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# 1 Introduction

As the National Airspace System (NAS) continues to modernize, new systems and equipment are continually being added to the existing architecture. The integration of human factors into the development and procurement of these new systems is vital to the success of the future NAS. Although the Human Factors Design Guide (HFDG) (Department of Transportation, 1996) has been available for a number of years and provided vital information, it did not have the weight and impact of a design standard. Instead, the Military Standard (MIL-STD) 1472 D (Department of Defense, 1989) was commonly cited in FAA system specifications. To meet the current needs of the FAA, information within the HFDG needed to be updated, broadened to include both Air Traffic (AT) and Airways Facilities (AF), and changed into standards instead of guidelines.

The present document revises and expands upon the previously published material. It broadens the focus to include both AT and AF systems and has been modified into a set of standards instead of a set of guidelines, providing a common source of FAA-specific design requirements. The resulting set of standards can then be tailored to meet the needs of AT and AF systems, as not all requirements are applicable to all systems.

In this revision, many changes have been made to the material from the earlier version of the document in order to meet the needs described above. These changes include major expansion and revisions to the content of key chapters and organizational changes made to enhance usability. It also includes a change of the name from Human Factors Design Guide (HFDG) to Human Factors Design Standard (HFDS). This introductory chapter describes the changes, serves to familiarize readers with the formatting conventions used in this document, and presents a framework for the application of the standards.

## 1.1 Background

The original document was modeled largely after the MIL-STD-1472. However, the original HFDG was published as a guidelines document. This revised version is released as a standard instead of a guidelines document to better match the original intent of the document as a replacement for the use of MIL-STD-1472 for FAA systems and equipment. As a standard, the HFDS contains design criteria in the form of “should” and “shall” statements. In line with the more stringent requirements of a standard, information that was not based on empirical evidence or best practices was removed.

The HFDS retains the goal of providing a comprehensive reference document. The organization, format, style, and contents have been revised for easy access and understanding. The original document contained 14 chapters covering a broad range of topics. The current document contains 15 chapters due

to the expansion of information already available in the 1996 version, including completely revised chapters on computer human interface and automation.

This document was developed as a comprehensive reference tool to help FAA and contractor human factors professionals carry out FAA human factors policy. As a guide, it consolidated human factors knowledge, practice, and prior experience for application to new systems and equipment. It was conceived as a “living document” to be revised as new information became available. Aside from revisions to individual chapters, this document represents the first major revision of the HFDG since its release in 1996.

When the original document was written, there was little in the way of comprehensive human factors guidelines. Human factors knowledge consisted of scattered papers, articles, and technical reports. This lack of formal documentation posed a problem for those wishing to apply human factors design criteria to the acquisition of new systems and equipment. In addition to the time and effort necessary to collect and sift through a multitude of different human factors sources, many documents were difficult or costly to obtain. The HFDG provided a more complete reference by collecting disparate information into a single consolidated reference source. This information was organized into 14 major chapters including general design requirements, maintenance automation, designing equipment for maintenance, human-equipment interfaces, computer-human interfaces, workplace design, user documentation, system security, personnel safety, environment, anthropometry, and biomechanics.

Since the release of the original HFDG, there has been an increased interest in guidelines, both within the government and in industrial and commercial organizations, with an associated increase in human factors research to support the guidelines. This increased interest has resulted in many government and commercial organizations developing in-house guidelines material, particularly on the topic of computer-human interface. Other, primarily government or government-sponsored groups, focused on developing ergonomic and accessibility guidelines. This document selectively draws upon these new information sources while covering a broad range of human factors topics to meet the needs of FAA missions and systems. This compilation of design criteria represents the most comprehensive information available within a single reference source; for this reason, this document is the primary human factors authority for the development and procurement of FAA systems and equipment.

The original HFDG focused principally on the Airway Facilities environment. Thus, a strong emphasis existed in the area of maintenance. Since the document was published in 1996, however, it has provided guidance not only for maintenance acquisitions but for acquisitions and development in other areas of the FAA as well. It is widely used to aid human factors professionals in supporting a broad range of acquisitions involving air traffic control, automation, aviation security, communication, navigation, and surveillance technologies.

