



**USABILITY AND ACCESSIBILITY OF
AIR FORCE INTRANET WEB SITES**

THESIS

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Abstract

The Air Force is moving to a network centric environment where information must be visible, accessible, and understandable. This transformation has seen the adoption of the Internet web browser as a *de facto* standard for information access. The Technology Acceptance Model suggests that information systems must not only be useful but also be usable and a large body of usability engineering knowledge exists to support usable design. In addition, the U.S. government mandates specific minimum design features required to support disabled user access.

This research effort seeks to establish an understanding of how well common practice usability design principles and government mandated accessibility guidelines are followed by Air Force intranet web sites. Heuristic evaluation is used to investigate web site usability. Accessibility is inspected against government guidelines.

The results of this study suggest that Air Force intranet web sites do not adequately comply with many usability principles and that accessibility compliance varies from site to site. Furthermore, although the majority of usability and accessibility design principles are not captured in military guidance, scores were higher for those principles that are captured in the guidance than for those that are not.

AFIT/GIR/ENV/06M-02

To my wife and daughter

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USABILITY AND ACCESSIBILITY OF AIR FORCE INTRANET WEB SITES

I. Introduction

As the Department of Defense (DoD) strives to transform itself from the Industrial Age to the Information Age, Internet based technologies have become a central enabler of the transformation process. DoD policy recognizes that “Data is an essential enabler of network-centric warfare (NCW)” and mandates that data “shall be made visible, accessible, and understandable to any potential user in the Department of Defense as early as possible in the life cycle to support mission objectives” (Department of Defense, 2004). Numerous enterprise and information architecture efforts are underway to ensure that data is technically accessible and usable. The Air Force recognizes the Internet as “an indispensable source for information” (Department of the Air Force, 2005b) and has implemented many web enabled solutions.

However, making the data technically accessible and usable is often not enough to ensure a system’s success. Particular attention must be paid to the human interface that allows the user to interact with the data. Technology solutions that users find difficult to use may be under-utilized or rejected outright. Interestingly, past research conducted at the Air Force Institute of Technology (AFIT) found that usability and disabled access of evaluated web sites were far from optimal (Felax, 2005; Kastenholz, 2005). This thesis explores Air Force intranet web sites with the goal of creating a better understanding of the current state of affairs of the usability and accessibility of those sites.

Problem Statement

As use of the World Wide Web (WWW) has increased and approaches the point of critical mass, the DoD, recognizing the potential benefits of embracing this technology, began to “strongly encourage” WWW use (Department of Defense, 2001). Today, the Air Force portal boasts over 700,000 U.S. military, civil service, ally, and contractor users (Department of the Air Force, 2006). However, the question of whether users will accept web based applications and integrate them into their daily processes remains unknown at this point in time. While information is a key instrument of national power and exploiting information remains a tenet of Joint doctrine (Department of Defense, 2005a), care must be taken to ensure that information and information systems are usable and actually reduce rather than contribute to the *fog* and *friction* of war-fighting operations.

This research expands upon previous efforts that found that the usability and accessibility of two Air Force web based applications failed to meet many common practice guidelines used in the civilian world. A range of Air Force web sites are investigated for usability and accessibility. Meanwhile, DoD and Air Force guidance are reviewed to determine the adequacy of current guidance for producing usable and accessible web sites.

Background

DoD transformation efforts address three major areas: conducting business within the Department, working with “interagency and multinational partners,” and how the DoD fights (Department of Defense, 2005b). Network-centric Warfare (NCW) is

primarily directed at how it fights, but touches all three areas. Data, as an enabler of NCW, must be made readily available for machine-to-machine, human-to-human, and human-to-machine interfaces. Where human-to-machine interfaces occur, human-computer interaction (HCI) theories and the technology acceptance model (TAM) provide valuable insight into the potential acceptability of these interfaces.

The technology acceptance model suggests that *perceived usefulness* and *perceived ease of use* are significant determinants of user acceptance of computer technologies (Davis, 1989). Usability and disabled accessibility both play significant roles in user's perceived ease of use. In fact, some definitions of usability are synonymous with ease of use (Bevan, 1995).

Comparing Air Force web sites with the most commonly accepted usability principles is a practical way to evaluate the usability of those sites. Similarly, evaluating Air Force web sites against the federal government's mandatory accessibility guidelines provides an understanding of how accessible those sites really are. Additionally, a review of DoD and Air Force guidance is warranted to examine how well common practice guidelines have been integrated into organizational policies and what impact this guidance may have on the usability and accessibility of Air Force intranet web sites.

Research and Investigative Questions

This research seeks to answer the question: *How well are appropriate common practice web usability principles and Section 508 accessibility guidelines followed by Air Force intranet web sites?* In order to answer this research question, several investigative

questions are used to narrow the research effort to a manageable scope. These investigative questions are:

- IQ1. How well do Air Force intranet web sites follow common practice usability principles identified in the literature?
- IQ2. How well do Air Force intranet web sites adhere to the accessibility requirements of Section 508 of the Rehabilitation Act?
- IQ3. Does a relationship exist between usability and Section 508 accessibility compliance scores?
- IQ4. Are common practice usability principles and government mandated Section 508 accessibility requirements reflected in or referenced by military guidance that is relevant to Air Force intranet web sites?
- IQ5. Does a relationship exist between compliance scores and the existence of common practice usability principles and Section 508 accessibility guidelines in military guidance?

