ote technical note techn

Design of Information Display Systems for Air Traffic Control

Tanya Yuditsky, Ph.D., ATO-P
Ferne Friedman-Berg, Ph.D., Titan Systems Corporation
Alfred Smith, Ph.D., ATO-P

November 2004
DOT/FAA/CT-TN04/33

Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

U.S. Department of Transportation
Federal Aviation Administration

William J. Hughes Technical Center
Atlantic City International Airport, NJ 08405

NOTICE

Technical Report Documentation Page

1. Report No. DOT/FAA/CT-TN04/33	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Design of Information Display Systems for Air Traffic Control		5. Report Date November 2004 6. Performing Organization Code ATO-P
7. Author(s) Tanya Yuditsky, Ph.D., ATO-P, Ferne Friedman-Berg, Ph.D., Titan Systems Corporation, and Alfred Smith, Ph.D., ATO-P		8. Performing Organization Report No. DOT/FAA/CT-TN04/33
9. Performing Organization Name and Address Federal Aviation Administration NAS Human Factors Group William J. Hughes Technical Center Atlantic City International Airport, NJ 08405		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Federal Aviation Administration 1575 I Street NW Suite 800 Washington, DC 20005		13. Type of Report and Period Covered Technical Note 14. Sponsoring Agency Code ATO-P
15. Supplementary Notes		

16. Abstract

This document presents standards and guidelines for the design of Information Display Systems for Air Traffic Control (ATC). A computer-based Information Display System (IDS) provides access to various types of information needed to perform a job. The ATC environment and the time critical nature of Air Traffic operations bring unique requirements for an IDS. We developed the standards and guidelines provided here based on existing design guidelines and a study that explored the information and design requirements in the various ATC domains. We conducted structured interviews with 112 ATC Specialists to identify the problems and benefits they experience with IDSs in the field today. We also conducted workshops with Specialists from the field to review and validate our findings. The standards describe the elements that emerged as being critical in the design of an IDS for ATC and the guidelines can be used to effectively implement the standards. We also provide recommendations for human factors activities to support development of IDS design and to evaluate the implementation of the standards.

17. Key Words Air Traffic Control, Design Guidelines, Display Design, Human Factors, Information Display	18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia, 22161		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 38	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Table of Contents

List of Illustrations

Executive Summary

A computer-based Information Display System (IDS) provides access to various types of information needed to perform a job. A well designed IDS can provide many benefits. It can be used to consolidate information into one source and it can reduce the amount of time it takes for the user to find information by providing a more logical structure and a standardized format. The Federal Aviation Administration (FAA) currently uses different types of IDSs in its Air Traffic Control (ATC) facilities. All of these systems use varied design styles, user interaction styles, and customization capabilities. The ATC Specialists experienced different levels of success in using existing IDS to access task relevant information.

This document describes design standards and guidelines for ATC IDSs. We describe the lessons learned from the successes and problems of existing systems to provide a context for the standards. The application of these design standards and guidelines will address the issues of proliferation of nonstandard systems in the National Airspace System (NAS), while providing the user with an IDS optimized to support their information needs. Furthermore, this document will serve to consolidate information on the specialized needs of ATC personnel for system designers, developers, and others involved in the selection or evaluation of an IDS for ATC.

We developed the design standards by studying current IDS use in the field and evaluating existing design guidelines and standards. We did this to identify principles that are particularly important in the design of ATC IDSs. We conducted structured interviews with 112 ATC Specialists to identify the benefits and problems they experience with IDSs in the field today. We also conducted workshops with Specialists from the field to review and validate our findings.

Based on the results we identified key design components and used them as the basis for the standards. For each standard, we list specific design guidelines that can be used to implement the standard. We also recommend activities that can guide the development of an effective design, or help evaluate the implementation of the standards.

1. INTRODUCTION

A computer-based Information Display System (IDS) provides access to various types of information needed to perform a job. A well designed IDS can provide many benefits. Users can consolidate information into one source, which allows the easy management of large amounts of data and eliminates the need for multiple displays. It can also reduce the amount of time it takes for the user to find information by providing a more logical structure and a standardized information display format. Finally, it can save money by reducing the need to produce paper documents and by increasing employee efficiency (Nielsen, 2003).

The Federal Aviation Administration (FAA) currently uses different types of IDSs in its Air Traffic Control (ATC) facilities. There are several types of ATC facilities: Towers, Terminal Radar Approach Controls (TRACONs), Air Route Traffic Control Centers (ARTCCs), and Flight Service Stations (FSSs). The personnel at each type of facility have different responsibilities and somewhat different information requirements to accomplish their tasks. FSS personnel, for example, provide preflight (e.g., weather briefings, filing flight plans) and inflight (e.g., weather updates, flight following, search and rescue) services. At terminal facilities (Towers and TRACONs) the Specialists are responsible for aircraft that are on the ground, landing, or departing the airport. At ARTCCs, the Specialists are responsible for en route aircraft as they traverse the country at high altitudes before they start their final approaches into an airport (Wickens, Mavor, & McGee, 1997).

ATC personnel require both static and dynamic information (see Table 1) to make timely and effective decisions. An IDS can provide access to all of these types of information through a single source. In addition, it can serve as a standardized platform for the integration of future data and tools.

Table 1. Examples of Static and Dynamic IDS Data that are Currently Used by ATC Personnel

Static Data	**Dynamic Data**
Aircraft identifiers	Airport lighting
Approach plates	Flow control restrictions
Sectional charts	Notices to Airmen (NOTAMs)
Radio frequencies	Runway Visual Range
Telephone numbers	Special Use Airspace
FAA orders	Weather
Facility directives	
Letters of agreement	
Memoranda of understanding	
Position relief checklists	

Currently, different Air Traffic domains use different systems for information display. Terminal facilities use either the Information Display System 4 (IDS4) or the Automated Surface Observing System (ASOS) Controller Equipment - Integrated Display System (ACE-IDS). FSS facilities have limited access to these systems as well, but they typically contain little FSS-specific information. The En Route IDS (ERIDS) is currently being deployed to the ARTCCs. All of these systems use different design styles, user interaction styles, and customization capabilities.

Recently, the Air Traffic Services organization implemented policies to reduce the proliferation of displays and nonstandard systems in the National Airspace System (NAS). Using an IDS as a single point of access to various tools or sources of information is one means of reducing the number of displays in the field. A recent congressional report H.R. Rep. No. 108-243, (2003) mentioned that future IDS efforts will require computer-human interface and requirements work before the procurement. The standards and guidelines provided in this document will help ensure that future systems comply with human factors guidelines and meet the needs of the users.

1.1 Purpose and Scope

The importance of providing good design guidelines for system development cannot be overstated. Without them, there is little likelihood that the system will be effective or easy to use. Guidelines are often ignored, however, and when they are used they are often implemented incorrectly. To provide effective and useful guidelines, we researched the factors that make designers more likely to use them and implement them appropriately. In one study, de Souza and Bevan (1990) asked designers to modify an interface to make it compliant with a set of design guidelines. After allowing the designers to modify the interface, they assessed compliance with the guidelines. They found that compliance was most likely to occur if the guidelines clearly explained the goals and benefits of applying them, the conditions under which the guidelines should be applied, and clear procedures on how to apply them. Henninger, Haynes, and Reith (1995) found that useful design guidelines must be focused, targeting design issues related to a particular user community. They also found that designers were more likely to use guidelines accompanied by concrete examples, and that the appropriate application of design standards was directly related to understanding the users' needs. Both groups emphasized the need for design guidelines to focus more clearly on the specific user group for which a product is being designed.

This document describes design standards and guidelines for ATC IDSs. We developed the design standards by studying current IDS use in the field and evaluating existing design guidelines and standards to identify principles that are particularly important in the design of ATC IDSs. We also describe the lessons learned from the successes and problems of existing systems to provide a context for the standards. The application of these design standards and guidelines will address the issues of proliferation of nonstandard systems in the NAS while providing the user with an IDS optimized to support their information needs. Furthermore, this document will serve to consolidate information on the specialized needs of ATC personnel for system designers, developers, and others involved with the selection or evaluation of an IDS for ATC. The system administrators of current IDSs can also use this document to improve their systems.

