUNY 96

Weight Change

Reason for Request:

Reliability Engineering has requested tracking of xx96 to analyze continuing problems with water dripping from the air condition system onto the passengers.

AD/FAR No.

ETOPS Requirement

PROJECT No.

References:

Est. Manhours

Est. Downtime

SPECIAL INSTRUCTIONS

Prepared by

Checked by

Approved by

1. *XX Dept.*:
   a. This CD is to be accomplished no later than 120 days from release to XX.
   b. If feedback sheet is not returned with completed paperwork, this CD must be rescheduled.

2. *SUNY Research*:
   a. Begin tracking the tail number, position, manufacturer's part number and serial number of xx92 on the SUNY 96 fleet.
   b. If feedback sheet is not returned with completed paperwork, this CD must be rescheduled.

Material Req'd to Accomplish:

Quantity	CCN	Description
N/A	N/A	N/A

Parts Removed:

Quantity	CCN	Description	Disposition
N/A	N/A	N/A	N/A

PRIORITY SUNY Requirement X_ NO LATER THAN : ___CHECK _____FLIGHT HOURS __CYCLES

FAA Mandatory ** See Note to Planning _____DAYS _____MONTHS _____YEARS

WORK INSTRUCTIONS

	Accomplished By	Checked By
1. Locate water separators in rear of aircraft. The manufacturer's part number is found on the data plate on the side of the water separator. The serial number may be found on the data plate or within close proximity to the data plate on the side of the water separator. See Figure 1 for location of data plate.		**NOT REQ'D**
2. On the Feedback Sheet attached, record manufacturer's part number and serial number from the right and left side water separator. Be sure to return the Feedback Sheet to SUNY FAA Research Group. NOTE: Removal of the water separator may be necessary. Refer to XX 11-00-22 for procedure.		**NOT REQ'D**
3. If removal of water separator was necessary, reinstall water separator per XX 11-00-22. NOTE: N/A this step if removal of water separator was not necessary.		**NOT REQ'D**

All Campaign Directive Work Instructions accomplished, all sign-offs legible and information completed.

AIRCRAFT_____ STATION_____ DATE_____

Logbook Page Number_____

LEAD MECHANIC OR SUPERVISOR _____ EMP. #_____

SUNY Airways	CAMPAIGN DIRECTIVE	**CD No. ABCD1234**
TITLE: AIR CONDITIONING - Record Serial Number of Left and Right Water Separators to Begin Tracking		

FEEDBACK SHEET

Please complete the following information:

Station: _____

Date : _____

A/C Tail Number: _____

Left Hand
Side

Manufacturer's Part Number: _____

Serial Number: _____

Right Hand Side

Manufacturer's Part Number: _____

Serial Number: _____

Upon completion of this Feedback Sheet, please return all paperwork to SUNY FAA Research Group.

8.7.2 Appendix B – DDA Version

SUNY Airways Campaign Directive-ABCD1234

Title: AIR CONDITIONING – Record Serial Numbers of Water Separators to begin Tracking Reliability	**Date :** 11/21/97 **ATA:**

Reason for Request: Reliability Engineering has requested tracking of form 92 to analyze continuing problems with water dripping from the air conditioning system onto the passengers.

AD/FAR No: N/A

ETOPS **Requirement:** NO

Project No: 7711x3

Aircraft/Engine Type: SUNY 96

Material Required to Accomplish: N/A

Effectivity:

