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HUMAN FACTORS DESIGN OF ELECTRONIC DOCUMENTS

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The Federal Aviation Administration (FAA), working with the Master Minimum Equipment List (MMEL) Industry Group, is developing a new MMEL electronic format. The MMEL refers to a series of documents controlled by the FAA that lists equipment that may be inoperative under certain conditions while still allowing the aircraft to be airworthy. Each aircraft model has an MMEL, and operators must work with that master document to determine the relief items for their specific aircraft. The resulting Minimum Equipment List (MEL) for an operator's aircraft is used by both ground personnel and pilots to determine the procedures for maintaining airworthiness. Currently, the MMEL is available in text format, and the industry needs an electronic format that is more efficient and that will be compatible with key aspects of future data standards. Members of the MMEL Industry Group were surveyed to determine the main user needs and human factors considerations for the development and evaluation of the MMEL electronic format. This study identifies key operator needs that can direct the development of not only the new MMEL format but also the broader category of aviation electronic documents.

Introduction

As the aviation industry continues the transition from paper to electronic documentation, the opportunity for standard and more efficient information exchange and reuse has been recognized, but the emphasis has often been on technical and engineering solutions and human factors efforts have not given full consideration to the needs of the different user groups. This study provides an opportunity to understand operator electronic document needs encompassing ground and flight organizations within airlines.

Organizations including the Air Transport Association (ATA) and the Federal Aviation Administration (FAA), with help of operators and suppliers, have been considering different approaches to the structure and format of aviation information used in flight and maintenance operations. There is a growing consensus that current technology, such as the eXtensible Markup Language (XML), can offer a viable solution, but less progress has been made on defining a complete set of user requirements and human factors considerations that should form the basis of electronic format, specifications or standards efforts.

Recently, the Master Minimum Equipment List (MMEL) Industry Group (IG) in collaboration with the FAA have been looking at ways to select or develop an MMEL electronic format that will facilitate MMEL publication and revision. The MMEL refers to a series of documents controlled by the FAA that lists equipment that may be inoperative under certain conditions while still allowing the aircraft to be

airworthy (FAR 121.628). Each aircraft model has an MMEL, and operators must work with that master document to determine the relief items for their specific aircraft. The resulting Minimum Equipment List (MEL) for an operator's aircraft is used by both ground personnel and pilots to determine the procedures for maintaining airworthiness.

This is a strategic project because enhancements to the MMEL revision process will, in turn, improve the MELs, a key document used by maintenance, dispatch, engineering and other ground personnel, as well as flightdeck crews. Further, in their timing, the MMEL IG is in a lead position to establish a working electronic format that can influence future data standards in related areas across the aviation industry. Because of the potential improvements and influence on aviation electronic documents, the MMEL IG was surveyed to determine key factors that should be considered in the development of a MMEL electronic format. The results are analyzed in the context of authoring, revising and reusing aviation information in more standard and efficient ways across ground and flight operations.

Background

The NASA/FAA Operating Documents Group has been meeting as an industry group over the past eight years to address key operating data and document issues (Kanki, Seamster, Lopez, Thomas, & LeRoy, 1999; NASA/FAA, 2000). With the shift from documents to electronic data, the Group has focused on user requirements that should be addressed during

this significant transition. Although the NASA/FAA Group has identified a wide range of issues including safety critical data, standardization, human factors, and security (Seamster & Kanki, 2002), the emphasis here is on human factors and end user requirements.

When working with industry data requirements, there are two important dimensions to consider. First is the interaction between operator, supplier and regulator requirements. Traditionally, each group has concentrated more on their own requirements and less on the overall industry needs. The challenge is to recognize the differences and define the common ground that can be used to develop industry requirements. Operators are most interested in the efficient conversion of supplier documents into their own document formats. Suppliers tend to concentrate on the efficient and accurate production of documents in whatever form the different operators require with less emphasis on standards. Regulators have been more concerned with the approval process, often focusing at the document page level.

The second dimension is the process to product human factor (Seamster & St. Peter, 2002). This dimension highlights the different requirements of those who work with the final product, such as the pilots, mechanics and other end users, compared with those who manage documents and data, such as those in publications. The transition to electronic documents provides an opportunity to ensure that improvements are made for both user groups, the data end users as well as the data managers.

More of the human factors research and guidance has been offered from the end user perspective. Pilots use operational data on the flight deck with its workload management and safety-critical requirements. Existing guidance for electronic documents such as the electronic flight bag (EFB) concentrate on how the system interacts with crews on the flight deck (see Chandra, Yeh, Riley, & Mangold, 2003). Maintenance workers are an important second set of end users with a different set of usability issues as identified by Chaparro, A., Groff, L. S., Chaparro, B. S., and Scarlett, D. (2002). Further, human factors issues related to maintenance documents and procedures including the MEL have been identified by analyzing incident reports submitted to the NASA Aviation Safety Reporting System (see Munro & Kanki, 2003; Patankar, Lattanzio, & Kanki, 2004).