This document should be used as an aid in the development of future IDS systems. The guidance presented here is not exhaustive in the sense that other, more general human factors design guidelines still apply. For example, several of the guidelines listed here discuss the use of labels. Though they are not covered here, there are human factors design guidelines that recommend font sizes and styles for labels. To maximize the usability of an IDS, designers should review the other guidelines (e.g., Ahlstrom & Longo, 2003).

Nielsen (1999) stated that "No design standard can ever specify a complete user interface." Thus, the application of these guidelines and standards does not guarantee an effective IDS. Although the guidance addresses usability issues and provides a framework for system designers, it is always important to take into consideration the specific needs of the user population. For example, a usability test conducted by Nielsen (1999) tested two navigational structures for a website: one that incorporated the user's mental model and one that incorporated a structure based on the corporation's mental model. Predictably, users had an 80% success rate in finding information using the site design based on the user's mental model compared to a 9% success rate with the design based on the company's mental model.

As pointed out by Ahlstrom and Longo (2003), the same standard may be implemented in a variety of ways. All systems, even those designed by following a set of standards, need to be tested with the user population to determine whether a specific design standard is implemented in the best way for that population. Designers should be aware that general standards may have to be made more specific to make them more applicable to the needs of the users and the design of the system. Ultimately, designers should work with user representatives in an iterative, spiral development process to help determine which of these standards will result in the most significant benefits and which are most applicable in a given situation. Throughout this document, we recommend evaluation and validation activities that can be used to verify or evaluate whether a guideline or standard has been implemented appropriately.

2. METHODS

The methods used and described here represent a series of applied techniques which provide results fairly rapidly and with relatively low cost. There is a significant history in the applied literature for the use of these procedures. Based on practical experience and successful prior use, we selected these methods to accomplish the goal of developing design guidance for IDSs.

In developing the design standards and guidelines, we adopted a multiphased approach. In each phase we involved participants from the field representing Certified Professional Controllers, Air Traffic Control Specialists, and Supervisory Air Traffic Control Specialists. Throughout this document we will refer to these participants as users or Specialists.

In Phase 1, we investigated the use of IDSs in the FSS domain. We observed Specialists at five FSSs as they interacted with their current systems and conducted structured interviews with 49 Specialists to assess frequency of use, commonly used functions, system benefits, and system problems.

In Phase 2, we developed IDS design concepts based on the results of Phase 1, input from Specialists from the field, and human factors design guidelines and standards (Ahlstrom & Longo, 2003; Department of Defense, 1996). We then integrated the concepts into a semi-interactive IDS prototype to provide a platform for the further development and evaluation of the design concepts. Rather than reviewing verbal or written descriptions of the concepts and imagining how they might be implemented, we used the prototype to illustrate the concepts to the users. We validated and refined the design concepts illustrated in the prototype with personnel from the field and developed an initial set of IDS design principles (Yuditsky & Friedman-Berg, 2003).

In Phase 3, we evaluated the initial set of design principles for extensibility to the other ATC domains. We conducted field visits to two towers, three TRACONS, and three ARTCCs, interviewed 43 Specialists from terminal facilities and 20 Specialists from ARTCCs and observed their use of current IDSs. We also conducted workshops with field representatives to further evaluate the applicability and comprehensiveness of the set of principles. We identified domain differences and evaluated how the principles might be applied based on the needs of the different user populations. We then refined the initial set of principles to extend their applicability to all the ATC domains.

3. RESULTS

3.1 General Findings

Our results indicate that terminal and en route Specialists use IDSs regularly to obtain operationally relevant information. When asked to rate (on a 4-point scale where 1 is *not at all* and 4 is *often*) how frequently they use the IDS during a typical shift, en route Specialists rated their frequency of use as an average of 3.6 (SD = 0.7) and terminal Specialists rated their use a 3.9 (SD = 0.3). FSS Specialists, who typically have limited access to their IDS, used a different, 5-point rating scale to indicate frequency of use. They reported using the system a few to several times a day on average. Ratings from facilities with more IDS workstations were higher than those from facilities with only one or two displays (see Figure 1).

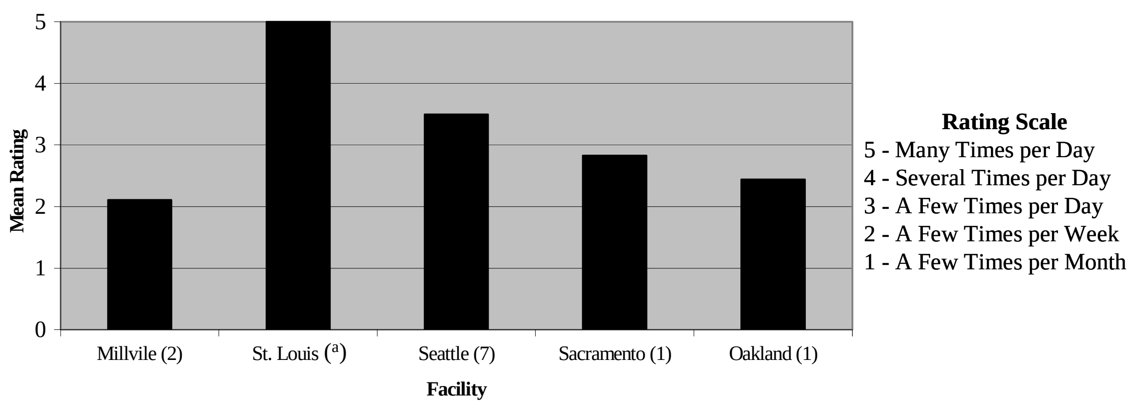

Figure 1. Ratings of IDS frequency of use.
Note: The number of available displays is listed in parentheses.
[a]St. Louis has an IDS at every position.

The Specialists identified the primary purpose of the IDS as providing comprehensive information in an efficient, easily accessible, automated format. This implies that they are using the IDSs in the field today as intended. Furthermore, the Specialists reported that what they like best about the systems is the fast access to information, the variety of information available in the system, and having the information in an electronic format.

Despite the overall positive feedback, the Specialists identified many areas where improvements in the design will lead to more efficient and effective IDS use. The following section describes these areas and the associated standards and guidelines that will rectify the problems.

3.2 IDS Design Standards and Guidelines

We organized the findings into five areas that emerged as critical components for designing an effective IDS. Each area is associated with a design standard. For each area, we describe the basic, underlying principles and discuss instances where the principles were not followed in today's IDSs. We provide specific guidelines for implementation of the standard, with references to the Human Factors Design Standard (HF-STD-001) (Ahlstrom & Longo, 2003). Appendix A presents a summary list of all the guidelines. Finally, we recommend human factors activities that can be used to evaluate the effectiveness of the implementation.

3.2.1 Accessible

For information to be accessible, it must be physically accessible and well organized.

3.2.1.1 Physically Accessible

A basic requirement for an IDS is that it has a display that is located where the Specialist can see it, reach it, and interact with it. Several of the FSSs had only one or two IDS displays for use by all personnel on duty. The Specialists expressed that this limited availability makes the system inconvenient to use. They recalled occasions when they could have used the system but, because someone else was using it, they went to other sources to obtain the information. The IDS should be available at every position that uses the information contained in the system.

The type of display and the availability of input devices also affect physical accessibility. These are covered in greater detail in our discussion of Hardware in Section 3.3.2.

3.2.1.2 Well Organized

Many of the systems surveyed in the field were poorly organized. When asked what they like least about their current systems, 42% of terminal Specialists reported counterintuitive menus, too many levels, and poor organizational structure. Forty percent of terminal controllers reported that there was too much clutter on their systems. In the ARTCCs, 30% of the Specialists reported having problems finding information due to the lack of an index and poor organizational structure.

Loss of efficiency is one of the most severe consequences of these issues. The Specialists in the field repeatedly stressed the time-critical nature of the information they access in their IDS. Their job tasks often require making quick decisions and providing critical information to pilots. The Specialists reported that it was extremely useful to have the most critical and commonly used information organized into a single status area in the system.

Another consequence was that the users did not know what information was available on their systems or how to access it. On several occasions, the Specialists believed that a specific type of information was available through their IDS but were not certain and could not specify how to find the information. For some systems, there was little organization beyond assigned page numbers, and the organization by page number was not intuitive. Most of the IDSs did not contain a convenient table of contents, help, or index that Specialists could use to find information. If a search engine or index was available, it was often cumbersome to use or did not pinpoint the exact location of the desired information. A search by keyword, for example, may produce results that point you to a document without any indication of where in the document to find the search term.