Therefore, an additional challenge for the revision effort was to broaden the focus beyond maintenance issues.

## 1.2 Purpose

The purpose of this HFDS is to provide a single easy-to-use source of human factors design criteria oriented to the needs of the FAA mission and systems. An additional goal is to facilitate use of appropriate design criteria by organizing the document so that users can easily locate the needed information.

## 1.3 Objectives

The objectives developed to create this document reflect the working philosophy used to form the HFDS into a useful human factors reference tool.

Some of the objectives were to

- a. place relevant human factors information in a single document rather than multiple diverse human factors documents;
- b. provide highly relevant information based on research or accepted practices for use by FAA and contractor human factors professionals in system acquisitions or modifications and in the evaluation and selection of Commercial Off-The-Shelf (COTS) and Non-Developmental Items (NDI) procurements;
- c. provide human factors information in the form of clear, concise, usable standards;
- d. organize the document so that users could easily locate the needed information;
- e. use credible, up-to-date sources;
- f. provide a strong and comprehensive computer-human interface section;
- g. promote human-interface consistency within and among subsystems; and
- h. serve as a basis for general human factors test and evaluation information and checklist procedures.

## 1.4 Scope

This document presents human factors design standards that are to be applied to new, modified, or updated facilities, systems, and equipment that will be managed, operated, or maintained by the FAA. It covers a broad range of human factors topics that pertain to input devices, automation, maintenance, controls, computer-human interface, workplace design, documentation, system security, safety, the environment, anthropometry, alarms, audio, and voice.

This document is relevant to all phases of the FAA development process, from the mission-need determination phase through production and deployment phases. It is to be considered for any engineering changes or modifications that affect the human interaction with the operational system. This document provides information that can be used in the evaluation and selection of COTS or NDI equipment. Similarly, it may be applied to advanced research programs transitioning to new FAA systems.

This document does not address technical efforts, developmental processes, methodologies, studies, or evaluations that are necessary during an acquisition or developmental process.

## 1.5 Process

A thorough, step-by-step process was used to achieve the stated objectives for this document. Some of the steps that were taken toward achieving our goals follow.

- a. The wording and scope of the guidelines and topics were carefully reviewed and revised to broaden the focus beyond the maintenance environment for the revised chapters.
- b. Standards without verifiable references were removed.
- c. The newly revised chapters were integrated into the document.
- d. Discrepancies and typographical errors in non-revised chapters were corrected.
- e. Sources were moved to the end of each standard.
- f. New reference lists were created for each chapter.
- g. New glossaries were created for each chapter.
- h. A cumulative reference list and glossary were created.
- i. New indices and tables of contents were created for each chapter.
- j. A new cumulative index and table of contents was created.

- k. The material in the document was compared against the standard FAA-G-2100, and any discrepancies were resolved.
- l. Material was reorganized to make the document more usable, resulting in the deletion of two chapters and the creation of three new chapters.
- m. Material was reviewed and revised by technical editors.

### 1.5.1 Expert review

These steps resulted in a draft document. Once draft material was created, the validity of it was assessed using a review process. A panel of human factors experts served as reviewers for updated chapter material and the document as a whole. The reviewers commented on the technical content of the material, the clarity of the design criteria, the usability of the information, and the organization of the material. The review process resulted in numerous suggested changes.

## 1.6 Significant changes

The revision resulted in several notable changes.

The revised Automation Chapter 3 includes 126 new source references. The review of these source documents resulted in the addition of over 100 new standards that were incorporated into the revised chapter.

The revised Computer-Human Interface Chapter 8 includes 22 new source references from government agencies and private industry. The review of these source documents resulted in the addition of 512 new standards that were incorporated into the revised chapter.

The reorganization of the revised Chapters 3 and 8 involved a systematic regrouping of information as well as the removal of redundant standards.