Less research and guidance is available for the data managers and related document developers. Data managers have workflow requirements to automate and simplify the creation, review, approval and distribution of operational information. They share

some needs with end users but have additional needs brought on by the data revision and the publication process.

Usability issues from these two types of user groups (end users and data managers) must be considered jointly in such a way that electronic documents and data can be efficiently managed while meeting the safety-critical end user requirements. Both user groups must ultimately participate in developing new electronic formats and standards working with suppliers and regulators. It is important that industry not gain efficiency for one group at the expense of the other.

The MMEL Industry Group has been working to develop a MMEL format that all data management users can access. This new format should allow documents to be electronically accessed and interchanged. XML is a candidate technology for the MMEL format based on the use of schemas. The MMEL Industry Group is tasked to define the requirements with an emphasis on technical capabilities such as the tracking of changes, deleted items and managing effectivity.

The NASA/FAA Operating Documents Group has supported the MMEL effort by identifying high-level human factors considerations concentrating on data management user groups. The reason for this data management user perspective is that it has received less attention up to this point. Moving forward, this perspective along with the results reported here need to be merged with end user requirements across operators, suppliers, and regulators to ensure a format that is usable for the larger aviation industry.

Methods

The MMEL and MEL Usability form was prepared by the NASA/FAA Operating Documents Group in conjunction with several members of the MMEL Industry Group. The purpose of the form is to determine the most important usability requirements as the MMEL Industry Group develops a new MMEL format based on eXtensible Markup Language (XML) schema. The form was designed to help the MMEL IG determine the most important MMEL improvements as they review options for the new MMEL XML format.

The instrument is a one page rating form. The top part of the form asks each rater for their background information to determine their current job, their experience with documents and publications along with their years of MEL experience. The middle

section of the form collects data on each rater's perspective on the MMEL revision process. The last section of the form, the focus of this paper, presents 22 possible MMEL improvements asking participants to rate each on its degree of importance using a five-point scale. For these ratings, "Most Important" is given a value of 1 and "Not at All Important" is given a value of 5.

The instrument was administered to approximately 40 participants at a recent quarterly MMEL Industry Group meeting. Some of the participants represented the same organization and worked together on a single form. The group received a detailed explanation of the form and respondents were asked to consider their organization's priorities when providing their ratings. The completed forms were sent on to the NASA/FAA Operating Documents Group facilitators for compilation and reporting.

Results

A total of 28 MMEL IG members completed the forms. One participant provided ratings on less than half of the MMEL improvement items so that data was removed from the analysis resulting in a total of 27 respondents. Of those, 21 represented operators including majors, regionals, and cargo. The remaining six represented suppliers and regulators. Most of these participants were experienced with the MMEL and MEL process having worked an average of 11 years on aviation documents or publications (range from 2 to 24 years), and they also had 11 years of MEL experience with a range from 1 to 23 years.

In addition to the ratings data, degree of certainty was also collected using a three-point scale from High degree of certainty to Low degree of certainty. The extra data was recorded in order to compute weighted scores that would highlight those ratings made with a High degree of certainty over those ratings made with less certainty. Ratings and their means were calculated using both the raw scores and the weighted scores. The results were similar, and because of some missing certainty data, the raw score rating data was used for this paper.

Table 1 shows the MMEL improvements listed in order from most to least important based on the means of the raw ratings. The top six items provide a coherent set of priorities around a more expedited and standard MMEL process involving the identification and authoring of internal MEL revisions. The next group of important requirements support those first six in that they address authoring, revisions, standards and MMEL format.

Table 1. *MMEL Improvements in Order of Importance Based on Ratings of 27 Participants (1 = Most Important and 5 = Not at All Important)*

MMEL Improvements	Rating Mean
Expedited MMEL authorization process	1.68
Identifying MMEL changes impacting your MEL	1.74
Downloading as XML file	2.00
Working with MMEL revisions	2.00
Authoring internal MEL revisions	2.04
Enforcing standard MMEL structure (FAA/manufacturers)	2.04
Identifying all MMEL changes since last revision	2.11
Enforcing standard MPM/DDG structure (manufacturers)	2.11
Reformatting the MMEL for MEL authoring	2.22
Viewing the MMEL in a more usable format	2.22
Improved FOEB process	2.33
Working with upgradable schema	2.35
Tracking effectivity	2.46
Standardizing on one ATA numbering system 6 digits	2.57
Downloading as DOC file	2.62
Handling MMEL deleted items (what was deleted)	2.63
Supporting PDF output for MMEL	2.65
Supporting MS Word output	2.69
Viewing the MMEL in a common browser	2.77
Printing the MMEL	2.93
Downloading as PDF file	2.96
Downloading as EXE file	3.63

The last group with decreasing importance include some of the technical items that are the current focus of the MMEL Industry Group. Supporting MS Word and PDF formats and viewing the MMEL in a common browser are less important, and downloading as PDF or EXE file along with printing the MMEL are the least important improvements.