The organization of information on an IDS greatly affects the users' interaction with the system. If the organizational structure is intuitive, the user can easily navigate through the system to find any piece of information. A well organized system also allows the user to access information that is needed at the same time, in the same place, or information that is needed in a particular order in the proper sequence. For example, if the Specialist needs three pieces of information in a particular order to make a decision, all three pieces should be accessible from the same place and in the proper sequence. A system that is not well organized may cause the user to pursue incorrect paths, to navigate repeatedly from area to area, or to keep one piece of information in memory while searching for the next. All of these difficulties can lead to user frustration, increased memory load, increased workload, and overall dissatisfaction with the system.

Because of the large amount of data warehoused on an IDS, it is critical that future systems be well organized. It is imperative that the organization of the system and its navigational structure provide quick and easy access to all of the information available on the system. To achieve this, it may be beneficial to customize the system for specific user roles (Nielsen, 2003). This will allow the users to have quick access to the specific types of information relevant for performing their job functions (HF-STD-001, 8.1.3.9). An organization that is consistent with the user's mental model will facilitate training and make user navigation through the system more efficient (HF-STD-001, 2.3.3). Figure 2 is an illustration of a system that organizes information by geographic area. All links that are relevant to a location are displayed in the same color.

Figure 2. An example of organization by geographic area. Each color represents information relevant to a particular location.

If the primary organizational scheme is operationally motivated (e.g., by operational position or task), it is advantageous to use a second organizational scheme that is logical to all users, such as by subject matter. This will allow the users to quickly locate any type of information, even items that do not neatly fall into an operationally defined category or are not used frequently. Figure 3 is an illustration of how an IDS can provide access to the same piece of information through multiple paths. Access to real time weather information is available from the “Weather” page as well as from the “Position 7” page.

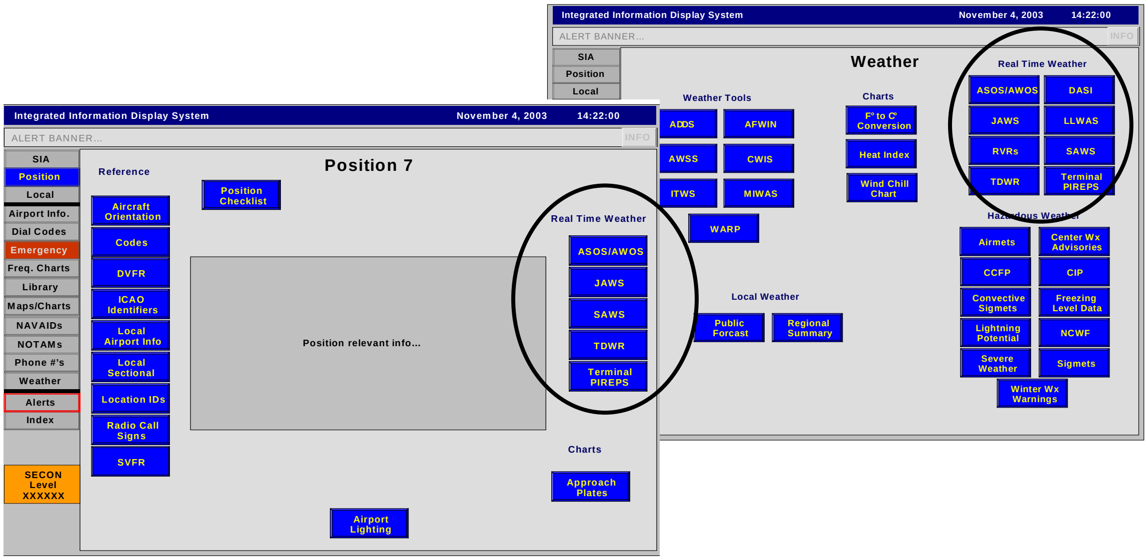

Figure 3. Illustration of multiple paths to the same real-time weather information.

Combining organizational schemes within a display can be tricky. For example, Figure 4 is an airport list that combines the color-coding by geographic area (illustrated in Figure 2) with an alphabetical organization.

Figure 4. An example of the combination of two organizational schemes.

The color coding becomes less effective at highlighting location-relevant information and adds clutter to the display. A more effective organization may group the airports by geographical area first and then apply the alphabetical organization to each group.

The availability of a search function and a comprehensive index (see Figure 5) will also help the users to quickly access any type of information available in the system (HF-STD-001, 8.16.2.16; 15.4.11).

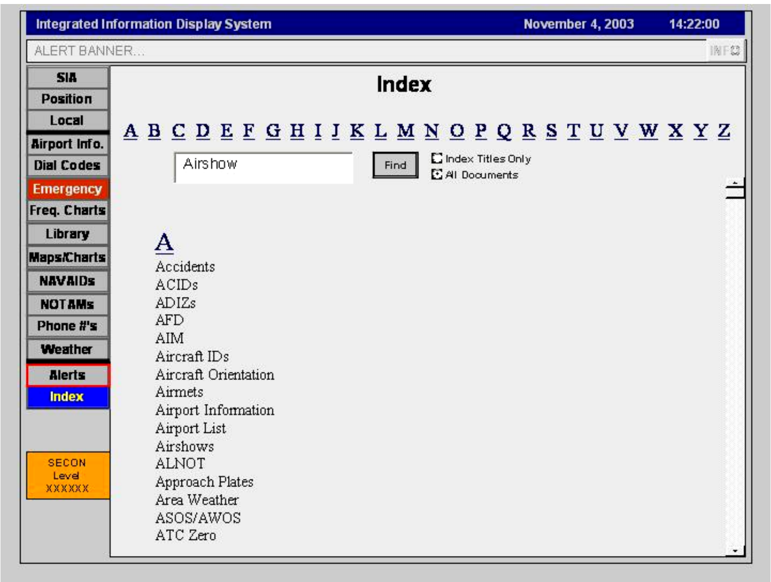

Figure 5. An example of an index and search by keyword capability.

3.2.1.3 Navigable

The Specialists identified problems with navigation in today's systems. In one system, for example, the *Back* button took the user back several steps with each click. This is not consistent with conventional use of a *Back* button and often increased the number of actions the users had to take to navigate to a particular area. Navigation within long lists or documents was also identified as a current problem. Participants from all domains reported that excessive scrolling is necessary to find the needed information.

Navigation is critical in making effective use of an organizational structure. Even a system with the most intuitive organizational structure can become cumbersome to use if the navigation tools are lacking or inappropriate. Commonly used navigation tools such as the *Back* button are helpful (when implemented correctly) and should be provided. Figure 6 is an example of a navigation bar that allows the user to access main areas directly from any page in the system.

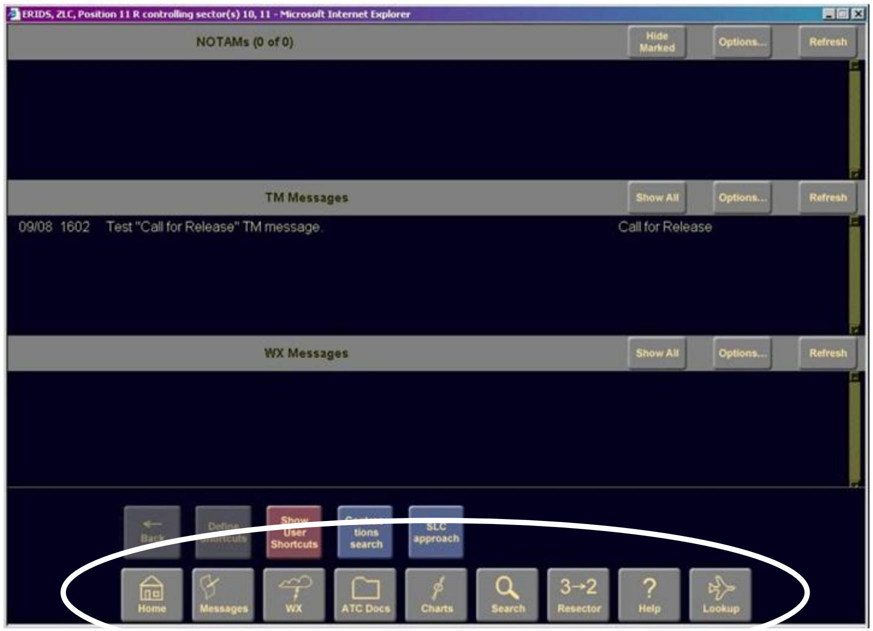

Figure 6. An example of a navigation bar.