Proposed Methodology

This research implements a case study approach. Nielsen's usability heuristics (Nielsen and Mack, 1994) are used to inspect usability for the sites in this study to answer IQ1. Each web site is then evaluated using a checklist of Section 508 mandatory compliance items to answer IQ2. Descriptive statistics are utilized to establish whether a relationship exists between the usability and accessibility compliance scores to answer IQ3. Next, IQ4 is addressed through a review of DoD and Air Force guidance relevant to web site design and maintenance. Lastly, descriptive statistics are utilized to establish the strength of the relationship between existence of usability and accessibility principles in military guidance documents and the respective compliance scores for those principles to answer IQ5.

Significance

The Department of Defense and the Air Force are making huge investments in the shift to NCW. Portals and other web sites provide the primary human-computer interface to access data in this new paradigm. For NCW to function at the most efficient level possible, it is essential that these interfaces meet user expectations for usability and are accessible to all users. Otherwise users may fail to fully accept these new web-based tools and are likely to rely instead on the old ways of doing business and develop workarounds for the newer systems.

Past research efforts found that specific Air Force web applications failed to meet reasonable standards of usability and accessibility (Felax, 2005; Kastenholz, 2005). The current research investigates a variety of additional Air Force web sites to determine if usability and accessibility shortcomings may be prevalent on a wide scale. Specific focus is given to the web development and maintenance guidance provided by the DoD and Air Force to determine if that guidance is sufficient to guide the development of usable and accessible web interfaces.

This research generates a better understanding of the current state of usability and accessibility of Air Force intranet web sites. Furthermore, the knowledge gained from assessing the adequacy of existing military guidance is useful to policy makers, web interface designers, and those who are responsible for acquiring web-enabled technologies.

Scope

Past research efforts have focused on specific web sites and web-based tools (Felax, 2005; Kastenholz, 2005). This study includes six Air Force intranet web sites whose purpose is to facilitate a transaction or an information exchange between a host organization and an authorized user for a business purpose, other than those with the general public. Although these systems are available worldwide, they are only accessible to military members and organizational partners. Therefore, these systems are treated as part of a single Air Force intranet. Internet sites whose primary purpose is sharing information with the public are not included in the scope of this study.

Limitations

This study attempts to overcome the primary limitation of past AFIT studies by using multiple usability evaluators. However, use of graduate students in lieu of experienced usability experts may result in less reliable scores. Although the scores may vary from those that would be obtained by using experienced evaluators, it is understood that experts will actually identify more shortcomings, resulting in lower scores (Nielsen, 1992). Additionally, use of a single accessibility evaluator provides weaker support for accessibility findings than would the use of multiple evaluators. However, accessibility evaluations are more technical in nature and the additional evaluators available for this effort did not possess the technical skills required to conduct accessibility inspections.

Two other limitations are the limited availability of relevant web specific military guidance and the unknown degree to which individual military units comply with that guidance. Although general guidance documents such as DoD Regulations and Air Force

Instructions are readily available for evaluation, it is nearly impossible to capture all design documents used for development and acquisition of web-based applications. It is equally difficult to obtain the indefinite quantity of organizational guidance that has been produced for use at the local unit level. Furthermore, although military guidance can easily be qualified as mandatory or optional, it is not possible to know with any level of certainty how well any given unit complies with that guidance or is even familiar with it without a unit compliance inspection which is beyond the scope of this thesis. Therefore, compliance with mandatory guidance must be assumed.

For the purposes of this research, the compliance scores obtained by the evaluators will be sufficient to indicate patterns and bring much needed attention to the issues of usability and accessibility of web interfaces in modern, information dependent network-centric warfare. Similarly a review of available military guidance is adequate to build a general understanding of whether policy makers have provided sufficient guidance to produce usable and accessible web-based solutions.

Thesis Overview

The first chapter of this thesis provided an introduction to the growing use of web interfaces for DoD and Air Force transformation efforts and network-centric warfare. It also introduced the role of usability and accessibility in technology acceptance and noted that Air Force web-based tools have performed poorly in past usability and accessibility evaluations, supporting the need for the additional research. Chapter II contains a literature review that more fully supports the need for usability, identifies common practice usability guidance applicable to web site development, defines Section 508

accessibility mandates, and addresses specific usability and accessibility evaluation methods. Chapter III details the methodology used to answer the investigative questions and describes the data collection effort. Data analysis is presented in Chapter IV. Chapter V contains additional discussion and recommendations for future research.

II. Literature Review

As the Air Force moves to a web-based environment, it is important to understand the factors that are driving this paradigm shift and recognize potential impediments to successful transformation. This chapter begins with an overview of Internet technology used for electronic business (e-business) and organizational intranets and discusses usability as a determinant of technology acceptance. A set of characteristics that capture the subjective concept of usability are identified and various usability inspection techniques assessed. Accessibility is established as a mandatory feature of Air Force intranet web sites and accessibility inspection techniques are identified. The theoretical relationship between usability and accessibility is discussed and the role of guidance in developing usable and accessible web sites is explored. This chapter concludes with a review of the findings of past research in this area and presentation of a model for the current research.