All statements that could not be verified by published reports, papers, technical notes, or other standard or guideline documents were removed.

All of the standards in the revised chapters were rewritten to contain only one “should” or “shall” standard per rule or guideline.

New material on wheelchair anthropometrics was added to Chapter 14.

## 1.6.1 Reorganization

A human factors reference book is only useful if it meets the users' needs. Vincente, Burns, & Pawlak, (1998) have criticized the usefulness of human factors reference documents. They state that these reference documents do not analyze the users' needs and that there is a gap between the research presented by the documents and the needs of system designers that impedes the transfer of information. Although there may always be some sort of gap between research and the needs of designers, the authors of this document have tried to minimize that gap. They evaluated how users make use of design guides by consulting with FAA human factors professionals and analyzing documents from acquisition and design programs.

Vincente et al. (1998) suggest four steps to ensure effective design guidance. The first step is to identify topics relevant to design problems and questions. The second step is to transform the research into usable guidance. The third step is to organize the material in a way that makes it easy for the users to find the information they need. Fourth, they recommend formatting the information so that is easy to use and understand.

These suggestions were considered during the development of the HFDS. The Computer Human Interface and Automation chapters are both very relevant to design problems and questions. The Computer Human Interface chapter is one of the most frequently used chapters by FAA human factors specialists in the design of products and systems. The revision of the Automation chapter reflects a trend toward increasing automation within the FAA. With increasing automation, there is a concomitant increase in the need for automation-specific guidance and design criteria. Both the Computer Human Interface and Automation chapters have been completely revised in the HFDS.

The authors have also taken steps to make the information within the HFDS more usable. They have rewritten the design criteria so that there is only one should or shall statement per paragraph. They added sources at the end of each design statement to help designers if they need to find additional information on the referenced topic and give the users the ability to weight the relevance of the design criteria based on the source. Also, they provided additional examples and discussions to help the users interpret the information that is presented. This additional information enables designers to make informed decisions regarding tradeoffs involved with certain design criteria. For example, if the criterion calls for not more than seven items in a menu and a designer wishes to have eight items, what might the consequences be? The additional information provided in the discussion can provide insight on tradeoffs such as this.

The authors have reorganized the topics and standards within the document to more closely align with the way the document was being used for FAA system acquisition and design, making it easier for users to find the needed information. In our analysis of



how the information has been used, we found that it is not often that users need the entire document at the same time. Instead, they tend to use a single topic area at a time. By creating table of contents, glossaries, references, and indexes for each chapter, we make it possible for users to use a single chapter in isolation of the remainder of the document.

After adding all of the new material and revising and updating the existing design criteria, the authors reorganized the topics and standards within the document to facilitate the location of information. They grouped related topics, created new chapters based on the analysis of use, and created new sections from areas that had been expanded due to new information. These changes are summarized in Exhibit 1.