The availability of hyperlinks can reduce the amount of scrolling necessary to get through a long document or list. The capability to create shortcuts is also extremely beneficial. The user can set up shortcuts to information that is not readily accessible but is frequently needed and can use the shortcuts to access the information through a single click rather than navigating through several pages. For example, when learning a new airspace, the user may want to create shortcuts to airspace information that is typically not needed. Finally, providing an indication of where the user is in the system through the use of highlighting, color coding, or a trail of breadcrumbs (a tool commonly used on websites to show users where they are and where they have been) helps the user learn the organizational structure of the system.

Not all systems may need all these navigation tools, and some may require additional tools. The tools that are included should be based on the user needs and the overall design of the IDS.

<u>3.2.1.4 Consistent</u>

In the field, we found that systems were lacking in consistency. Between facilities we found identical systems implemented with very different interfaces. Even within a single facility, we often found no design consistency from page to page. We encountered systems where button placement was haphazard, with buttons placed to fit in the available screen space. Often a navigation bar that contained one set of buttons on one page contained a different set of buttons on a different page. In other instances, navigation bars only appeared on the top level display and disappeared once the user drilled down into the system. We also found inconsistency in color use and button labels. Some systems used color to represent meaning (e.g., geographical areas), but others applied the same color to different types of information making it an ineffective coding scheme. The labels for buttons that link to the same information were also sometimes different.

Consistency in the design of a system can reduce training time, facilitate execution of functions, and improve the user's ability to access information (HF-STD-001, 2.3.1). With experience, the user learns the placement of links, the location of functions, and the organization of the system. To the extent possible, designers should maintain consistency throughout the system. The users should perform similar functions in similar ways and find them in consistent locations (HF-STD-001, 2.6.9). For example, the *Print* command should always be located in the same menu or location on the display, and it should always produce the same type of system response. Figure 7 illustrates consistency in the design and implementation of a navigation bar. The bar is available on every page, in the same location, and with the same set of buttons.

Figure 7. An illustration of consistency in the design and implementation of a navigation bar.

Design inconsistencies have user performance consequences. When users encounter an unfamiliar design scheme, they must visually scan each page to determine the location of buttons, navigation bars, and other elements. Consequently, the amount of time needed to find information increases and search efficiency decreases. The users lose the benefits that come from using a system with a consistent design scheme.

Standard 1: Information on an IDS shall be accessible.

The following guidelines address the issues of physical accessibility, organization of information, navigation, and consistency. Although the guidelines refer to buttons as links to information, there are other ways of implementing links that would be equally effective.

(1.1) The system display should be located such that the user can see it and interact with it.

(1.2) Information should be organized by category and by an operationally relevant/meaningful scheme (HF-STD-001, 8.1.3.9).

(1.3) Information that is particularly important, or that requires immediate user attention should be displayed in the primary viewing area (HF-STD-001, 8.1.3.13).

(1.4) Buttons should be grouped by subject matter.

(1.5) Button groups should be labeled (HF-STD-001, 8.13.5.3).

(1.6) Button labels should accurately describe the information or tool they represent (HF-STD-001, 8.13.5.6; 8.2.5.5.1).

(1.7) Contractions and abbreviations in labels should be avoided. If it is necessary to use them due to space considerations, they should only be used if they are in common usage and easily understood by all users of the system. (HF-STD-001, 8.2.11.4.6).

(1.8) When abbreviations or acronyms are used, they should be used consistently (HF-STD-001, 8.1.4).

(1.9) Buttons within a group should be ordered either alphabetically or in an operationally meaningful way (HF-STD-001, 8.1.3.16; 8.2.9.7).

(1.10) A comprehensive index with a search function should be available (HF-STD-001, 8.16.2.16; 15.4.11).

(1.11) The system should provide a *Help* function.

(1.12) Links to main topic areas or position areas should always be available for direct access through a navigation bar or menu (HF-STD-001, 2.3.1; 6.1.1.3; 8.1.3.2).

(1.13) Items contained in a navigation bar or menu should be consistent from page to page (HF-STD-001, 8.1.4).

(1.14) When a navigation bar or menu is available, it should be present on every page of the system in a consistent location (HF-STD-001, 8.1.4).

(1.15) The system should not require the user to navigate through more than four levels of menus or links to reach information (HF-STD-001, 8.7.5.11.5).

(1.16) The most commonly needed information should be available from, or displayed in, a top-level display (HF-STD-001, 8.1.3.9).

(1.17) Web-like navigation tools such as *Home* and *Back* buttons should be available (HF-STD-001, 2.6.9).

(1.18) The user should receive an indication of where they are in the system (e.g., a trail of breadcrumbs) (HF-STD-001, 3.4.5).

(1.19) If informational content cannot be displayed in the available screen/window space, then a scroll bar may be used (HF-STD-001, 8.3.4.4.1).

(1.20) If scrolling is necessary (i.e., in a long document), the system should provide the user with an alternative means of navigation (e.g., table of contents with links to chapters or a search tool).

(1.21) Button groups that represent the same subject matter should be placed in consistent locations (HF-STD-001, 8.1.4.1; 8.1.4.2).

(1.22) Buttons that provide links to the same information or tool, should have consistent labels (HF-STD-001, 8.2.5.1.1; 8.2.5.5.3).

(1.23) Button groups that provide links to the same category of information should have consistent labels (HF-STD-001, 8.2.11.1.2; 8.2.5.1.1; 8.2.5.5.3).

(1.24) Similar functions should be performed in similar ways (HF-STD-001, 8.7.7.4).

(1.25) If color is used to differentiate categories of information, it should be used consistently throughout the system (HF-STD-001, 8.6.2.1.3).

(1.26) Icon use should be consistent throughout the system (HF-STD-001, 8.1.4; 8.13.3.6).

Recommended Activities:

There are several human factors activities that can be used to ensure that the organizational scheme in a system is operationally meaningful and that it is implemented in an appropriate manner. Initially, user surveys can be conducted to identify the types of information that should be available in the system. By using surveys, large amounts of data can be collected in a relatively efficient manner providing a large, broad sample. Researchers can use a card sorting task to determine how the types of information should be organized. In this task, representative system users sort cards that list specific pieces of information into groups that are related or similar to each other. They can either group the cards into predefined categories or simply by relation. If the categories are not predefined, then categories can be determined after the sort is complete.

After an organizational structure has been determined, it is still necessary to validate that the user can find information in the system in a quick and efficient manner. To do this, ask the users to find information in the system (or a prototype of the system). Include commonly used information as well as rarely used information. Ask them to use the search engine, scroll bars, shortcut menus, and other features. This method can also be used to evaluate and compare different organizational schemes to determine which one is most intuitive and provides easiest access to information.

We also recommend that system designers validate that they have maintained consistency in the system. These evaluations are more objective than organizational evaluations. A human or computer may be used to systematically determine whether button labels and other critical components follow the given standards for consistency (Whitmore, Berman, & Chmielewski, 1996).

3.2.2 Current

One issue that we encountered with several systems was that they did not indicate when information was last updated. In some cases, the Specialists assumed that the information was current, but in other cases, they used other sources for the information because they did not feel confident that the IDS was up to date.

The inefficient dissemination of updates to the field is an issue that contributes to this problem. Some document updates are only provided in hard copy, making it is necessary for someone at each facility to scan the information into the system. This delays the availability of the latest information. It would be beneficial if all information was updated electronically.

User acceptance and trust of an IDS depends greatly on the quality of the information it contains. Many operational tasks rely on the user having current information. Outdated information is dangerous in that it may lead to inappropriate decisions or actions by the user, and it quickly causes the user to lose faith in the system and rely on it less and less (HF-STD-001, 3.5.5).

Standard 2: Information on an IDS shall be current.

We recommend the following guidelines to help maintain the user's awareness of the currency of displayed information. Items (2.1) and (2.2) are illustrated in Figure 8. We discuss how the system might notify the user of information updates in the Notifications section.

(2.1) There should be an indication as to when information was last updated (HF-STD-001, 3.10.6).

(2.2) The current date and time should always be visible (HF-STD-001, 8.1.1.8).