Electronic Business and the World Wide Web

Businesses have long recognized the value of computer technologies for reducing transaction costs associated with daily activities. E-business integrates these technologies to create new business processes that facilitate lower operating costs, better service, and network effects (Van Slyke and Belanger, 2003). IBM, an early developer of e-business concepts, defines e-business as “The transformation of key business process through the use of Internet technologies” (Tracy, 2000). Academic definitions tend to coincide with IBM’s characterization. For instance, according to Jones et al, “E-business is the

carrying out of business activities that lead to an exchange of value, where the parties interact electronically, using network or telecommunications technologies” (Jones et al., 2000). More simply stated, e-business “is the use of electronic communications networks to allow organizations to send and receive information” (Van Slyke and Belanger, 2003).

E-business transactions use a variety of electronic communications techniques, many of which are based on Internet technologies and utilize hypertext based interfaces originally developed for use on the World Wide Web (WWW). Although Tim Berners-Lee is credited with creating the WWW in 1990, many of the Internet technologies that underpin the WWW had already been in development for a number of years. Among the most significant of these technologies, the concept of linking documents to related documents was first envisioned by Vannevar Bush in 1945 and was later coined *hypertext* by Ted Nelson in 1965. Although numerous independent projects implemented hypertext concepts from 1965 through the late 1980s, the WWW was the first to make this powerful capability available to anyone with Internet access (Myers, 1998).

Hypertext is implemented through a markup language, the most common of which is HyperText Markup Language (HTML). These markup languages describe how the document should be displayed by a web browser. Web browsers reside on the client’s local machine and are capable of retrieving and displaying a variety of hypertext formatted documents from remote servers. This combination of browser technology and HTML web documents provides the human-computer interface whereby users can access the vast body of information available on the WWW.

Intranets and Extranets in Organizations

It is important to note that e-business is not limited to the Internet but also occurs on private and semi-private networks known as *intranets* and *extranets*. By strict definition, intranets are networks open only to organizational members. In contrast, extranets allow organizational partners limited, controlled access to internal resources. Intranets and extranets may reside on privately owned or leased data communications circuits, take advantage of modern technologies to create a virtual private data communication path using the Internet as a backbone, or simply reside on the Internet and utilize network security technologies to limit access (FitzGerald and Dennis, 2005; Van Slyke and Belanger, 2003).

The textbook distinction between intranets and extranets is useful in a learning environment where each can be assigned a clearly defined role. In practice however, extranets are often simply extensions of organizational intranets. Indeed, the line between intranets and extranets is often blurred as organizations find increased value in efficient communications with its partners (Emery et al., 2005; Yen and Chou, 2001).

A fundamental role of these intranet/extranets is to serve as an information integrator, drawing together information from various functional areas and incompatible information systems into a single system that provides a common interface to access organizational resources (Emery et al., 2005; Scheepers and Damsgaard, 1997). Intranets reduce costs and improve efficiency by providing an alternative to paper-based information distribution and reduce infrastructure and training costs by implementing user interfaces that are compatible with existing, inexpensive assets. Applications such as electronic mail (e-mail) and web servers save time by speeding up communications

and allowing easy access to new and updated information (Yen and Chou, 2001). Other uses of intranets in the commercial sector include dissemination of organizational policies, workflow management, just-in-time training, and multi-point document authoring (Emery et al., 2005).

Although the purpose of intranets and extranets differs from the greater functionality and reach of the Internet, many of the same design principles that apply to Internet site design are equally applicable to these smaller networks. However, some nuances exist such as the user's purpose and the hardware used to access the network. Intranets and extranets should be organized for employees and organizational partners to gain quick access to work related information. Meanwhile, internet sites are typically designed to make only a limited amount of the organization's public information available to a wide range of external users. Another difference is that intranet site designers have more freedom to use design solutions targeted at a known environment where Internet and extranet site design must provide technical accessibility for a wider range of technologies (Nielsen, 2000).

E-business and the Department of Defense

Recognizing the success of e-business practices in the commercial sector, the United States government began implementing e-business policies in the mid-1990s. The DoD quickly followed suit with the Secretary of Defense's Defense Reform Initiative Report in November 1997 (Department of Defense, 1997). The report encouraged the DoD to look beyond traditional electronic commerce efforts and explore "expanding functional applications beyond supply, procurement and accounting to enabling process

improvements in other functional areas such as health, personnel, systems acquisition and science and technology” (Department of Defense, 1999). Today, DoD e-business initiatives can be found throughout all functional areas.

E-business concepts leverage information technology to break paradigms and create more efficient processes. These are shared objectives of network-centric warfare, a central enabler of DoD force transformation efforts (Department of Defense, 2005a). By moving to a highly interconnected environment, the DoD hopes to leverage the resulting network effects to realize a shift to a “more effective warfighting style characterized by the new concepts of speed of command and self-synchronization” (Cebrowski and Garstka, 1998).

E-business concepts and network-centric warfare infer a certain amount of interoperability between processes and between systems. To that end, the DoD has established extensive guidance to ensure systems are interoperable and network ready. Relevant guidance such as DoD Directive 8100.1 and Chairman of the Joint Chiefs of Staff Manual 3170.01B lay the foundation for force transformation and network-centric warfare and reiterate the importance of interoperable systems and accessible data (Department of Defense, 2002; Joint Chiefs of Staff, 2005).