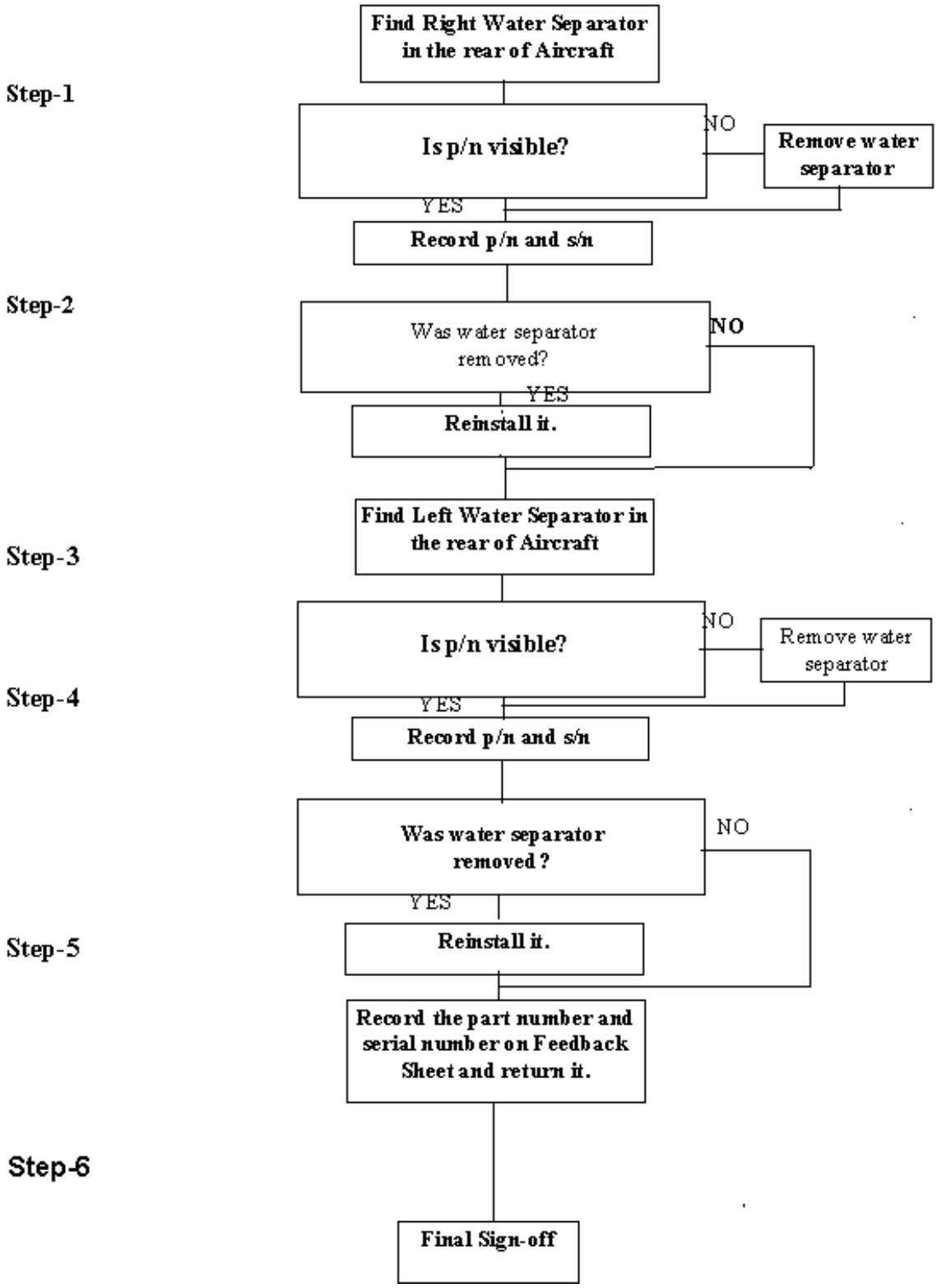
Date	**Effectivity**
11/21/97 **(Original)**	

SUNY Airways Campaign Directive-ABCD1234

Title: AIR CONDITIONING – Record Serial Numbers of Water Separators to begin Tracking Reliability	**Date :** 11/21/97 **ATA:**

FLOW CHART

WARNING: This flow chart is only for information purposes. Please do not use this flow chart to perform the steps in this Campaign Directive.


