

Text signals in the aircraft maintenance documentation

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Abstract: After a brief description of the aircraft maintenance documentation through its functions and content, this paper presents results from two types of studies about the use of text signals in the maintenance documentation used in the aeronautical field. The first study is based on the observations and interviews of the maintenance operators during their task; the second study concerns ergonomic inspection of the documentation based on ergonomic criteria about structure and content. The two results confirm the problem linked to the information presentation (characters size, bad quality of figures, etc.) and structure and allow also concluding that aircraft maintenance documentation must be improved by the use of more efficient text signals in order to make easier the use the documentation at the work place and to avoid maintenance errors.

Keywords: Aircraft maintenance documentation, procedural documentation, text signals.

1 Introduction

Maintenance and inspection are the major factors of aircraft accident for 12 % (Hobbs, 2000) because of errors made during the operation. According to Chaparro et al. (2002) and the FAA (Federal Aviation Administration), the cause of most of the maintenance errors is the documentation used to guide maintenance tasks. For Lattanzio et al. (2008), procedural errors in aeronautic maintenance have different forms and are due to both document quality and users errors (see Figure 1).

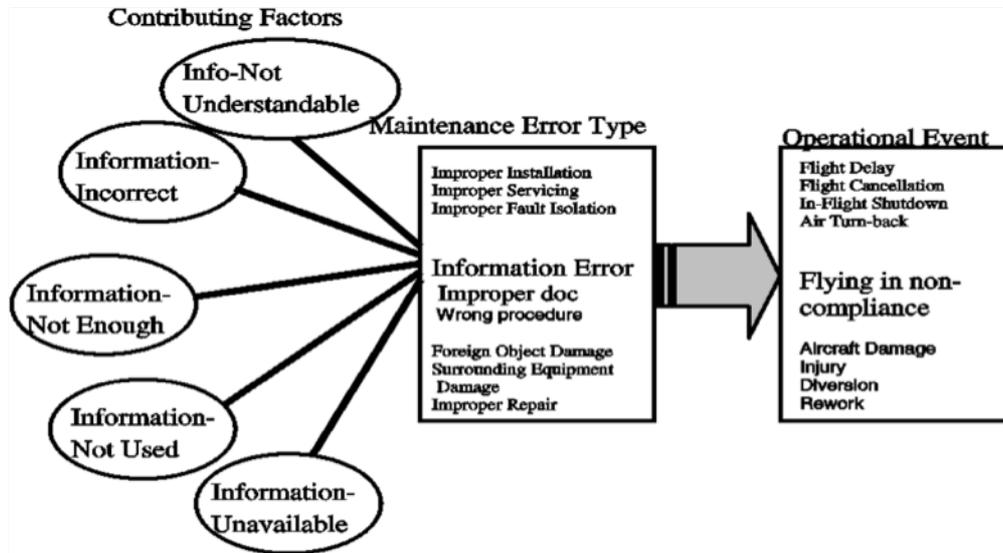


Figure 1 The relationship between information quality (contributing factors), maintenance error types and operational events (Lantazio et al., 2008).

Consequently, the usefulness (relevance of the content) and the usability (relevance of the access to the content) of the maintenance documentation must be improved in order to encourage at least the operators to use the documentation. Indeed, according to Chaparro et al. (2004), the 64% of maintenance technicians report using their own manner to execute maintenance procedure. Some routine maintenance tasks are completed in a different manner than the procedure in the documentation (McDonald et al., 2000). Van Avermaete and Hakkeling-Mesland (2001) also report that 34 % maintenance technicians turn away from the documentation.

In view of the issue of a documentation which is not used systematically, or if used constitutes a factor of human errors, this article concerns information presentation in the maintenance documentation in order to make an inventory of the features (signals) used for this purpose, their role and to determine the points to be improved. Indeed, according to Caro et Bétrancourt (2001), beyond the document content, the structure and the layout have a repercussion in the reader's representation, and consequently in his later task performance. This influence is particularly important in the technical documentation because of the disastrous human and equipment consequences of the bad interpretation of the content.