The Air Force in the Web Environment

DoD E-business and force transformation initiatives are present in all DoD services. Within the Air Force e-business, formally named Electronic Business/Electronic Commerce (EB/EC), is defined as:

1. The interchange and processing of information via electronic techniques for accomplishing transactions based upon the applications of commercial standards and practices.
2. The conducting of business communications and transactions over networks and through computers. As most restrictively defined, EB/EC is the buying and selling of goods and services, and the transfer of funds, through digital communications. EB/EC also includes all intercompany and intracompany functions (such as marketing, finance, manufacturing, selling, and negotiation) that enable commerce and use electronic mail, electronic data interchange, file transfer, facsimile, video conferencing, workflow, or interaction with a remote computer (including use of the World Wide Web). (Department of the Air Force, 2004)

These definitions are very similar to the academic and practitioner e-business definitions previously discussed. Like the commercial sector, Air Force e-business efforts exist on the Internet as well as on intranets and extranets. However, the US military is somewhat unique in that they operate their own domain (.mil) which is part of the larger Internet but not all of which is accessible to all Internet users. Some restricted portions of the military domain serve an intranet and are only open to military users. Other restricted portions also function as an extranet and are accessible by military users and by organizational partners including foreign militaries, research institutes, and military contractors who may be granted limited or full access for officially sanctioned use.

Within the Air Force, “firewall servers and other security measures” are used to create a global intranet that allows authorized users to share resources “without making sensitive information available to users with Internet access” (Department of the Air Force, 2004). This policy tolerates the blurring of intranets and extranets commonly found in the private sector but clearly recognizes the need for separate private and public use networks. This research effort therefore defines an Air Force intranet web site as one

whose purpose is to facilitate a transaction or an information exchange between a host organization and an authorized user for a business purpose other than those with the general public. This working definition does not include local intranets open only to local organizational users such as wing or base intranets nor does it include information providing web sites open to the general Internet user.

Air Force use of the Internet and intranet technologies has seen an explosive growth over the past decade. However, very little research documenting this growth is available. In 1996, Quintero found that Air Force users who she surveyed used Internet access to “conduct research, obtain answers to specific questions, obtain or access regulations, and access their own organizational or other organization’s homepage” and “to obtain forms, weather reports, and travel information, as well as conducting market research, gaining access to Congressional reports, and researching legal databases” (Quintero, 1996). By 2001, Internet usage had become so common that the Air Force implemented the Air Force Portal web site in an effort to consolidate access to the growing number of web sites and applications used by its members. As of January 2006, the portal boasted more than 700,000 users and provided access to over eighty tools and applications (Department of the Air Force, 2005a; Department of the Air Force, 2006).

With the current emphasis on the use of intranets and the Internet, it is important to consider what factors are necessary for a web site to be successful. A primary concern for any information system (IS) is whether it will be used by organizational members and Air Force intranet web sites are not exempt from this concern. Considerable research has been accomplished in the area of understanding the factors that lead to information system success. The Technology Acceptance Model (Davis, 1989) is one such model

and its underlying concepts support the need for information systems to be usable and accessible.

Technology Acceptance

As use of information technology continues to expand and technological barriers to use disappear, people's willingness to use the information systems remains a concern of researchers and practitioners alike. At present, there are several theories and models that attempt to understand determinants of information system adoption and predict user acceptance of new computer technologies. Some of the most widely used include the technology acceptance model (TAM), the theory of planned behavior (TPB), and innovation diffusion theory. Although many of the current adoption theories are widely supported, TAM has been validated in a number of environments (Dasgupta et al., 2002; Lederer et al., 2000) and its *perceived ease of use* determinant makes it especially relevant to this research.

Although several extensions to TAM have been proposed, the core model relies on two determinates, *perceived usefulness* (PU) and *perceived ease of use* (PEOU), as depicted in Figure 1. Perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" while perceived ease of use is "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989). More simply stated, PU corresponds to how helpful the user believes the system to be and PEOU represents the usability of the system. These determinates have been widely researched and are supported by an "accumulated body of knowledge regarding self-efficacy, contingent decision behavior,

and adoption of innovation” (Davis, 1989). Proponents of TAM theorize that these determinants create a favorable attitude toward using the system which positively affects intention to use the system (Davis, 1989).

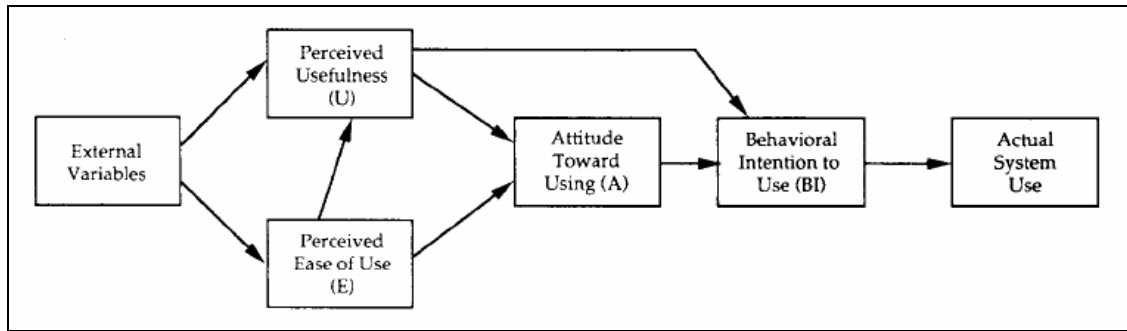


Figure 1. Technology Acceptance Model (Davis et al., 1989)