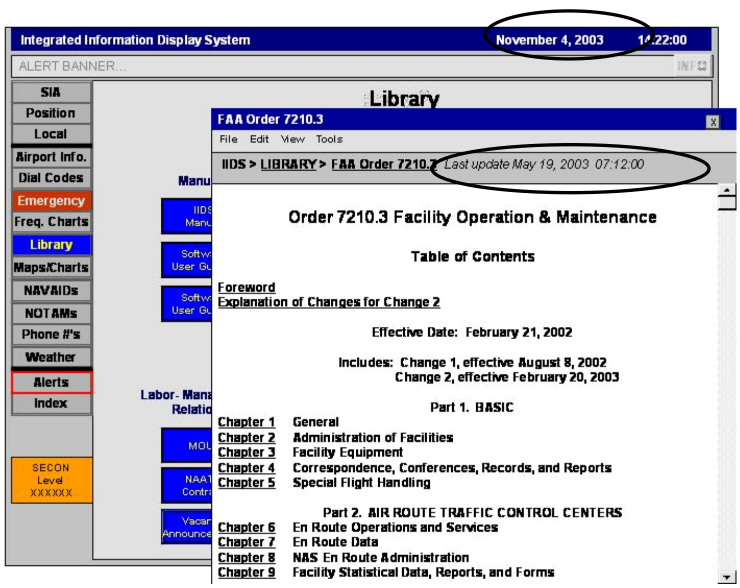

Figure 8. Indication of when a document was last updated and the current date.

(2.3) The system should notify the user when it is no longer receiving updates to dynamic information (e.g., hourly weather update was not received) (HF-STD-001, 8.17.3.10).

3.2.3 Comprehensive

To maximize the benefits of using an IDS, the information it contains should be complete, relevant to the user's tasks, and usable.

3.2.3.1 Complete and Relevant

Specialists from all domains identified some types of information that are not available on today's systems. The most significant problem with IDSs not containing relevant information was at the FSSs. The informational content of the FSS system is primarily relevant to terminal operations. Several Specialists reported that this greatly reduced the usefulness of the IDS. They found it inefficient to use the IDS for accessing some types of information while still having to rely on other sources for most of the information needed to do their jobs.

Adding useful information to the IDSs was difficult at most of the facilities visited for a variety of reasons. Most facilities were able to add content, but the tools provided by the system made adding information difficult. Because the process was tedious and time consuming, some system administrators did not have enough time to add all of the relevant content in a timely fashion. Some FSSs did not have any control over informational content and had to coordinate with system administrators at other facilities to add information.

It is important that the information found on the IDS be both complete and relevant. Users should be able to use the system as a single access point for retrieving data. Otherwise, Specialists need to go to many sources to collect data, which increases the amount of time devoted to searching for information and reduces user efficiency. It is also critical that information on the IDS be relevant for the current operational and physical (local) environment. The lack of relevant information counteracts the potential benefits of using an IDS, such as reducing printed materials, reducing the proliferation of displays, and greater efficiency in operations. Therefore, the system must provide the capability to add or create content that is operationally and locally relevant and to remove content that is not. Otherwise, the user may have to sort through large amounts of irrelevant information to find the content relevant to their operations and facility.

As a caveat, while it may seem that the greatest benefits of using an IDS may be obtained by having the maximum number of information sources all integrated into a single system, there are some types of information that should not be included. Information that requires continual monitoring, such as the tactical radar display, should not be on an IDS where it may become hidden or obscured by other information. If such information is displayed on an IDS, provisions must be made to ensure that the information is always visible.

3.2.3.2 Usable

We found that it is sometimes not sufficient to simply make information available. The user must be able to use or manipulate the information in a meaningful way. For example, the system administrators scanned charts into the system that could be viewed in sections, but they were not able to zoom in or move around in an image. Similarly, the users were not able to print selected sections of documents or search the documents by keyword.

The ability to display information simultaneously in multiple windows or by dividing the screen may also be advantageous for manipulating data in useful ways. For example, a Specialist may want to display textual information about a particular airport at the same time as an approach plate for that airport. Many of the Specialists reported that this capability would be useful and described types of information that they would like to display side by side. One factor to consider with systems that allow the user to open multiple windows is how those windows will be managed. The process may become inefficient if the user has to move them or resize them to make the information visible. An alternative to simultaneous display may be the capability to easily toggle between two displays. This eliminates the need for window management yet still allows the user to quickly switch between displays of two pieces of information.

Standard 3: Information contained in an IDS shall be comprehensive.

We recommend the following guidelines to ensure that the information on the IDS is complete, relevant, and usable.

(3.1) The system should provide access to all task-relevant documents (e.g., lists, charts, and maps).

(3.2) The system should provide access to task-relevant tools and displays.

(3.3) The system should provide the capability to easily add or remove content.

(3.4) The system should provide the capability to make global changes in the system (e.g., changing the label of a button in one place causes the change in all areas where that button is used).

(3.5) If the system displays information that must be continuously monitored, the information should not be covered up or hidden.

(3.6) Menus should be used to provide access to functions (HF-STD-001, 8.7.5).

(3.7) The system should provide the user with the ability to resize, minimize, maximize, center, and zoom on images (HF-STD-001, 8.2.4.2.1).

(3.8) The system should provide the user with the ability to select or print a section of a document (HF-STD-001, 8.2.4.1.1).

(3.9) Digital images (vector graphics) should be used (HF-STD-001, 8.3.1.4) for best image quality at all levels of zoom.

(3.10) The system should provide the user with the ability to display multiple windows (HF-STD-001, 8.14.1.2), to split the screen into two panes, or to easily toggle between two pieces of information.

Recommended Activities:

One method of evaluating system content, relevance, and usability, is a cognitive walk-through with participants from the field. The researchers can systematically ask the participants to think about how they might perform standard operational tasks using the system. Then, they can collect data on the types of information that would be required to support the user's tasks and how they manipulate that information to make it usable. This activity is especially beneficial if performed early in the spiral development process because it provides a method for collecting data without having a completed system. For an assessment of the completed system or its prototype, we recommend a structured walk-through or simulation, where researchers ask the users to perform normal operations. These evaluation methods will identify any gaps in the information available in the system and any usability issues that need to be addressed.

3.2.4 Notifications

Current IDSs provide notifications of information updates. Based on our findings, however, today's systems produce notifications for events that do not require them, do not produce notifications for events that do require them, and provide inappropriate levels of notifications. The Specialists described two categories of information: information that directly affects their primary task of ATC and information that they used as reference. When new information is available that directly affects their primary task (e.g., new NOTAM is issued for their area of control), the system should notify them with an alarm. However, if reference information is updated (e.g., FAA orders), the system should provide an indication of when the update occurred but should not distract the Specialist or require a response.

In addition, notifications should be tailored to the user's responsibilities. Systems that produce alarms or alerts that are irrelevant to the user quickly become nuisances and lose their effectiveness to draw the user's attention. The Specialists described that some of the notifications provided by the IDSs in the field are already regarded as nuisance alarms and are typically ignored.

One very important finding regarding system notifications is that the notification should never stop the Specialist from continuing what they were doing by locking the display or covering it up with a warning message. The time criticality of many ATC tasks may require that the Specialist complete a task before responding to even the most urgent notification. Some of the IDSs used in the field today prevent the user from doing anything on the system until they acknowledge the alarm. This interrupts the Specialist's workflow and reduces efficiency.

Standard 4: An IDS shall provide effective notifications.

Notifications on an IDS can draw the user's attention to important information. Whether it is an emergency or a change in status, notifications ensure that the user is aware of the information.

A notification can be highly salient and attention getting or very subtle. For example, an emergency situation usually requires an immediate response and should draw the user's attention. An update to reference information, however, is typically not something that the user has to be made aware of immediately. In that case, a notification that the user will notice when accessing that piece of information may be more appropriate. Notifications of critical information that require an immediate response are often referred to as alarms, whereas those that do not call for immediate action but are operationally relevant are referred to as alerts (HF-STD-001, 7.1.2.5-8). Alarms may produce an audible signal to draw the user's attention if it is directed elsewhere, while alerts may only require a visual indication. The design of alarms and alerts for any new system is a difficult task. We found that designers need operational input to determine which types of events require alarms and which types require alerts.

We recommend the following guidelines to help maintain the user's awareness of new information without creating situations that interfere with their tasks or cause them to disregard the notification.

