

DESIGN AND USE OF OPERATING DOCUMENTS

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ABSTRACT

Operating documents, especially those used by crews in the cockpit, need to be compatible with regulations, aircraft systems, and, most importantly, the operational environment. In addition, operating documents must be internally consistent with the entire system of documents. There are many guidelines covering most aspects of document development. It is difficult for operators to use these guidelines in their current form which is distributed across a number of reports and other publications. To correct this situation, representatives from many of the US operators have been involved in two workshops to identify their most important document development issues and to organize those issues in a way that is operationally meaningful. Results from the workshops are being used to assess existing guidelines and reorganize them into a manual for operators. One group of results indicates differences in priorities among the three different types of operations involved in these workshops: 1) Majors, 2) Regionals, and 3) Cargo. A second set of results identifies the most important guideline issues. These results provide a detailed outline for organizing operating document guidelines according to five primary issues: 1) organization of documents, 2) standardization of documents, 3) usability of documents, 4) document development process, and 5) transition to electronic media. Additional results from these workshops have shown the importance of using examples to illustrate issues and to demonstrate the application of specific guidelines. Collectively, the results highlight the main document development issues and show how guidelines should be organized and presented in order to help carriers address those issues.

INTRODUCTION

This NASA/FAA project grew from two independent efforts to integrate CRM principles into flightcrew procedures. The original research projects focused on enhancing crew performance, addressing standardization and compliance issues, and improving the link between procedures and operational reality. Specifically, guidelines for across-fleet standardization of normal checklists and the development of a quick reference handbook (QRH) for abnormal and emergency procedures were researched. In each of these cases, many aspects of design were called into play: procedure content, structure, logic, format, terminology, roles and usage. In addition to these features, it became obvious that the design process also required a consideration of the overall information system.

One of the two research projects (see Seamster, Boehm-Davis, Holt, & Schultz, 1998) has documented the need to consider operational constraints and problems when designing new procedures and documentation. In addition, all re-design efforts should consider consistencies across departments (e.g., training, evaluation, safety, maintenance), and consistencies across other documents (aircraft operating manuals, training documents, checklists, company policies, etc.). To invoke Degani and Wiener's 4 P's (1994), operating documents should be internally consistent with the organization's philosophies, policies, procedures and practices. In addition, external consistency must be maintained with regulations, manufacturer requirements, and with human factors principles and guidelines, with usability testing the foundation of the design and development effort.

The current project is called the NASA/FAA Flight Operating Documents project, funded by FAA AAR-100, Air Carrier Training Research and supported by NASA Ames Research Center. Industry participation includes operators, and manufacturers with America West, American Airlines, American Eagle, Delta Air Lines, TWA, and US Airways playing a major role in the effort.

Research Goals and Approach

There are numerous guidelines applicable to procedure and document development grouped by checklist (Degani & Wiener, 1993; FAA, 1995; Turner & Huntley, 1991), procedure (Degani & Wiener, 1994), and display/typography (Adamski & Stahl, 1997; Degani, 1992) considerations. It can be difficult for operators to make the best use of these guidelines in their current form distributed across a number of reports and publications.

The goals of this project are threefold: 1) Identify the key issues in the development of operating documents 2) Assemble guidelines that address those issues in a way that will help operators develop operating document systems, and 3) Incorporate examples of current approaches to resolving key issues. Detailed descriptions of current approaches including both potential pitfalls and successful solutions are useful lessons learned. In addition to information sharing through workshops and focus groups, the product for this project will be an Operating Documents Manual. It is important for this Manual to be based on participation and input from as many operators as possible so that it will have a high degree of operational relevance.

METHODS

Two workshops were held to identify key issues in the development of operating documents and lessons learned. From 35 participants in Workshop I to over 70 in Workshop II, 20 organizations represented a cross section of major, regional, and cargo operations, and manufacturers. The workshops provided a dynamic environment in which operators could present, discuss, and ultimately rate the importance of operating document topics and issues.

Workshop I: Key Topics

Participants provided three sets of survey results in Workshop I, and those results have guided the direction of this project. The first set of results, based on the responses of 35 participants, identified the most important guideline topics. These results provided a detailed outline for organizing operating document guidelines according to five primary topics: 1)

organization of documents, 2) standardization of documents, 3) usability of documents, 4) document development process, and 5) transition to electronic media. Topic areas 1-4 are applicable to nearly all operating documents projects although existing guidelines do not address all issues equally well. Topic 5, transition to electronic media is a special topic of growing importance among the major carriers and cargo operators.