The aircraft maintenance documentation will first be described by its different functions and its content. Secondly, ergonomic inspection results about the signals in the aircraft maintenance documentation will be presented. An inventory of signals rarely or not used in the documentation will then be established. Finally, information from a field study about the role of signals in the aircraft maintenance documentation use will be presented.

2 Brief description of the aircraft maintenance documentation

2.1 The functions of the aircraft maintenance documentation

The maintenance documentation used in aeronautic domain has three functions: a support of maintenance task, a legal document and a support of training.

2.1.1 The documentation as a support of the maintenance task

The technical documentation used in the aeronautical maintenance is a procedural document: it is used to complete an action, which is the maintenance task. It aims to guide the maintenance operator through a list of instructions in the task execution (Montmollin, 1997; Cellier, 2005). The documentation corresponds to the prescribed task of the operator: it describes how the work must be completed. The documentation consultation is a part of the maintenance task. It is strongly linked to the operator's task.

2.1.2 The documentation as a legal document

In the aeronautic field, documentation use is legally obligatory. It constitutes a proof that maintenance operation has been executed in accordance with the instruction. Thereby, the maintenance documentation is a mean certifying safety and security of the aircraft system after the maintenance operation. Indeed, the maintenance operator must sign in the documentation used at the end of the maintenance operation. The signature has an important legal role. For the maintenance center, it constitutes a protection in case of a conflict with the customer after the delivery of the aircraft.

2.1.3 The documentation as a support for the training

The maintenance documentation has also a role of a support for the training of maintenance operators. In developing countries, as maintenance operators have a thorough knowledge of the job since their training, the maintenance documentation is mainly used as a support to the maintenance task, contrary to the least developing countries where users (operators) most frequently discover the documentation during the task completion.

2.2 The maintenance documentation content

Aircraft maintenance documentation makes available different information such as maintenance tasks references and titles, a list of figures (a figure illustrates the procedure of the task selected by the user), the identification code of the task (called *code FIN*), warnings message, caution message, the *job set-up information* which corresponds to the information about the task context and material required (e.g. Fixtures, Tools, Test and Support Equipment) with the reference, the quantity and the designation ; the work zones (job

location) and the access panels (i.e. how to access to the work zone) ; the *Job set-up* which gives details about other information required before the completion of the main procedure, such as the *safety precautions* (e.g. “Put the warning notice in the cockpit to tell persons not to operate the landing gear”), a check to do before the main procedure, information about the aircraft maintenance configuration (e.g. “make sure that the PARK BRK control switch is set on ON”) ; the *Procedure* (the main procedure which constitutes the object of the maintenance operation). A procedure can be a set of subtasks. Thus, the *Procedure* section contains information about the reference, the object and the procedure of each subtask and sometimes a caution; the *Close-up* which consists in the information about the tasks to be completed after the maintenance operation (e.g. setting right the aircraft, cleaning the workplace, etc.).

The description of the task in the maintenance documentation corresponds to the MAD formalism (Analytic Description Method) described by Sébillotte (1991). According to the MAD formalism, task disposes of different characteristics:

- An identification: title, number (reference)
- Elements: the aim of the task, an initial state of the task, pre conditions (constraints concerning the initial state of the object, which corresponds to the warnings in the maintenance documentation), the “body” of the task (information about how the task is executed, i.e. the subtasks), the postconditions (constraints concerning the final state of the object, which corresponds to the close-up part), the final state of the object (a list of the elements modified by the task)
- The attributes: specific characteristics of some subtasks (optional, iterative, priority, interruptible). According to the aircraft maintenance documentation, some tasks cannot be executed under some weather conditions or need specific qualification.