The most important improvement is an expedited MMEL authorization process. Figure 1 shows that the majority rated it as "Most Important" with the majority of the rest rating it at "Very Important." Independent of the type of technology or format, participants want whatever system is implemented to speed up the MMEL authorization process.

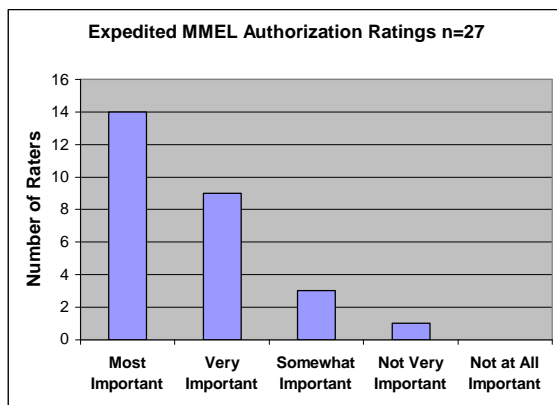


Figure 1. Ratings distribution for "Expedited MMEL authorization process."

Specification of the type of technology to be used, in this case XML, was also rated toward the top, but it is interesting to note that the rating distribution was not as clear cut with more participants giving it a neutral rating (Somewhat Important) than those who gave it a "Very Important" rating (see Figure 2).

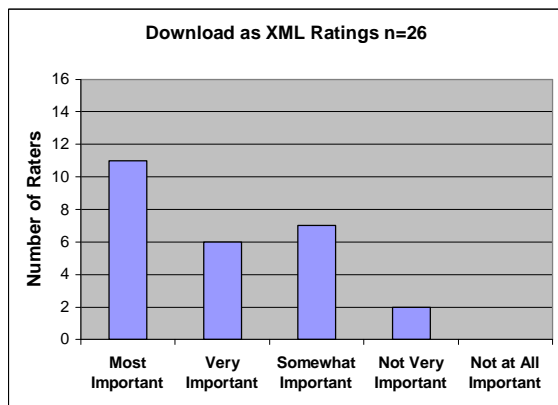


Figure 2. Ratings distribution for "Downloading as XML file."

The results of this survey can be very helpful in directing the development of a new MMEL format to be used by the aviation industry in updating their own MELs. The most surprising finding is that this group of data managers are most concerned with general, high-level improvements and less focused on the lower-level technical issues that seem central to current industry efforts. This is significant from a human factors perspective and argues for a greater understanding of the MMEL and MEL authorization and revision process based on a user-centered rather than a technology-centered approach.

Discussion

The results of this survey emphasize the relative lack of attention paid to the requirements of the data manager user group. Even as pressure is applied to the document developers and distributors for timely, accurate information, the data managers work within a system that is inefficient. The top-rated improvements requested by this group of users are relatively high level process oriented changes that can improve both accuracy and efficiency. More specific, technical improvements are valuable but in themselves, fail to set the system-level efficiencies and standards that are needed.

The process and results reported here suggest ways to improve the development of electronic data formats and to foster the acceptance of the resulting formats and standards. Interpretation of these results indicates several ways to improve industry participation and also suggest ways to improve the acceptance and successful implementation of the resulting standards.

To achieve industry acceptance, a user-centered approach must be used in the development of electronic data solutions. As the technical work proceeds in developing electronic formats for the MMEL and other documents affecting flight and maintenance documentation, it is essential to continue collecting data and working with key user groups such as the flight operations data managers and the flight deck data end users. In the case of the MMEL and resulting MELs, a large number of users will have a stake in the process. But as indicated by the ratings, it may be more important to address the industry-level requirements and standards first since these improvements can alleviate the inconsistencies that data managers must work around.

Similarly, the consistencies and standards developed at the company level can alleviate the inconsistencies that individual end users across the company must work around. For example, when complementary

procedures are developed or updated independently within their own organizations (e.g., pilot and ramp de-icing procedures), inconsistencies can develop because each group has its own tasks, responsibilities and priorities. Even the most basic terminology and format differences may go unnoticed for a long time. In contrast, if all company procedures are built and revised from a common reusable data source, this type of divergence can be avoided without compromising end user requirements.

The results of this survey represent a small step in the larger user-centered approach to developing new aviation information data formats and structures. Fortunately, data manager requirements have been identified early in the process providing an opportunity for additional steps that can ensure a good fit between electronic data formats and structures and aviation industry user groups. The next steps include:

- Identify and analyze key data management and authorization tasks most tightly coupled with the MMEL format
- Identify relevant human factors measures to be used in the evaluation of new electronic data formats and structures
- Harmonize data management requirements with end users across operations, suppliers, and regulators.

In summary, the MMEL IG has identified top-rated improvements which focus on the resolution of industry-level processes and standards. While not directly addressing end-user issues, these are fundamental improvements required for a better workflow and greater efficiencies in the preparation and timely distribution of essential information. By providing data managers with these improvements, they can be more responsive to their multiple end users because they have the data structures to support effective and efficient document management.

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