Traditional TAM models indicate that PEOU operates on *behavioral intention to use* through *attitude toward using* and operates directly on PU. Research efforts have resulted in mixed findings on the impact of PEOU on *behavioral intention to use* through *attitude* (Geffen and Straub, 2000) but repeatedly confirm the affect of PEOU on PU (Dasgupta et al., 2002). One possible explanation for these varied findings is that new users initially view the system from a self-efficacy perspective, determining PEOU based on how successful they expect to be in using the system. However, as they become more proficient with the system PEOU evolves to into an “instrumental issue” of how useful the system is considering on the relative amount of effort required to use it (Davis et al 1989).

Geffen and Straub offer another explanation. They suggest that the varying findings of the effects of PEOU may be related to the nature of the task to be performed. Their research indicates that PEOU operates on *behavioral intention to use* when the task

is intrinsic in nature and “the IT itself provides the primary product or service” as in the case of an information inquiry (Geffen and Straub, 2000). In contrast, PEOU may have no direct affect on *behavioral intention to use* when the IT is simply a “means” as in the case of purchasing an item from a web site where PEOU of the web site “is not an inherent quality of the purchased product” (Geffen and Straub, 2000). Taken together, Davis’s and Geffen and Straub’s explanations suggest that user perception of a web site’s usability will directly affect user acceptance through *behavioral intention to use* when the primary purpose is information sharing and have an indirect affect through PU for both information and transaction oriented web sites.

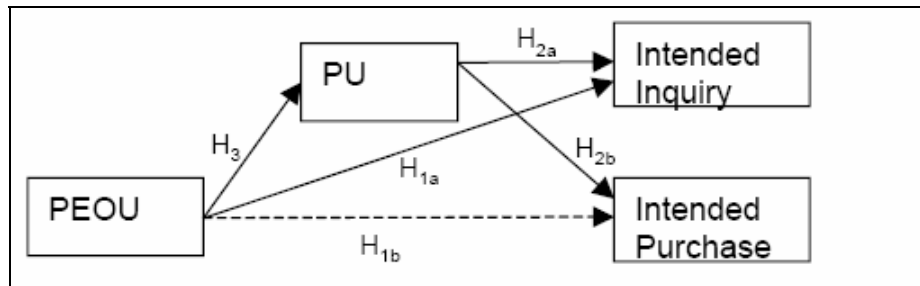


Figure 2. Geffen and Straub's Research Model (Geffen and Straub, 2000).

Two additional issues must be addressed to support TAM’s applicability to Air Force intranet web sites and web-enabled applications. The first is issue whether TAM is applicable to the Internet and Internet-technology based intranets. The second issue is whether TAM is applicable in the military’s mandatory adoption environment. Regarding the first question, several studies have found support for TAM in web environments (Dasgupta et al., 2002; Geffen and Straub, 2000; van der Heijden, 2003).

Even more relevant to the current research effort, Horton's research indicates that that TAM is also applicable to Internet-technology based intranets (Horton et al., 2001).

Rawstorne defines a mandatory adoption environment as one where the "end user is forced by the organization, through reward inducements or threats of punishment or a combination of both, to utilize the IS in a way that replaces at least one previous work practice" (Rawstorne et al., 1998). However, the applicability of TAM to any environment presupposes some variance of adoption exists. Hartwick and Barki were among the first to recognize and document that variance does indeed exist in mandatory adoption environments (Hartwick and Barki, 1994). Rawstorne also observed this phenomenon and theorized that the existence of variance in individual adoption within a mandatory adoption environment may stem from "(1) the extent to which an individual wishes to comply with the mandate, (2) the extent to which the organization enforces its mandate, and (3) individual differences in using the technology" (Rawstorne et al., 2000).

Based on the literature, TAM is applicable to Air Force intranet web sites. This suggests that user perceptions of a web site's usefulness and usability are important determinants for successful implementation, user adoption, growth, and a corresponding shift to e-business paradigms. While both determinants are important, this research focuses on the usability aspect of Air Force intranet web sites.

Usability

Usability engineering is focused on developing technologies that are useful and usable. One facet of this discipline is ensuring that human-computer interfaces maximize rather than reduce system ease of use. Usability has an important role in user acceptance

and is especially important in WWW sites where the first defense against usability problems is to leave and find a more usable system (Nielsen, 2003). Low usability can cost an organization in time, resources, and productivity and may ultimately cause a system to be rejected outright. From a user's perspective, high usability reduces frustration and leads to more efficient, accurate and complete task accomplishment (Foraker Design, 2005).

Despite many years of research, no universally accepted definition of usability has been developed (Frøkjær et al., 2000). Some define usability in terms of "quality of use" (Bevan, 1995) while others focus on "ease of use" (Nielsen and Phillips, 1993). Quality of use definitions emphasize the quality and usefulness of the data provided, while ease of use definitions focus on the design of the interface (Bevan, 1995; Frøkjær et al., 2000). The ease of use definition is the most widely used (Bevan, 1995) and clearly links usability to TAM's *perceived ease of use* determinant.