(4.1) The system should have the capability to produce both audible and visual alarms (HF-STD-001, 7.1.1.11; 7.1.1.12).

(4.2) Alarms should capture the attention of the user (HF-STD-001, 7.1.1.12).

(4.3) Use of the color red should be reserved for visual indication of alarms (HF-STD-001, 8.6.2.4.3).

(4.4) Audible signals should only be used for indicating critical situations that may require immediate user action (HF-STD-001, 7.2.1.1). The limited use of audible alarms will maintain the sense of urgency associated with them.

(4.5) The signal used for the audible alarm should be one that is different from other audible alarms in the operational area (HF-STD-001, 7.2.3.2).

(4.6) The signal used for audible alarms should be intermittent (HF-STD-001, 7.2.5.1).

(4.7) If the audible alarm sounds for more than a few seconds, the system should provide the capability to quickly silence the existing audible alarm without affecting future alarms (HF-STD-001, 7.2.9.8).

(4.8) An alarm or alert notification should be displayed in a location that is always visible.

(4.9) The alarm or alert notification should include text that indicates the type of problem (HF-STD-001, 7.1.1.4).

(4.10) The alarm or alert notification should provide a link to a simple and understandable description of the problem (HF-STD-001, 7.1.1.9; 7.1.2.10).

(4.11) An alarm or alert notification should not stop operations in progress at the time of the alarm.

(4.12) The system should display all alarm and alert messages in a specific area until they no longer exist or are cleared (e.g., by a supervisor).

Recommended Activities:

As we discussed earlier, user involvement is needed to identify events that warrant alarms or alerts. We recommend forming a user team with representation from different facilities within a domain. The team should consider the information available on the IDS and whether changes to the information may be critical to operations. The team can work with Human Factors Engineers to select an audible signal that is distinct and not masked by environmental noise, and visual indications that are noticeable but do not make information on the display unreadable. A simulation can be used to verify that the application of alarm or alert classifications was appropriate and that the audible or visual signals are effective.

<u>3.2.5 Standardized</u>

Standardization brings benefits such as reduced training and improved configuration management. When a system is standardized, the same look and feel of the system is maintained, regardless of facility differences. From a usability perspective, standardization ensures that the user interface adheres to human factors design guidelines by providing users with a standardized template that has been specifically designed and tested for usability. In the field, many of the IDSs we observed were difficult to read, used too many colors, and had little or no organizational scheme.

However, we also learned that across facilities Specialists do things somewhat differently and information that is useful at one facility may not be useful at another. We also found differences between domains and between positions in a domain. For example, we found that FSS personnel require more in depth information on a larger number of topics than those typically accessed by the Specialists in the en route and terminal domains. They also have more time available to navigate through the IDS to find the information they need. Both the en route and terminal domains require quicker access to information due to the time-critical nature of their tasks. However, there are also differences between the en route and terminal domains. En route Specialists engage in more strategic control whereas the Specialists in the terminal domain engage in more tactical control (Wickens et al., 1997), which can result in differences in the types of information used.

Even within domains, we found differences in Specialist tasks and information needs. For example, data controllers use IDSs to access reference information, whereas radar controllers focus on more task-critical information. Specialists working in the same facility can differ in their information needs solely because of geographic differences in the areas under their control. Due to these variations, it is beneficial for facilities to have some control over the information displayed on their IDS. As we discussed earlier, maximizing the availability of relevant information while eliminating irrelevant information on an IDS makes the system more efficient and more useful. Because the benefits provided by standardization are so important, we recommend that users be allowed to customize a system within limits. For example, systems can provide the users with a standard design template that conforms to usability guidelines. This template can specify a number of important graphical user interface components such as the button colors, a limited selection of background colors, predetermined button shapes and sizes, category labels, and other components that do not vary. The facilities will have control over the content that is displayed on their IDS.

Standard 5: An IDS shall be standardized.

To provide some level of flexibility in content while preserving a standardized look and feel (DOD HCISG 14.1), we recommend the following guidelines:

(5.1) A standard design scheme should be used throughout the system (HF-STD-001, 2.3.1).

(5.2) The system should provide the capability to add buttons, windows, documents, and tools.

(5.3) The system should include the capability to tailor which of the available buttons will be displayed on each page.

(5.4) The system should include the capability to create and label links to locally relevant content using the standardized format.

(5.5) The system should provide no more than three color palettes for display design (HF-STD-001, 8.6.2.9.1). The color palettes should be selected to accommodate the range of environmental conditions that exist in the field (e.g., for bright, moderate, and dark ambient lighting).

Figure 9 displays a sample set of color combinations for three levels of lighting. We propose three shades of gray for the background color, a light gray for bright environments, a medium gray for moderate lighting, and a dark gray for dim lighting. We propose three background and text color combinations for the buttons. Any of the button color combinations can be used with any of the background colors.

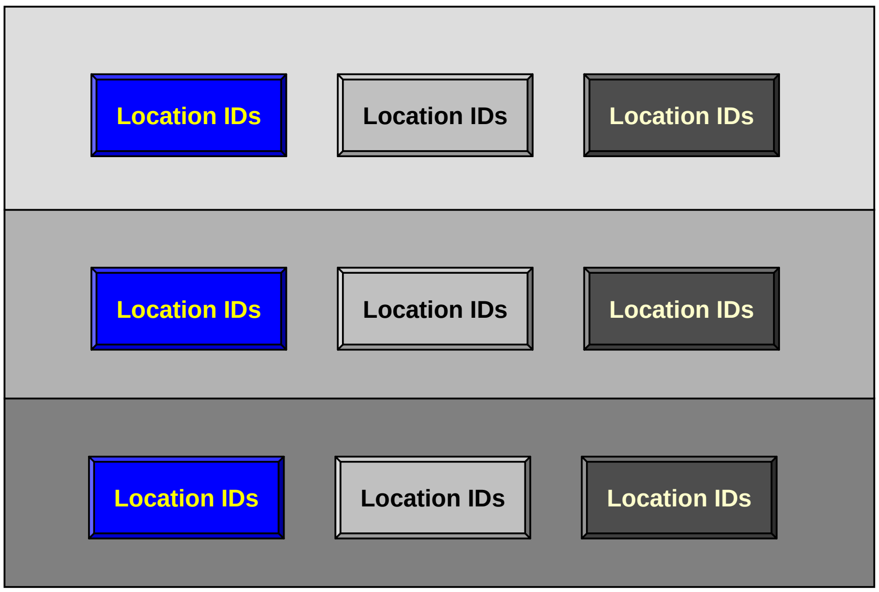

Figure 9. Sample color combinations.

(5.6) The format for buttons, menus, and other display objects should not be user-configurable beyond the available color options (HF-STD-001, 8.2.5.5.3).

(5.7) Colors that are used to indicate status should not be configurable (HF-STD-001, 8.6.2.9.4).

(5.8) Font style and size options should be limited (HF-STD-001, 8.2.5.7.3).All information should be available at every facility - customization should only be used to tailor what is displayed (HF-STD-001, 2.6.9).

Recommended Activities:

We recommend determining which aspects of the system should be standardized and what those standards are. This activity should be conducted by (or with input from) Human Factors Specialists who can refer to existing design guidelines and standards to make the best decisions for the operational environment. Because environmental factors, such as lighting and noise, can greatly affect one's perception, it is important to evaluate the selected standard under operational conditions.

3.3 Other Topics

3.3.1 Use of Color

Color can be an extremely effective cue for highlighting information, drawing the user's attention, reducing clutter, or grouping similar elements (HF-STD-001, 8.6.2.1). If used improperly, however, color can lose its effectiveness at drawing the user's attention and can add clutter and noise to a display. We describe some general guidelines for the use of color here. A more comprehensive set of guidelines is available in the Human Factors Design Standard (HF-STD-001, 8.6.2) as well as in other sources (e.g., Cardosi & Hannon, 1999).

Color should be used conservatively and consistently. Color should be used to designate meaningful categories of displayed information if it will facilitate user understanding or performance (HF-STD-001, 8.6.2.7.1). Because only eight or nine highly saturated colors can be easily discriminated, the total number of colors used should not exceed four for a single display and seven for a set of related displays (HF-STD-001, 8.6.2.7.3). Additional colors should be reserved for special use (for example, in map displays) (HF-STD-001, 8.6.2.7.4).