**Exhibit 1.** Summary of changes resulting in the HFDS

<b>Original chapter number</b>	<b>Original chapter titles</b>	<b>Current location of information</b>
1	Introduction	Completely revised and rewritten.
2	Complementary documents	Integrated with reference section where appropriate.
3	Definitions	Individual definitions moved to the end of appropriate chapters and in entirety as a glossary at the end of document.
4	General design requirements	Revised and moved to Chapter 2 – entitled General design requirements.
5	Maintenance automation	Completely rewritten, reorganized, and updated with new information added; expanded focus beyond maintenance, renamed “automation.” moved to Chapter 3.
6	Designing equipment for maintenance	6.12.1 Alarms has been moved to Chapter 7 Alarms, audio, and voice. 6.12.3 Diagnostic aids has been moved to Chapter 3 – Automation.
7	Human-equipment interfaces	7.2 Video displays moved to Chapter 5 – Displays and printers. 7.3 Audio displays moved to Chapter 7 – Alarms, audio, and voice. 7.4 Controls changed to Chapter 6; entire chapter renamed as Controls and visual indicators.
8	Human-computer maintenance	Completely revised chapter, renamed Computer-human interface: 588 new design criteria. 8.2.17 Alarms moved to Chapter 7 – Alarms, audio, and voice. 8.21 Input devices moved to Chapter 9-Input devices.
9	Workplace design	Moved to Chapter 10 Removed some design criteria that could not be verified against the original source material. Revised and updated accessibility material; reorganized chapter to accommodate accessibility material.
10	User documentation	Removed some design criteria that could not be verified with the original source material, moved to Chapter 15. Revised and updated accessibility material.
11	System security	Removed some design criteria that could not be verified with the original source material.
12	Personnel safety	Removed some design criteria that could not be verified with the original source material.
13	Environment	Removed some design criteria that could not be verified with the original source material.
14	Anthropometry and biomechanics	Re-created tables to fix discrepancy discovered with source material. Added material on wheelchair anthropometrics.
	References	Updated format to reflect APA style and added new references as appropriate, moved out of Appendix to References section.
	Sources	Sources were placed at the end of the standards throughout the entire document
	Standard actions-push buttons	Integrated as appropriate into glossary and standards.
	Standard verbs	Integrated as appropriate into glossary and standards.
	Glossary	Contains definitions from all chapters.
	Index	Completely updated.
	HFDG to HFDS Cross reference	Table that allows users to find where specific information from the HFDG is now located in the HFDS

## 1.7 Using this document

No single human factors professional or designer can be expected to be knowledgeable in all aspects of human factors. By collecting information based on research and best practices, this document makes available the collective knowledge of many human factors professionals.

Contrary to the idea that human factors standards apply only to developmental acquisition programs, COTS items can also benefit from the application of human factors standards. COTS items, software, in particular, have a great deal of variability in quality of interface design. The information within this document can be useful to compare the quality of design for different COTS items, facilitating informed acquisition decisions.

The application of the standards in this document cannot guarantee good design for a variety of reasons. Although this document focuses on achieving good design and consistency within and between systems, the standards within this document can be implemented in different ways. Standards cannot replace good human factors expertise. A designer who is very knowledgeable in human factors might do well without using any standards whereas a novice designer might do poorly even with the help of standards.

The result of using this document in development and acquisitions will be a more usable system. However, even systems that are carefully designed using this document in conjunction with a human factors expert will need to be verified through means such as prototyping and testing with representative users. Testing will allow the designer to confirm the positive design features and identify any negative design features that may have been missed by the standards and the human factors professional.

Although these standards are necessarily general in order to apply to the wide range of systems and equipment within the FAA, they can be made into system specific rules. Not all of the standards proposed here may be applicable to every system. For any particular system, some of the standards will be relevant and some will not. Additionally, the use of this document cannot substitute for knowledge of task (user and system) requirements. It assumes the user has detailed knowledge of user and system needs.

### 1.7.1 Tailoring

Design standards such as those contained in this document must be generally worded so that they might apply to many different system applications. Before they can be applied to a specific system or piece of equipment however, these generally worded standards often need to be converted into system-specific rules. For example, a standard that states that the options in a menu should be ordered in a way that minimizes user navigation may

be rewritten for a specific system to specify the exact ordering of the items used for the system. This process is known as tailoring.

**Tailoring** is the process of selecting and evaluating individual standards to determine the extent to which they apply to a specific system or piece of equipment. It includes the process of modifying these standards to ensure that there is an optimal balance between operational needs and cost.

Tailoring of the standards may not always be possible. If the specifics of a system are not known in advance, a chapter or section of the HFDS may need to be cited in its entirety, with tailoring occurring later in the process. The HFDS has been reorganized to facilitate these cases. For example, the information on input devices has been given its own chapter, as has audio alarms.

Not every standard contained within this document will be applicable to every system. The application of every standard within this document to a single system would likely result in a system that was cost prohibitive. Tailoring the standards contained within this document to ensure applicability to a specific system avoids unnecessary efforts, overly restrictive design, and exorbitant costs.