The second group of survey results based on a total of 24 participants underscored the differences in priorities among the three categories of operators: 1) Majors, 2) Regionals, and 3) Cargo (see Table 1). Major carriers tended to focus on one or two topics within topic areas (e.g., CRM policies and procedures, Training new procedures). Regionals, on the other hand, found numerous topics to be of equally high importance within almost all topic areas. A few topics (e.g., Reducing number of documents, Human factors of checklist design) showed similar rating patterns across all three types of operations. Another emergent pattern showed that cargo operators placed greater importance on topics related to Use and Transition to Electronic Media compared with majors and regionals. These ratings reflect current and perhaps transitory interests, but the patterns indicate variations in interests and concerns, presumably due to operational differences as well as organizational commitment and economic factors.

The third survey based on input from 24 organizations indicated that operating documents are organized in very different ways. Although there are standard requirements for what information must be carried in flight (e.g., Subparts G and K of FAA Part 121 operating requirements), operators coordinate with their local FAA Principal Operations Inspector (POI), combining and distributing information in a variety of ways. The location of that information (e.g., flightbag, aircraft, base/home) creates further operator differences in responsibility and maintenance of documents.

Workshop II: Key Issues

Workshop II was organized around the following five focus groups: 1) Organization of Documents, 2) Standardization of Documents, 3) Usability of Documents, 4) Development and Maintenance of Documents, and 5) Transition to Electronic Media. Within these focus groups, participants identified and discussed the issues of greatest importance to them. During the first day, participants shared current approaches and future plans, pointed out potential problems and tradeoffs, and discussed regulatory constraints and operational benefits. Similar to Workshop I, the description of approaches, discussion points and the application of specific guidelines were

greatly enhanced through illustration with actual examples from the operators. On the second day, each focus group presented the results of their discussion and participants again rated specific issues on

importance. Although organizations were engaged in a wide range of document re-design projects, they collectively identified the issues in Table 2 as most important.

Table 1: Topic Ratings by Operator Type

Topic Areas	Topics	Ratings by Operator Type*		
		Major	Regional	Cargo
ORGANIZATION OF DOCUMENTS	Cockpit-based vs. flight bag vs. at home	2.89	3.14	4.25
	Merging/consolidation of manuals	4.00	4.00	3.25
	Consolidation of checklists	3.11	4.00	3.25
	Reorganizing documents	3.67	4.57	3.00
	Reducing number of documents	4.44	4.14	4.25
	Redundant information issues	3.78	4.14	3.75
	Index across documents (system index)	4.22	4.29	3.00
PHILOSOPHY & POLICIES	Flow-driven procedures & checklists	4.22	4.14	4.00
	CRM procedures & policy	4.22	4.00	3.50
	Manual revision policy	3.78	4.00	4.25
STANDARDIZA- TION	Standardization across fleets	4.33	3.71	4.50
	Standardized flows	4.22	3.57	3.75
	Standardization across documents	3.78	4.29	4.25
	Standardization of terminology	3.89	4.43	4.50
DEVELOPMENT PROCESS	Integration with Regulations & Manufacturers	3.78	4.00	3.50
	Involvement of POI's	3.89	4.14	4.25
	Integration of vendor documents	3.11	3.71	4.00
	Training of new procedures	4.11	4.00	3.75
	Revision and updating document content	3.44	4.29	3.50
USABILITY & INDEXING	Human factors of checklist design & format	4.22	4.71	4.50
	Techniques vs. procedures	3.89	4.14	3.00
	Memory Items / Immediate action items	3.44	4.57	4.00
	Managing the accomplishment of checklists	3.78	4.43	3.50
	Navigating within documents	4.22	4.00	3.25
	Navigating within procedure	4.00	3.57	3.25
	Navigating from one checklist to another	3.89	4.14	3.75
ELECTRONIC MEDIA	Integrate electronic media with FAA standards	3.89	4.00	4.50
	Design guidelines for electronic documentation	4.11	3.86	4.00
	Onboard computer systems	3.44	2.43	4.50
	Use of intra/internet	3.89	3.00	4.50
Total Number of Highly Rated Topics		7	19	14

* 5-point scale with 5=Most Important

Note: Topic with Means ≥ 4 are **BOLD** in Shaded Area. A few means ≥ 4 are unmarked due to inter-rater variability

Table 2. Top Ten Issues (lower ratings indicate higher importance)

Issues	Focus Group Topic	Importance Rating*
ORGANIZATION OF DOCUMENTS		
Required for flight	Document Location	1.67
Develop for Time Critical Information	Guides / Cards / Checklists	1.80
Get feedback from flight crews and others involved in operation	Reorganizing Documents	1.85
Test organization logic in simulator under real time operation	Reorganizing Documents	1.91
Non-normal** indexing is very time critical and important	Indexing	2.00
STANDARDIZATION & USABILITY		
Maintaining consistency	Standardization of Procedures and Flows	1.87
Style manuals	Standardization Across Fleets	1.87
Style guide and master templates	Document Design, Format, and Typography	1.87
Abnormal** procedure flow (associated system abnormal)	Managing the Accomplishment of Procedures	1.97
DEVELOPMENT AND MAINTENANCE OF DOCUMENTS		
Communicating Mechanisms	Introduction of New Procedures / Information	1.97