Although users often express a preference for color, it does not always improve their performance (HF-STD-001, 8.6.2). If used to represent meaning, each color should only represent a single category of information (HF-STD-001, 8.6.2.4.1). In the field, we observed some IDSs that successfully used color to organize the display and to draw the user's attention to information that was relevant to their tasks. We also observed displays that appeared noisy due to the use of too many colors or inconsistent application of meaning to color.

The issue of color selection is complex and very important. The use of color should not reduce the readability of information on the display (HF-STD-001, 8.6.2.1.7). Therefore, colors should be selected carefully for the display of information, particularly for combinations of text and background. Readability should be evaluated with users under operational conditions such as ambient lighting and display type (HF-STD-001, 8.6.2.5.3). If multiple colors are used to represent categories of information, they should be distinguishable under operational conditions (HF-STD-001, 2.6.9). It is also important to be aware of existing color-coding conventions and reserved meanings, such as the use of red for emergency or failure conditions. In Figure 10 for example, red is only used for the emergency checklist button and to highlight closures.

Figure 10. An illustration of how the color red may be used to indicate emergency conditions.

3.3.2 Hardware

The IDS typically consists of a display and an input device (i.e., mouse or trackball). Because the system is primarily used to display information, a keyboard is only necessary at the system administrator's workstation or a supervisory position, if data entry is required. An alternative to traditional, hardware keyboards is an online keyboard that is displayed on the IDS when data entry is required (see Figure 11). This alternative is quite tedious to use because every letter key must be touched or clicked in turn, and is only viable if limited data entry is required.

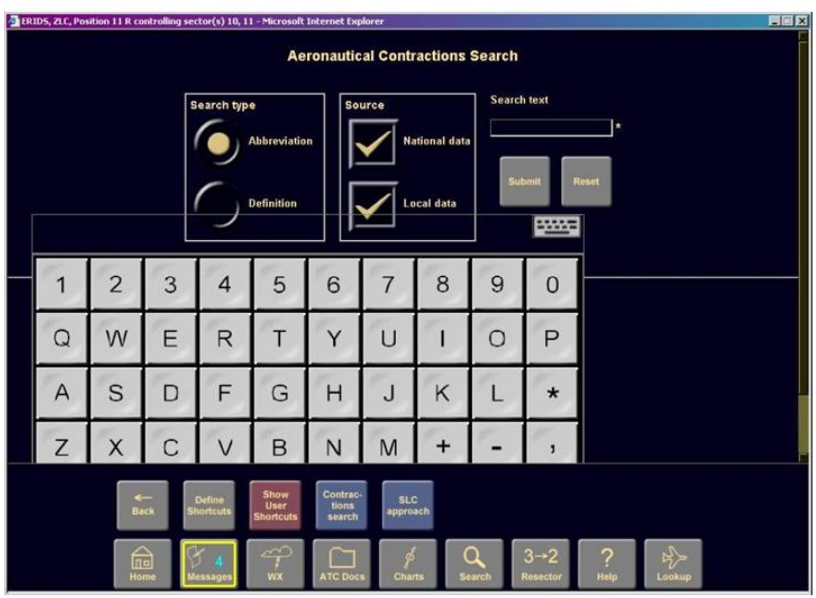

Figure 11. An online keyboard is provided for searches in ERIDS.

Some of the IDSs in the field used touch screen displays. There are both advantages and disadvantages to using these displays. One advantage is that they are a fast way for the user to navigate through a system (HF-STD-001, Exhibit 9.0). Touch screens provide a more direct form of interaction than pointing devices. When using a pointing device such as a mouse, users must coordinate the position in *xy* space on a mouse pad with the position in *xy* space on the screen. With a touch panel, they are dealing with only one two-dimensional Cartesian space. A disadvantage of touch screens is that they sometimes have low touch resolution (HF-STD-001, Exhibit 9.0). That is, if the user has a large finger and is trying to activate a single button in a set of buttons placed close to one another, it is easy for the user to accidentally press the wrong button. Other problems that have been associated with the use of touch screens include (a) users blocking information on the screen with their finger, (b) poor visibility due to finger prints on the display, and (c) arm fatigue after extended use (HF-STD-001, Exhibit 9.0).

In the field, the most commonly reported problems with the use of touch screens were misalignment or sensitivity of displays and difficulty with manipulating small objects. The misalignment and sensitivity issues are hardware problems that cause the system to activate the object next to the one the user touches or make it difficult to activate an object. When an alternative input device was not available, the Specialists reported becoming frustrated with having to perform repeated actions to get the system to respond. The difficulty with small objects, such as toolbar buttons, is that people's fingers are too big to activate and deactivate them precisely.

The touch screens we observed in the field were typically placed within reach of the Specialists or on an articulating arm that allowed the Specialists to pull the display closer or push it out of the way. Placement is a consideration with any type of display, but a particularly important one with touch screen displays. All users, regardless of their height or whether they are left or right-handed, must be able to see and touch the display from their normal working position. Based on our observations, the articulating arm was a good solution to this problem.

Input devices are also an important consideration for an IDS. Our findings show that even with touch screen displays, an effective input device can facilitate the user's interaction with the system. Based on their reports, touch screen users often preferred using a trackball over their finger or a stylus. In the ATC environment the workstations typically have little desk space, making trackballs the preferred device. Specific guidelines for non-keyboard input devices are available in Ahlstrom and Kudrick (2004).

Finally, display characteristics should be considered. The same amount of information can appear cluttered on a small display and well spaced on a large display. The many pieces of information that may be presented on an IDS call for a display that is large enough to effectively present the required information and still be accommodated in the workstation. A larger display will also enable the user to make effective use of capabilities such as manipulating graphics and displaying multiple windows. Display resolution, brightness, and contrast should be adequate for viewing under operational conditions. To accommodate the users' individual preferences for display brightness, the brightness and contrast should be adjustable.

3.3.3 Training

Training is a topic that is not directly related to IDS design, but one that was often mentioned by the Specialists is training. It is critical that adequate training be provided on a new IDS. Hands-on training will allow the Specialists to learn the organizational structure, the coding schemes, and the design style used in the system. This level of learning will promote more effective use of the IDS operationally.

4. CONCLUSION

An IDS offers many benefits in the ATC environment. IDSs are an effective means for providing access to useful tools and different types of information through a single display. This document presents a set of design standards and guidelines that are particularly important in the ATC environment. The information available through the IDS must be easily accessible, current, and comprehensive. The system should provide notifications of changes to information, and there should be standardization in its design. More importantly, this document relays some of the lessons learned from the successes and problems of today's systems, and describes recommended activities for evaluating whether a guideline was implemented effectively. This guidance should be used to ensure that future systems meet design guidelines as well as provide standardization throughout the NAS.

References

Ahlstrom, V., & Kudrick, B. (2004). *Human factors criteria for the design and procurement of non-keyboard interaction devices: A human factors design standard update.* Atlantic City International Airport, NJ: Federal Aviation Administration, William J. Hughes Technical Center, NAS Human Factors Group (ATO-P).

Ahlstrom, V., & Longo, K. (2003). *Human factors design standard: For acquisition of commercial-off-the-shelf subsystems, non-developmental items, and developmental systems*. (DOT/FAA/CT 03/05). Atlantic City International Airport, NJ: Federal Aviation Administration, William J. Hughes Technical Center.

Cardosi, K., & Hannon, D. (1999). *Guidelines for the use of color in ATC displays* (DOT/FAA/AR-99/52). Washington, DC: Office of Aviation Research.

Department of Defense. (1996). *Technical architecture framework for information management. Volume 8: DOD Human computer interface style guide. Version 3.0*. Washington, DC: Defense Information Systems Agency/Center for Information Management DISA/CIM.

De Souza, F. & Bevan, N. (1990). The use of guidelines in menu interface design: Evaluation of a draft standard. *Proceedings of IFIP INTERACT'90: Human Computer Interaction*, 435-440. Elsevier, North-Holland.

Henninger, S., Haynes, K., & Reith, M.W. (1995). A framework for developing experience-based usability guideline. *Symposium on Designing Interactive Systems*, 43-53, Ann Arbor, MI. NY, NY. ACM Press.

H.R. Rep. No. 108-243 at 36. (2003).