Whose responsibility should it be to tailor the standards? Ideally, it should be the joint responsibility of human factors experts, vendors or system developers, users, and program managers. In order to tailor standards, the members of this working coalition must have a thorough understanding of task requirements and user characteristics. Each of these groups has something unique to contribute to the process. Users have knowledge of the task, people from the program office and vendors have knowledge of the costs involved in implementing recommendations, and human factors experts have knowledge of human factors. Together, these representatives can determine which of the items will provide the most benefit overall.

As a first step in standards tailoring, a human factors practitioner must review the sections of this document to identify those standards that are relevant to the acquisition being considered. Chapters of this document have been reorganized to facilitate this process. For example, someone wishing to procure a new keyboard for a system can easily skip to the chapter on input devices and extract the relevant information.

For a complex system or one with many components, the list of relevant standards may be extensive (for example, elements of the chapters on automation, input devices, auditory alarms, and computer-human interfaces). Once all relevant standards have been identified on a general level, the standards should be reviewed to decide which specific ones are most appropriate for the particular system or equipment.

## 1.8 Format

This section discusses the formatting conventions used in this document, which facilitate the use of the material. The format of this document is intended to help the user easily navigate through, locate, and use information. By using this information on organization and format, the user of the document should be able to skim the material and quickly find information on topics of interest.

Each chapter now contains its own table of contents, glossary, reference list, and index. This allows the chapters to be used relatively independently, if necessary, and for the user to quickly identify the sources if they need additional information.

Each standard is now followed immediately by the source citation. This allows the user to better understand the context that the reference came from and make better-informed decisions about the applicability of the particular standard to a system.

### 1.8.1 Measurements

Measurements and dimensions used throughout the document are expressed in International System units. As a convenience, the metric units are accompanied by their customary English system equivalents in parentheses. This practice is consistent with other standard and handbook sources.

### 1.8.2 Topical completeness

Within each chapter, when a standard is applicable to more than one topic, that standard has been included in a general information section. In the original document, guidelines were often repeated in more than one area of a chapter or more than one chapter. To the extent possible, these redundancies were removed, particularly in the revised chapters. Instead, associated information, which may be related, is appropriately cross-referenced, noted as "(see x.x. ...)."

Where directly relevant information is found elsewhere in the document, a cross reference, which states "(see section or paragraph x.x. ...)," is used. To ease the users' tasks, such direct cross-referencing was held to a minimum.

### 1.8.3 Headers and footers

Headers and footers are provided to simplify navigation through the document. The major section topic number and name appear in the header of each page. The footer contains the page number centered on each page preceded by the chapter number.

## 1.8.4 Heading and text locations

Introductory text, standards, and explanatory text appear in the right-hand column. Headings appear in the left-hand column and provide a concise title that reflects the contents found in each section.

## 1.8.5 Features specific to each standard

Each standard has features that provide specific information to the user of this document. Each feature is described in this section.

### 1.8.5.1 Contents

Each standard provides clear and concise information concerning a single specific topic.

### 1.8.5.2 Identification and use of "shall" and "should"

Each statement specified in this document is identified as a "shall" or "should" statement. As a standard, this document contains both requirements and recommendations. Requirements are indicated by "shall" statements, whereas, recommendations are indicated by "should" statements. Requirements and recommendations are collectively referred to in this document as standards.

A solid black square (■) adjacent to the statement identifies the "shall" statements. These requirements originate from or are comparable to statements from authoritative sources such as those associated with FAA orders, standards, and military specifications.

Each "should" statement is identified by an open white square (□). These recommendations represent best practices information that is applicable in most cases but may involve trade-offs or be influenced by context-specific factors.

### 1.8.5.3 Numbering of standards

The standards are numbered consecutively within each section with each having a distinct number that indicates the section/subsection in which the standard is located.

### 1.8.5.4 Titles

Each standard has a relevant and concise title, which allows the user to quickly evaluate the content of the standard.