* 5-point scale with 1=Most Important

** Note: Operators use the terms abnormal, emergency, and non-normal in different ways. In reporting survey results, we are not imposing one particular definition over another

Top Ten Issues

The top issues in Table 2 do not exclusively represent one topic area. Rather, they extend across different aspects of document and procedure design, ranging from high level organizational issues (e.g., implementing communication mechanisms for introducing new information), to specific formatting and typography decisions (development of style guides and master templates). Further, these importance ratings probably represent more than one dimension of “importance” (e.g., highest risk consequence, greatest impact on user performance and acceptance, most in need of improvement). For whatever the underlying reasons, there is consensus that information requirements for time critical procedures in flight are of unique importance within the overall information system. Highlighted is the importance of determining abnormal procedure flows from one procedure or document to another with an effective indexing system. It is recommended that the organization logic be tested in the simulator under realistic conditions. Additionally, key issues in the document development process emphasize the need for communication to and feedback from the crew members involved. Finally, key issues are identified for maintaining consistency across the entire document system through

standardization at both procedure and document design levels.

Transition to Electronic Media

The issues discussed above are relevant to documents of any media type. However, the transition from paper to electronic media alters critical aspects of the design and use of operating documents. Specific guidelines for standardization and usability may no longer apply in the same way which means new guidelines must be written for FAA approval. To illustrate some of the differences between paper and electronic documents, let us re-consider the issues described above.

Top Issues Applied to Developing Paper Documents

The organization of the document system defines the structure of how information is distributed across documents and locations to satisfy information requirements. Organizing criteria focus on how often the information is used, when it is needed, what level of accessibility is required and a number of other time and location requirements. An example of time critical, abnormal/emergency procedures required in flight is the information contained in a Quick Reference Handbook (QRH), a paper document usually located and maintained on the aircraft.

Using QRH development as an example, feedback from pilots would be solicited throughout the development or re-design process. Communication mechanisms for introducing the QRH to pilots would be made in a timely way with appropriate guidance for use.

At the procedure level, the QRH would necessarily contain aircraft specific procedures, such as how to shut down an engine. But standardization of procedures should be applied when appropriate. As an example, an operator may decide that at the first indication of an engine fire all aircraft types will proceed to the nearest suitable airport for landing. In addition to standardization, abnormal/emergency procedure flows that maximize usability would also be determined.

At the document formatting level, both standardization and usability could be enhanced through the development of style guides and templates. A key design issue to be resolved would be an indexing system that promotes accurate and efficient navigation from one procedure to another. While satisfying usability requirements, the indexing system would also help to ensure standardization across other documents in the information system.

The development process requires numerous design decisions and tradeoffs to be made for which there are no absolute guidelines. In spite of some regulatory, manufacturer and human factors guidance, many decisions would be tailored to the specific operations, resources, fleet characteristics, and existing information system of the operator. Therefore, when possible, it is important to test the organizational logic of one's documents and procedures in the simulator under real time conditions. Testing the logic of a QRH would focus on time critical abnormal/emergency procedures used in flight. It would specifically evaluate the usability of the document and whether the information needed can be correctly accessed and used in the time allowed. Effective testing would answer questions such as: Does the procedure flow correspond to how pilots are trained and how they must perform under realistic conditions? Can the pilot navigate within the QRH from one procedure to another or back to normal operations? Test results would feed back into the design process as well as highlight potential issues for training.

Top Issues Applied to Developing Electronic Documents

Following the example above, developing an electronic document would again start with a focus on information requirements. Can an electronic document provide the information needed when it is needed?

Obviously, issues of information access are dramatically different comparing paper to electronics, since the concepts of a page, and of "page-turning" are no longer relevant. Although it is possible to design a display to look like a page and to make button pushes or touchscreens equivalent to turning pages, such constraints are unnecessary and inefficient especially when information needs are time critical. In addition, the concept of standalone manuals loses significance, as electronic documents are not constrained by size or location in the same way as paper. In sum, the chief benefit of electronic media from a users standpoint is ease of navigation through use of electronic linking for rapid access to time-sensitive information. However, pilot feedback and realistic simulator helps to validate whether organization logic and media access satisfy the information requirements.