Web browsers have become a de facto standard in e-business environments and the same usability principles that apply to traditional human-computer interfaces are equally applicable to these environments (Brinck et al., 2002; Mayhew, 2005). Usable web sites are intuitive and "allow users to accomplish their goals quickly, efficiently, and easily" (Brinck et al., 2002). Design goals for the web include efficiency, learnability, memorability, error tolerance, and satisfaction where:

- Efficiency refers to the time or effort required for users to perform tasks after repeated exposure to the system interface.
- Learnability addresses the level of difficulty involved in accomplishing basic tasks during the user's first experience with the system.

- Memorability determines the level of difficulty required for infrequent users to re-learn the system interface following periods of non-use.
- Error tolerance describes how well errors are prevented, the number and severity of errors a user experiences, and the level of effort required to recover from errors.
- Satisfaction is a subjective assessment of how pleasant the design is to use. (Brinck et al., 2002; Nielsen, 2003)

Usability Inspection and Heuristic Evaluation

According to Zhu, there are at least six primary classes of methods that are applicable to evaluating web site usability. These include usability inspections, usability testing, prototyping, field methods, interviews, and web-based methods (Zhu et al., 2005). Usability inspections evaluate the system with usability experts and reliance on the evaluator's judgment is their key trait (Nielsen and Mack, 1994). Usability testing most often evolves observing and analyzing user interaction with the system in a laboratory environment. In a prototyping approach, a mock-up of the system is used to conduct usability inspection or testing to identify problems early in development. Field methods are similar to user testing but differ in that observation of users occurs in the users' environment. Interviews provide the ability to assess user tasks and needs and to better understand the user's subjective point of view. Web-based methods leverage Internet technologies to capture information about user sessions for analysis and provide the ability to solicit user feedback through questionnaires (Zhu et al., 2005).

Among these general methods, usability inspection has emerged as one of the most widely-used. This is largely due to its high success-rate for identifying usability problems and low cost to implement (Nielsen and Mack, 1994). Although a variety of inspection methods exist, all share the basic assumption that it is possible to identify what

features are required for usability. Most inspection methods share two common characteristics. The first is recognition that there are many components of usability and a variety of measures is required for a full, accurate assessment. The second characteristic is that many inspection measures are not intrinsically objective and instead rely on subjective assessments by the inspector (Agarwal and Venkatesh, 2002). Examples of the various usability inspection methods are summarized in Table 1.

Table 1. Usability Inspection Methods Summarized (Nielsen and Mack, 1994)

Inspection Method	Description
Cognitive Walkthroughs	Detailed procedure aimed at determining whether the user's problem-solving process will lead to the next correct action
Consistency Inspections	Designers of multiple systems inspect interfaces to evaluate consistency across related products
Feature Inspections	Focuses on the function delivered by the system
Formal Usability Inspections	A structured approach where participants follow a six-step process similar to software code inspections to inspect the interface and create a merged list of problems
Guideline Reviews	Interface is checked for conformance against a comprehensive set of usability guidelines
Heuristic Evaluation	Usability specialists judge interfaces based on general usability principles called heuristics
Pluralistic Walkthroughs	Users, developers, and human factors experts discuss usability issues based on step-by-step scenarios
Standard Inspections	Interface is inspected against an interface standard by an expert on that standard with the goal of increasing the degree of compliance relative to other interfaces that follow the same standards

One particular inspection method, heuristic evaluation, stands out in web site usability literature. In heuristic evaluation “a number of evaluators are presented with an interface design and asked to comment on it” (Nielsen and Molich, 1990). Evaluators are provided with a list of heuristics on which to judge the system. These heuristics are more “rules of thumb” than specific guidelines (Nielsen and Mack, 1994).

Heuristics may be so popular because many web designers view other usability evaluation methods as too intimidating or too resource intensive. Proponents claim that heuristic evaluations cost less and consume less time than other methods and enjoy a small learning curve that allows evaluators to become efficient quickly (Nielsen and Mack, 1994). Comparisons of usability evaluation methods have substantiated the value of heuristic evaluations. Jefferies found that heuristic evaluation identified more problems and more serious problems at lower cost than usability testing, guidelines, or cognitive walkthrough (Jefferies et al., 1991). In another study, Nielsen found heuristic evaluation would have lead to the correct decision every time if at least three evaluators were used (Nielsen and Phillips, 1993). Other researchers have found that larger numbers of evaluators identify more usability problems, but most agree that five evaluators strikes the best balance of findings to resources consumed (Barnum, 2003).

Nielsen and Mack developed a list of ten usability heuristics for interface design that has been widely used by academics and practitioners (Nielsen and Mack, 1994). Pierotti developed a robust checklist to guide evaluators in applying these heuristics and added three additional heuristics (Pierotti, 1995). These thirteen heuristics are summarized in Table 2 and have been previously detailed by a number of researchers (Felax, 2005; Instone, 1997; Kastenholz, 2005).

Usability as discussed above is driven by user needs and preferences. Traditional usability concerns are based on a desire to gain user acceptance and produce measurable efficiencies. Meeting usability standards is optional for any organization, albeit at the potential cost of lost users. However accessibility is federally mandated for government entities.