### 1.8.5.5 Sources

Each standard is followed immediately by the source citation. The source citation shows the document author and the date the document was either written or published. This allows the user to better understand the context that the reference came from and make more informed decisions about the applicability of the particular standard to a system. Complete citations for the sources used are listed at the end of each chapter. A master list of all of the references used in the document is located at the end of the document.

### 1.8.5.6 Additional information

There are times when additional information can help to clarify a standard. When a standard requires additional information to clarify the meaning, the information is provided by adding a discussion, explanation, or an exhibit immediately following the standard.

Some of the standards are followed by a discussion paragraph. These paragraphs generally provide the reasoning behind the paragraph or, sometimes, further definition of terms used in the paragraph.

Examples can help the user to better understand a standard, however, there is a risk that the specific example used to clarify the standard could cause the user to interpret the standard more narrowly than intended. Therefore, we remind the reader that examples are meant to clarify the standard but are not meant to narrow the application of the standard.

Rather than two separate series of tables and figures, the HFDS has a single series of exhibits. An exhibit contains tabular information, illustrative information, or both. Thus, tabular and graphic information, which are to be used together, can be found within the same exhibit. Exhibits follow closely to the text that refers to them.

### 1.8.6 Glossary

Following the reference list at the end of each chapter is a glossary of words found in that individual chapter. The glossary defines words used in the standards, particularly terms that may be unfamiliar to the user, have multiple possible definitions, or may be used more narrowly in the standards than the general definition of the word. At the end of this document is a cumulative glossary that combines the glossaries from each of the individual chapters.

### 1.8.7 Index

Following each chapter is a topical index of the material found in that chapter. At the end of the document is a consolidated index that includes all of the chapters. The index is intended to help readers find information on a particular subject, independent of the topical organization of the information within the chapters.

### 1.8.8 References

At the end of each chapter, following the standards, is a list of references from that chapter. A cumulative reference list containing references from all of the chapters is located at the end of the document.

## 1.9 Superseded documents

The current document represents the first major revision of the HFDG. However, prior to the release of this document, two key chapters, Chapter 8 on Human Computer Interface, and Chapter 3 on Automation, were revised and released as final reports and/or technical notes. The Human Factors Design Standard supercedes the following documents:

HFDG Version 1.0 (Report Number DOT/FAA/CT-96/01)-  
January 1996

HFDG Version 1.1-December 1997

Computer-Human Interface Guidelines: A revision to Chapter 8 of the Human Factors Design Guide (DOT/FAA/CT-TN00/30). (Ahlstrom, V., & Longo, K., 2000).

Human Factors Design Guide Update (Report Number DOT/FAA/CT-96/01): A Revision to Chapter 8-Computer Human Interface Guidelines (DOT/FAA/CT01/08). (Ahlstrom, V., & Longo, K., 2001).

Human Factors Design Guide Update (Report Number DOT/FAA/CT-96/01): A Revision to Chapter 5-Automation Guidelines. Atlantic City International Airport, NJ: Federal Aviation Administration William J. Hughes Technical Center (DOT/FAA/CT02/11). (Ahlstrom, V., Longo, K., & Truitt, T., 2002).



## 1.10 Future of this document

The HFDS is considered to be a living document. It will be updated as needed to keep current with emerging research, technological advances, and user feedback. This will provide the most current human factors knowledge in a usable tool. The authors welcome suggestions for improvement of this document. Comments and suggestions should be addressed to:

The NAS Human Factors Group  
Attn: HFDS Project Manager  
Research, Development, and Human Factors Laboratory  
Building 28  
FAA WJHTC  
Atlantic City International Airport, NJ 08405

### Glossary

**Tailoring** - The process of selecting and evaluating individual standards to determine the extent to which they apply to a specific system or piece of equipment. It includes the process of modifying these standards to ensure that there is an optimal balance between operational needs and cost.

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Workforce Investment Act of 1998, Section 508, Electronic and Information Technology. PL 105-220, enacted on August 7, 1998, 112 Stat 936; codified as: Section 504 of the Rehabilitation Act, 29 U.S.C. § 794d.

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