At a generic level, the issues of standardization and usability for onboard documents are the same regardless of media. For instance, it is always important to determine procedure flow, and maintain standardization across fleets and documents. However, at the procedure level, there are subtle differences. Consider a specific procedure that requires the pilot to refer to and accomplish one or more additional partial or complete procedures, in order to complete the original procedure. Because the electronic document is not page-constrained, it would incorporate all relevant steps into a single procedure. This difference effectively reduces the number of unique procedures that must be trained and used.

At the document level, differences are numerous. Paper documents have the advantage of some external guidance from industry, research and experience. Electronic documents have few standards to follow, and research often falls outside the unique requirements of in-flight usage. Probably most difficult is the concept of standardization of documents when parts of the information system are paper-based and other parts are electronic. The document development process for electronic media has similarities to that of the paper document but not without major changes. For instance, the introduction of a new electronic document may require media training in addition to procedure training, thus re-emphasizing the need for effective communication mechanisms.

There are many areas in which the information system can be enhanced through electronic media. In the organization of the entire information system, electronic media can help to resolve issues of redundant information and cross-referencing, indexing and navigation within and across documents. With proper implementation and training, this has the potential for reducing "heads down" time in the cockpit environment. In the areas of standardization and

usability, the use of style guides and templates acquire great power in maintaining consistency across fleets, across documents, and across departments. Consistency can be checked and maintained with respect to format, terminology, and indexing, as well as conventions pertaining to the actual accomplishment of the procedure (e.g., use of conditionals, decision trees). The document development process for electronic media requires greatly revised methods and standards (e.g., internal and external approval process, production process, communication mechanisms), but an effectively revised document development process can take advantage of its improved capabilities for distributing and tracking revisions, checking and ensuring consistency within the entire information system.

Summary

This paper discusses the approach and results of the Flight Operating Documents project in which an industry team was formed to 1) identify key issues in the development of operating documents, 2) assemble guidelines that help operators address those issues in the development of operating documents and 3) incorporate examples of different approaches to resolving key issues. Operators have specific needs and concerns whether they are developing a single manual or an entire document system. They are particularly interested in the best way to organize and present information required for flight, with an emphasis on

time critical elements. This chief area of concern is not limited to checklists, but also includes manuals and handbooks; it is not limited to abnormal and emergency procedures, but also includes time critical normal procedures.

Although this project evolved from research efforts to integrate CRM into operations, it is interesting to note how our initial approach to document development grew to include a broader view of the document system, an appreciation for regulatory and manufacturer requirements, as well as the production and maintenance process for developing and distributing essential flight information. It was rewarding to see that all participants involved in this project consider usability testing and collection of user feedback important aspects of the design and development process.

The culmination of this effort will result in the production of an Operating Documents Manual based on participation and input from major, regional and cargo operators. The manual will address the most important operator issues and provide current examples of different approaches. This collaborative effort between researchers and operators has helped to focus the development issues and highlight the need to support guidelines with specific examples and approaches that operators have taken in applying these guidelines.

Administration.

REFERENCES

Adamski, A. J. & Stahl, A. F. (1997). "Principles of Design and Display for Aviation Technical Messages". *Flight Safety Digest*, Vol. 16: 1-29.

Degani, A. (1992). On the typography of flight-deck documentation (NASA Contractor Report 177605). Moffett Field, CA: NASA Ames Research Center.

Degani, A., & Wiener, E. L. (1993). Cockpit checklists: Concepts, design, and use. *Human Factors*, 35, 345-359.

Degani, A., & Wiener, E. L. (1994). *On the design of flight-deck procedures*. (NASA Contractor Report 177642). Moffett Field, CA: NASA Ames Research Center.

FAA (1995). *Human performance considerations in the use and design of aircraft checklists*. Associate Administrator for Aviation Safety, Human Factors Analysis Division. Washington, DC: Federal Aviation

FAA 8400.10 (1994). Air Transportation Operations Inspector's Handbook, Volume 3, Chapter 15. Manual, Procedures, and Checklists. Washington, DC: Federal Aviation Administration.

NASA/FAA (1997). Proceedings of the NASA/FAA Operating Documents Workshop: April 17-18, 1997. Moffett Field, CA: NASA Ames Research Center.

NASA/FAA (1997). Proceedings of the NASA/FAA Operating Documents Workshop II: September 10-11, 1997. Dallas/Forth Worth Airport: American Airlines Flight Academy.

Seamster, T. L., Boehm-Davis, D. A., Holt, R. W., & Schultz, K. (1998). *Developing Advanced Crew Resource Management (ACRM) Training: A Training Manual*. Washington DC: FAA, Office of the Chief Scientific and Technical Advisor for Human Factors.

Turner, J. W., & Huntley, M. S. (1991). *The use and design of flight crew checklists and manuals*. (DOT/FAA/AM-91/7). Cambridge, MA: National Transportation Systems Center.