3 Signals in the aircraft maintenance documentation

The inventory of the following signals means is based on the study of Caro and Bétrancourt (2001) about the ergonomic study of electronic document, and on the definition given by Terrier et al. (2005) of features used to draw reader’s attention. For Terrier et al. (2005), important elements and information within a text are distinguished by the use of different types of means (called MFM or Mise en Forme Matérielle): typographical properties (bold characters, italic characters, etc.), layout properties (space, indentation), and colour. The lack of those means makes reading difficult and cognitively costly because of the necessity to read the text entirely to find the information required.

3.1 Layout properties

- Space: in some maintenance documentation, there is no space between items.

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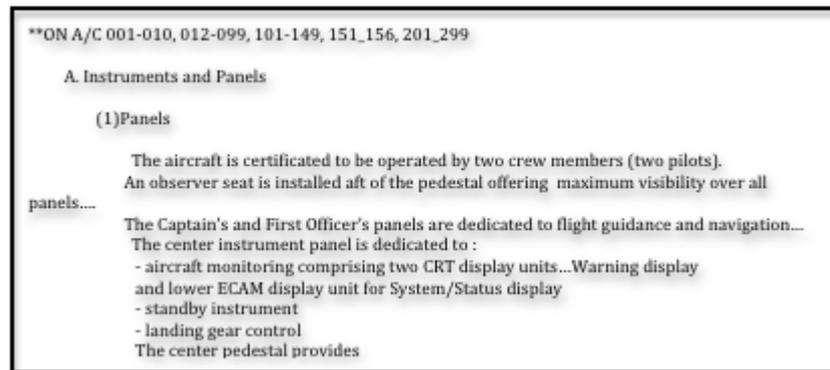


Figure 2 Text spacing in the maintenance documentation

The lack of space between different items can induce difficulty to the user when reading the documentation. According to Caro and Bétrancourt (2001), more space improves the reading speed.

- Listing: numerical and alphabetical listings are used in the aircraft maintenance documentation.

The numerical listing can be a number followed by a dot to indicate a section in the procedure (e.g. 4. Job set-up) or a number between brackets to indicate a step in the procedure (e.g. (1) Put the safety barriers in position).

The alphabetical listing can be a capital letter followed by a dot used for the subsection or a minuscule letter between brackets to list the different actions of a step in a procedure

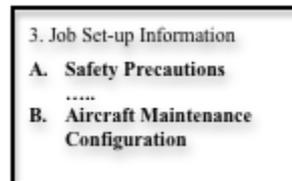


Figure 3 alphabetic listing using Capital letter + dot

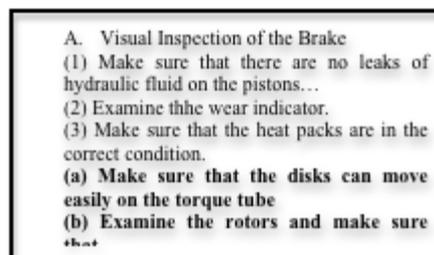


Figure 4 alphabetic listing using minuscule letter between brackets

3.2 Typographical properties

3.2.1 Use of capital letters

The text combines capital and miniscule letters. Capital letters are used in different cases:

- The first letter of each word in the titles (e.g. Job Set-up Information, Fault Confirmation, Procedure, etc.) and subtitles (Safety Precautions, Aircraft Maintenance Configuration, etc.). Using a capital letter at the beginning of each word makes easier the information locating. Furthermore, contrary to the miniscule characters, capital letters are more readable from a certain distance (Smith & Mosier, 1986).
- To indicate tools and equipment even though they are cited in the text of the procedure (e.g. « Lock the impeller with the **DISASSEMBLY TOOL** »)
- To indicate information about hygiene and safety (**WARNING, CAUTION, NOTE**)

Those capital letters are used to attract the user attention (Smith, Mosier, 1986), particularly when the operator doesn't read entirely the procedure in the maintenance documentation.