Table 2. Combined List of Nielsen and Pierotti's Heuristics (Nielsen and Mack, 1994; Pierotti, 1995)

Heuristic	Description
1. Visibility of System Status	The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
2. Match Between System and the Real World	The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
3. User Control and Freedom	Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
4. Consistency and Standards	Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
5. Help Users Recognize, Diagnose, and Recover From Errors	Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
6. Error Prevention	Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
7. Recognition Rather Than Recall	Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
8. Flexibility and Efficiency of Use	Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
9. Aesthetic and Minimalist Design	Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
10. Help and Documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.
11. Skills*	The system should support, extend, supplement, or enhance the user's skills, background knowledge, and expertise – not replace them.
12. Pleasurable and Respectful Interaction With the User*	The user's interactions with the system should enhance the quality of her or his work-life. The user should be treated with respect. The design should be aesthetically pleasing with artistic as well as functional value.
13. Privacy*	The system should help the user to protect personal or private information belonging to the user or his/her clients.
*Added by Pierotti	

Accessibility

There are more than 50 million people in the U.S. alone who suffer from disabilities (Waldrop and Stern, 2003). Many of these disabilities make interacting with computers more difficult than for non-disabled people. Although military users are not traditionally thought of as including large numbers of disabled people, it is important to realize that today's military relies on a large workforce of civil service employees, contractors, and civilian partners who play a vital role in mission accomplishment. Air Force intranet web sites must be accessible to all of these users regardless of disability.

Simply stated, web accessibility means making internet technologies useable by people with disabilities. Vanherheiden describes an accessible web site as one where the content is "perceivable, operable, and understandable" by any individual regardless of the circumstances or constraints they are operating under (Vanderheiden, 2005).

Accessibility can be further refined into *technical accessibility* and *usable accessibility*. Technical accessibility ensures the system is compatible with assistive technologies that allow interaction with disabled people. For example, proper use of HTML 'alt' tags allows associative technologies to convey the meaning of visual images on web pages. Useable accessibility refers to the application of basic usability principles for user interfaces. Examples include consistent navigation and management of cognitive load (Paddison and Englefield, 2004).

There are numerous reasons for web sites to be accessible. From a humanistic perspective, accessibility is the right thing to do. This is especially true when one considers that an underlying purpose of the WWW is to make information available to everyone. A second advantage is the increased marketability of the site or product. Non-

accessible web sites automatically exclude disabled users. Another reason is that accessibility may have spillover effects that benefit all users by improving overall usability. In addition, many countries have enacted legislation that requires accessibility for commercial and government web sites (Carter and Markel, 2001).

This last reason clearly impacts the DoD. Section 508 of the Rehabilitation Act of 1973 contains guidance to ensure access to the electronic and information technology (EIT) of Federal agencies by disabled persons. Subsequent additions in 1986 and 1998 further legislated access requirements and established enforcement provisions (U.S. Access Board, 2005). Section 508 mandates that all Federal departments and agencies develop EIT that is accessible to “individuals with disabilities who are Federal employees” and “individuals with disabilities who are members of the public seeking information or services” unless doing so causes an “undue burden” on the organization (Code of Federal Regulations, 2000). Specific guidelines for web accessibility were developed in 2000 and codified into law in 2001 (Ellison, 2004).

Although standards for web compliance have been in place since 2001, accessibility compliance continues to be an issue for some government agencies. In 2003, Jackson found that only 60 percent of 100 government web sites tested with an automated tool passed evaluation without any critical problems (Jackson-Sanborn et al., 2002). In a similar study conducted by Ellison in 2004, 44 percent of 50 government web sites tested exhibited one or more Section 508 compliance errors and only 22 percent exhibited no errors (Ellison, 2004). These studies suggest that government agencies have yet to meet the federally mandated rate of 100 percent compliance. It is also interesting

that Jackson's study found that the 60 percent compliance rate for government web sites was higher than that of any of the other five types of web sites included in her study.

Why do so many web sites remain inaccessible? One reason is a perception that accessibility is costly. However, experts believe that making a site accessible adds only one to two percent to the overall cost and is really as simple as implementing HTML as it was originally conceived (Carter and Markel, 2001). HTML was primarily intended to describe content but its conventions are commonly misused as a presentation format. This improper use of HTML impedes assistive technologies that rely on HTML tags to provide a description of the content. According to the World Wide Web Consortium (W3C), the most common web site accessibility problems include failure to provide alternate text for images and imagemap hot-spots, misleading use of structural elements, and tables that are difficult to decipher when linearized (World Wide Web Consortium, 1999b). Additionally, multimedia content has become commonplace alongside the primarily text content that HTML was designed to support. Poor implementation of this multimedia content often creates additional difficulties for people with disabilities (Carter and Markel, 2001; Nielsen, 2000).

Evaluating Accessibility and Section 508 Compliance

As with usability evaluations, there are a number of ways to determine the accessibility of a web site. Heuristic evaluations and guidelines are two methods that appear frequently in the literature. Heuristics are recognized as a fast, easy method to ascertain a site's general accessibility and determine which problems are priorities. However, accessibility heuristics tend to be simple mnemonics intended for use by

accessibility experts. These mnemonics are sufficient to guide the expert in his evaluation but do not perform as well when used by non-experts. Another drawback is that although heuristics are able to highlight areas of concern for disabled access, heuristics alone are not able to substantiate compliance with government legislation (Paddison and Englefield, 2004).