Find Right Water Separator in the rear of Aircraft
Step-1
Is p/n visible?
NO
Remove water separator
YES
Record p/n and s/n
Step-2
Was water separator removed?
NO
YES
Reinstall it.
Find Left Water Separator in the rear of Aircraft
Step-3
Is p/n visible?
NO
Remove water separator
Step-4
YES
Record p/n and s/n
Was water separator removed ?
NO
YES
Step-5
Reinstall it.
Record the part number and serial number on Feedback Sheet and return it.
Step-6
Final Sign-off

SUNY Airways Campaign Directive-ABCD1234

Title: AIR CONDITIONING – Record Serial Numbers of Water Separators to begin Tracking Reliability	**Date :** 11/21/97 **ATA:**

Work I nstructions: **Accomplished by** **Checked by**

1. Find right side water separator in rear of aircraft. Then, find manufacturer's part number on the data plate on the side of right water separator and record it. Then, find serial number on the data plate or within close proximity to the data plate on the side of the right water seperator and record it. See Figure 1 for location of data plate.

Note: If part number and serial number are not accessible, removal of the water separator may be necessary. Refer to XX 11-00-22 for procedure.

Right Water Separator Part Number_____

Right Water Separator Serial Number_____

2. If removal of right water separator was necessary, reinstall water separator per XX 11-00-22.

Note: N/A this step if removal of water separator was not necessary.

3. Find left side water separator in rear of aircraft. Then, find manufacturer's part number on the data plate on the side of left water separator and record it. Then, find serial number on the data plate or within close proximity to the data plate on the side of the left water seperator and record it. See Figure 1 for location of data plate.

Note: If part number and serial number are not accessible, removal of the water separator may be necessary. Refer to XX 11-00-22 for procedure.

Left Water Separator Part Number_____

Left Water Separator Serial Number_____

4. If removal of left water separator was necessary, reinstall water separator per XX 11-00-22.

Note: N/A this step if removal of water separator was not necessary.

5. On the Feedback Sheet attached, record manufacturer's part number and serial number from the right and left side water separator. Be sure to return the Feedback Sheet to SUNY FAA Research Group.

6. All Campaign Directive Work Instructions accomplished, all sign-offs legible and information completed.

Aircraft_____Station_____Date____/____/_____

Logbook Page Number_____

Lead Mechanic Or Supervisor _____ Emp. #_____

SUNY Airways **Campaign Directive-ABCD1234**

Title: AIR CONDITIONING – Record Serial Numbers of Water Separators to begin Tracking Reliability	**Date :** 11/21/97 **ATA:**

FEEDBACK SHEET

Please complete the following information:

Station:_____

Date:_____

A/C Tail Number:_____

Right Hand Side

Part Number:_____

Serial Number:_____

Left Hand Side

Part Number:_____

Serial Number:_____

Upon completion of this Feedback Sheet, please return all paperwork to SUNY FAA Research Group, Buffalo

SUNY Airways **Campaign Directive-ABCD1234**

Title: AIR CONDITIONING – Record Serial Numbers of Water Separators to begin Tracking Reliability	**Date :** 11/21/97 **ATA:**

(Example only. No actual figure included.)

Figure-1: Water Separator

SUNY Airways **Campaign Directive-ABCD1234**

Title: AIR CONDITIONING – Record Serial Numbers of Water Separators to begin Tracking Reliability	**Date :** 11/21/97 **ATA:**

Management Data Section:

Prepared by S. Felix/P. King_____

Checked by J. Oberdick

_____

Approved by M. Rudo_____

References:

Allied Signal CMM 21-70-3

MD-80 MM 21-20-02

DC-9 MM 21-20-
02

Weight Change: N/A

Estimated Manhours: 1.0

Estimated Downtime: 1.0

Special Instructions:

1. **Planning:**
   a. This CD is to be accomplished no later than 120 days from release to planning.
   b. If feedback sheet is not returned with completed paperwork, this CD must be rescheduled.

1. **Technical Records**:
   a. Begin tracking the tail number, position, manufacturer's part number and serial number of rcn 92131 on the MD-80/DC-9 fleets.
   b. If feedback sheet is not returned with completed paperwork, this CD must be rescheduled.

Priority

US Airways Requirement: YES

FAA Mandatory:
NO

No Later Than: _____ **Check** _____ **Flight Hours** _____ **Cycles**

(**See Note to Planning**)_____ **Days** _____ **Months** _____ **Years**