3.2.2 Use of bold characters

The use of bold characters to mark information is better than the use of capital letters in information retrieval task (Foster, 1979). For Rivlin et al. (1990) cited by Caro and Bétrancourt (2001), bold character is one of the most salient means to point up an element. This mean is rarely used in the maintenance documentation (only for the column titles in the tables).

REFERENCE	QTY	DESIGNATION
No specific		Warning notice
MG174-04	1	DISASSEMBLY TOOL

Table 1 - use of bold character

3.2.3 Underlining

In the aircraft maintenance documentation, the underlining is used :

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- To accentuate some elements as WARNING, CAUTION, NOTE, or section title of the document. Indeed, the maintenance documentation is divided into different sections corresponding to the different information the operator needs before the execution of the maintenance operation.



Figure 5 Use of underlining (1)

- To indicate hypertext links: within the documentation, the main procedure can include some subtasks available through hyperlinks. Hyperlinks are also used to view the figure corresponding to a procedure. Those hyperlinks allow saving space on the page. Indeed, a given procedure can concern different aircraft versions or models. In order to not encumber the page with the different figures corresponding to different models, hyperlinks let the user opening a little window to visualise the figure required.

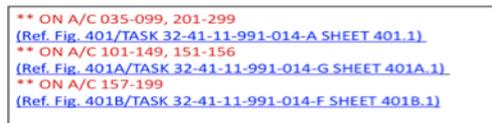


Figure 6 Use of underlining (2)

3.3 Colours

The colours used take into account on the one hand the standard and on the other hand the aeronautical norm ATA (Air Transport Association). Thus, the orange letters are used for the cautions, the red letters for the warnings, the blue for the hyperlink and the yellow underlining to indicate modification in the procedure. In all, five colours are used in the maintenance documentation. It is in accordance with the document ergonomic recommendation, which advises not to use more than five colours in a document to avoid user difficulty in reading. Moreover, a regularity (use of the same colour to indicate the same type of information) can be noted in the use of colours in the maintenance documentation: the red to indicate a danger (warning), the yellow for the attention (caution), the black for normal information (i.e. the procedure) and the blue for the hyperlink

4 Signals rarely or not used in the maintenance documentation

- Indentation: some maintenance documentations don't use the indentation to organise information. The text is formed by a left centred block without any space between the different sections.

003 OPERATIONAL TEST OF VHS SYSTEM
1. VHF1 TEST IN RECEPTION MODE
A. ON ELECTRICAL CENTER PEDESTAL, ON AUDIO CONTROL PANELS SELECT VHF1 RECEPTION...
B. ON VHF1 CONTROL UNIT
- PLACE « OFF/PULL/TST » SELECTOR
- PERFORM TEST BY PULLING...
C. SELECT A LOCAL FREQUENCY

Figure 7 Lack of indentation in the procedure

- Italic characters: the aircraft maintenance documentation never contains any italic character to distinguish information.

In addition to the ergonomic inspection, a field study allows having more contextual information about the use and the role of signals in the aircraft maintenance documentation. Some results of a field study are presented below.

5 Information from a field study about the role of signals in the aircraft maintenance documentation use

5.1 Presentation of the study

In 2008, we lead an explorative field study with the maintenance operators to understand the use of the aircraft maintenance documentation at the work place. The aim of the study is to grasp the work practice and to analyse the use, the context and the use conditions of the maintenance manual. The study involved 13 operators (11 maintenance operators, 1 foreman and 1 quality manager) aged from 22 to 50, with 12 males and 1 female, at three aircraft maintenance and repair centres in Toulouse. An observation grid has been established in order to gather information concerning the study issue. The object is to know when, how, what for the operator uses the documentation, and if he/she doesn't use it, why? Those questions are synthesized on the figure below.