Nielsen, J. (1999, August 22). Do interface standards stifle design creativity? *Jacob Nielsen's Alertbox*. Retrieved December 8, 2003 from http://www.useit.com/alertbox/990822.html

Nielsen, J. (2003, March 31). Intranet Portals: A Tool Metaphor for Corporate Information. *Jacob Nielsen's Alertbox*. Retrieved December 8, 2003 from http://www.useit.com/alertbox/20030331.html

Whitmore, M., Berman, A.H., & Chmielewski, C. (1996). *Independent Verification and Validation of Complex User Interfaces: A Human Factors Approach* (NASA Technical Paper #3665). Houston, TX: NASA Johnson Space Center.

Wickens, C.D., Mavor, A.S., & McGee, J.P. (1997). *Flight to the future: Human factors in air traffic control*. Washington DC: National Academy Press.

Yuditsky, T. & Friedman-Berg, F. (2003). *Human factors design requirements and recommendations for the integrated information display system (IIDS).* Atlantic City International Airport, NJ: FAA, William J. Hughes Technical Center, NAS Human Factors Group (ATO-P).

Acronyms

ARTCCs	Air Route Traffic Control Centers
ASOS	Automated Surface Observing System
ATC	Air Traffic Control
ERIDS	En Route IDS
FAA	Federal Aviation Administration
FSS	Flight Service Station
IDS	Information Display System
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NOTAM	Notice to Airmen
TRACON	Terminal Radar Approach Control

Appendix A

IDS Design Guidelines

Guideline	Description
1.1	The system's display should be located such that the user can see it and interact with it.
1.2	Information should be organized by category and by an operationally relevant/meaningful scheme (HF-STD-001, 8.1.3.9).
1.3	Information that is particularly important, or that requires immediate user attention should be displayed in the primary viewing area (HF-STD-001, 8.1.3.13).
1.4	Buttons should be grouped by subject matter.
1.5	Button groups should be labeled (HF-STD-001, 8.13.5.3).
1.6	Button labels should accurately describe the information or tool they represent (HF-STD-001, 8.13.5.6; 8.2.5.5.1).
1.7	Contractions and abbreviations in labels should be avoided. If it is necessary to use them due to space considerations, they should only be used if they are in common usage and easily understood by all users of the system. (HF-STD-001, 8.2.11.4.6).
1.8	When abbreviations or acronyms are used, they should be used consistently (HF-STD-001, 8.1.4).
1.9	Buttons within a group should be ordered either alphabetically or in an operationally meaningful way (HF-STD-001, 8.1.3.16; 8.2.9.7).
1.10	A comprehensive index with a search function should be available (HF-STD-001, 8.16.2.16; 15.4.11).
1.11	The system should provide a *Help* function.
1.12	Links to main topic areas or position areas should always be available for direct access through a navigation bar or menu (HF-STD-001, 2.3.1; 6.1.1.3; 8.1.3.2).
1.13	Items contained in a navigation bar or menu should be consistent from page to page (HF-STD-001, 8.1.4).

Guideline	Description
1.14	When a navigation bar or menu is available, it should be present on every page of the system in a consistent location (HF-STD-001, 8.1.4).
1.15	The system should not require the user to navigate through more than four levels of menus or links to reach information (HF-STD-001,8.7.5.11.5).
1.16	The most commonly needed information should be available from, or displayed in, a top-level display (HF-STD-001, 8.1.3.9).
1.17	Web-like navigation tools such as *Home* and *Back* buttons should be available (HF-STD-001, 2.6.9).
1.18	The user should receive an indication of where they are in the system (e.g., a trail of breadcrumbs) (HF-STD-001, 3.4.5).
1.19	If informational content cannot be displayed in the available screen/window space, then a scroll bar may be used (HF-STD-001, 8.3.4.4.1).
1.20	If scrolling is necessary (i.e., in a long document), the system should provide the user with an alternative means of navigation (e.g., table of contents with links to chapters or a search tool).
1.21	Button groups that represent the same subject matter should be placed in consistent locations (HF-STD-001, 8.1.4.1; 8.1.4.2).
1.22	Buttons that provide links to the same information or tool, should have consistent labels (HF-STD-001, 8.2.5.1.1; 8.2.5.5.3).
1.23	Button groups that provide links to the same category of information should have consistent labels (HF-STD-001, 8.2.11.1.2; 8.2.5.1.1; 8.2.5.5.3).
1.24	Similar functions should be performed in similar ways (HF-STD-001, 8.7.7.4).
1.25	If color is used to differentiate categories of information, it should be used consistently throughout the system (HF-STD-001, 8.6.2.1.3).
1.26	Icon use should be consistent throughout the system (HF-STD-001, 8.1.4; 8.13.3.6).
2.1	There should be an indication as to when information was last updated (HF-STD-001, 3.10.6).
2.2	The current date and time should always be visible (HF-STD-001, 8.1.1.8).

Guideline	Description
2.3	The system should notify the user when it is no longer receiving updates to dynamic information (e.g., hourly weather update was not received) (HF-STD-001, 8.17.3.10).
3.1	The system should provide access to all task-relevant documents (e.g., lists, charts, and maps).
3.2	The system should provide access to task-relevant tools and displays.
3.3	The system should provide the capability to easily add or remove content.
3.4	The system should provide the capability to make global changes in the system (e.g., changing the label of a button in one place causes the change in all areas where that button is used).
3.5	If the system displays information that must be continuously monitored, the information should not be covered up or hidden.
3.6	Menus should be used to provide access to functions (HF-STD-001, 8.7.5).
3.7	The system should provide the user with the ability to resize, minimize, maximize, center, and zoom on images (HF-STD-001, 8.2.4.2.1).
3.8	The system should provide the user with the ability to select or print a section of a document (HF-STD-001, 8.2.4.1.1).
3.9	Digital images (vector graphics) should be used (HF-STD-001, 8.3.1.4) for best image quality at all levels of zoom.
3.10	The system should provide the user with the ability to display multiple windows (HF-STD-001, 8.14.1.2), to split the screen into two panes, or to easily toggle between two pieces of information.
4.1	The system should have the capability to produce both audible and visual alarms (HF-STD-001, 7.1.1.11; 7.1.1.12).
4.2	Alarms should capture the attention of the user (HF-STD-001, 7.1.1.12).
4.3	Use of the color red should be reserved for visual indication of alarms (HF-STD-001, 8.6.2.4.3).
4.4	Audible signals should only be used for indicating critical situations that may require immediate user action (HF-STD-001, 7.2.1.1). The limited use of audible alarms will maintain the sense of urgency associated with them.

Guideline	Description
4.5	The signal used for the audible alarm should be one that is different from other audible alarms in the operational area (HF-STD-001, 7.2.3.2).
4.6	The signal used for audible alarms should be intermittent (HF-STD-001, 7.2.5.1).
4.7	If the audible alarm sounds for more than a few seconds, the system should provide the capability to quickly silence the existing audible alarm without affecting future alarms (HF-STD-001, 7.2.9.8).
4.8	An alarm or alert notification should be displayed in a location that is always visible.
4.9	The alarm or alert notification should include text that indicates the type of problem (HF-STD-001, 7.1.1.4).
4.10	The alarm or alert notification should provide a link to a simple and understandable description of the problem (HF-STD-001, 7.1.1.9; 7.1.2.10).
4.11	An alarm or alert notification should not stop operations in progress at the time of the alarm.
4.12	The system should display all alarm and alert messages in a specific area until they no longer exist or are cleared (e.g., by a supervisor).
5.1	A standard design scheme should be used throughout the system (HF-STD-001, 2.3.1).
5.2	The system should provide the capability to add buttons, windows, documents, and tools.
5.3	The system should include the capability to tailor which of the available buttons will be displayed on each page.
5.4	The system should include the capability to create and label links to locally relevant content using the standardized format.
5.5	The system should provide no more than three color palettes for display design (HF-STD-001, 8.6.2.9.1). The color palettes should be selected to accommodate the range of environmental conditions that exist in the field (e.g., for bright, moderate, and dark ambient lighting).
5.6	The format for buttons, menus, and other display objects should not be user-configurable beyond the available color options (HF-STD-001, 8.2.5.5.3).

Guideline	Description
5.7	Colors that are used to indicate status should not be configurable (HF-STD-001, 8.6.2.9.4).
5.8	Font style and size options should be limited (HF-STD-001, 8.2.5.7.3).
5.9	All information should be available at every facility – customization should only be used to tailor what is displayed (HF-STD-001, 2.6.9).