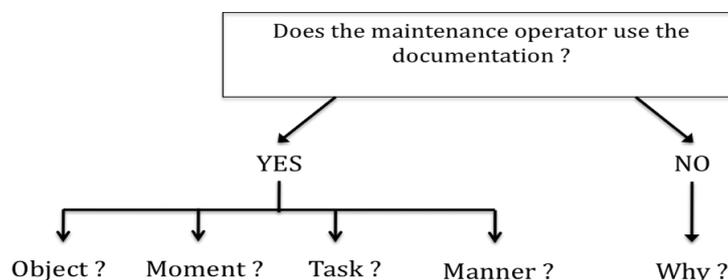


Figure 8 Questions about the use of the documentation by the operator

Interviews with the managers have first been lead and have been completed by the observations of the operators during the task execution. Individual and collective interviews have been carried out with the same operators in order to complete information resulted from the observations.

5.2 Study Results

The results of the study carried out with the operators in the field confirm that the layout and the content of the documentation are the main reasons of the difficulty of the documentation use in the aeronautical maintenance. Indeed, maintenance operators don't use the maintenance documentation. If they use it, they don't read the whole documentation to don't spend too much time to the task execution. Indeed, according to the operators, the maintenance documentation is not easy to use because of different reasons. Those reasons can be divided into two categories depending on the document format (electronic or paper).

5.2.1 Electronic documentation

Reasons of the difficulty can concern the document structure or the document content.

- Document structure

According to the maintenance operators involved in the field study, the maintenance documentation is not very efficient due to the bad information structure and presentation. For instance, elements of the same information are spread over several pages.

- Document content

Other efficient problem is linked to the content: when the user clicks on hyperlink, the system answer doesn't correspond on his expectation. The electronic documentation is efficient for the achievement of some actions (e.g. spare information search from a hyperlink or the reference as key-word) but not to execute maintenance procedure. A map consultation to have a global view of the aircraft is also difficult on a screen documentation consultation. Moreover, information in the electronic documentation can also be insufficient (e.g. the procedure gives the designation of a spare or a tool to be used but any information, such as characteristics and functions about it is in the documentation), or on the contrary in excess when some unnecessary information are presented with the task procedure. According to the operators, it is due to the fact that designers are not in contact with the real work situation, so they could have a bad work situation model. The text they put in the documentation could consequently produce to the user a bad situation model and a bad text understanding. Van Dijk et Kintsch (1983) have proved the role of the situation model on the text understanding. In addition, the procedure is written with complex sentences hard to understand by the operators. In fact, the turn of the phrases in the documentation can sometimes lead up to a bad interpretation of the meaning.

Text in the documentation is monotone because of the lack of text layout, colour, etc. Characters are too small, making reading more difficult and cognitively costly. Figures are difficult to visualise and sometimes don't correspond to the text they are supposed to illustrate

More colours on the figures can help to better understand the procedure because the text is insufficient. Moreover, as the text is not “ventilated”, the operators prefer a text organisation in different sections corresponding to each step of the procedure.

5.2.2 Paper Documentation

For the maintenance operators, the paper documentation is the best format to consult a map or to execute technical task, i.e. to follow task procedure. They consider the paper format less efficient to have an overview of the procedure. However, the paper documentation allows them a page-by-page progress in the procedure without a risk of a cognitive disorientation like with the electronic documentation, notably in the case of a long text. Nevertheless, they admit that the ease-of-use of the documentation depends on the content structure and clarity.

6 Conclusion

The field study results and ergonomic inspection show that the maintenance documentation contains some features to distinguish information. However, the means used are not sufficient to make easier the documentation use. The next step would be to take into account the user suggestion and ergonomic recommendation in the documentation design and to evaluate the impact of this modification in the user performance. For maintenance operators, consulting documentation during the task completion constitutes a heavy load. So, according to them, the documentation design has an important role. For operators, an efficient documentation is the one which doesn't require too effort. The availability of clear information and the use of signals could allow having documentation easy to use because of the facilitating of the reading, the information research and consultation.

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