In contrast to heuristics, guidelines tend to be bulkier, more resource intensive, and more difficult to remember. However, guidelines are straightforward and, although a level of technical competence may be required, the evaluator does not need to be an accessibility expert. In fact, many software programs are available to automatically evaluate web sites against set guidelines. Another strength of guidelines over accessibility heuristics is their ability to assess compliance with government regulation (Paddison and Englefield, 2004).

The Architectural and Transportation Barriers Compliance Board, commonly referred to as the Access Board, is the source of specific, mandatory accessibility compliance guidelines for federal agencies. The Access Board “is an independent Federal agency that develops and maintains accessibility requirements, provides technical assistance and training on the standards, and enforces accessibility standards for federally funded facilities” (U.S. General Services Administration, 2005). The Access Board fully defined web accessibility compliance guidelines in *Electronic and Information Technology Accessibility Standards* (Code of Federal Regulations, 2000). Paragraph 1194.22 of this regulation outlines the specific provisions that federal agencies must adhere to when producing web pages.

Many of the standards mandated by the Access Board provide for interoperability with assistive technologies and focus primarily on addressing visual disabilities. Furthermore, most of the provisions are based on checklist items from the W3C Web Accessibility Initiative (WAI) Web Content Accessibility Guidelines version 1.0* (WCAG 1.0) which was designed to help web site designers meet the accessibility needs of the Internet community (World Wide Web Consortium, 1999a). WAI guidelines are divided into three categories:

- Priority 1 checkpoints that must be satisfied to allow access to all disabled groups.
- Priority 2 checkpoints that should be met to remove significant access barriers.
- Priority 3 checkpoints that may be addressed to improve access to documents. (World Wide Web Consortium, 1999b)

Section 508 web compliance items mandated by the Access Board are predominately based on Priority 1 and 2 items. Table 3 summarizes the sixteen Access Board requirements for federal agencies and describes the relationship between each Section 508 compliance item and its corresponding WCAG 1.0 checkpoints as interpreted by Thatcher (Thatcher, 2005).

Relationship Between Usability and Accessibility

With an increasing emphasis on both accessibility and usability, it is reasonable to attempt to understand what, if any, relationship exists between them. Three views are that accessibility is a subset of usability, accessibility is a necessary but not a sufficient

* Web Content Accessibility Guidelines 2.0 were available for public comment at the time of this research. However these updated guidelines but have not been ratified and are not considered in this thesis effort.

Table 3 Section 508 Web Compliance Items (Thatcher, 2005)

1194. 22 Paragraph	Compliance Item	Related WCAG 1.0 Checkpoint and Priority	Relationship
a	A text equivalent for every non-text element shall be provided (e.g., via "alt", "longdesc", or in element content).	1.1 (P1)	Similar
b	Equivalent alternatives for any multimedia presentation shall be synchronized with the presentation.	1.4 (P1)	Same
c	Web pages shall be designed so that all information conveyed with color is also available without color, for example from context or markup.	2.1 (P1)	Same
d	Documents shall be organized so they are readable without requiring an associated style sheet.	6.1 (P1)	Same
e	Redundant text links shall be provided for each active region of a server-side image map.	1.2 (P1)	Same
f	Client-side image maps shall be provided instead of server-side image maps except where the regions cannot be defined with an available geometric shape.	9.1 (P1)	Same
g	Row and column headers shall be identified for data tables.	5.1 (P1)	Same
h	Markup shall be used to associate data cells and header cells for data tables that have two or more logical levels of row or column headers.	5.2 (P1)	Same
i	Frames shall be titled with text that facilitates frame identification and navigation.	12.1 (P1)	Same
j	Pages shall be designed to avoid causing the screen to flicker with a frequency greater than 2 Hz and lower than 55 Hz.	7.1 (P1)	Same
k	A text-only page, with equivalent information or functionality, shall be provided to make a web site comply with the provisions of this part, when compliance cannot be accomplished in any other way. The content of the text-only page shall be updated whenever the primary page changes.	11.4 (P1)	Same
l	When pages utilize scripting languages to display content, or to create interface elements, the information provided by the script shall be identified with functional text that can be read by assistive technology.	6.3 (P1) 6.4 (P2) 8.1 (P2) 9.3 (P2)	508 Less Restrictive
m	When a web page requires that an applet, plug-in or other application be present on the client system to interpret page content, the page must provide a link to a plug-in or applet that complies with §1194.21(a) through (l).	6.3 (P1) 6.4 (P2) 8.1 (P2)	Similar
n	When electronic forms are designed to be completed on-line, the form shall allow people using assistive technology to access the information, field elements, and functionality required for completion and submission of the form, including all directions and cues.	9.3 (P2) 10.2 (P2) 12.4 (P2)	Similar
o	A method shall be provided that permits users to skip repetitive navigation links.	13.5 (P3) 1.6 (P3)	508 More Specific
p	When a timed response is required, the user shall be alerted and given sufficient time to indicate more time is required.	None	Not in WCAG

condition for usability, and that usability and accessibility are non-related, sometimes opposing concepts (Alexander, 2004).

Proponents of the first point of view suggest that accessibility simply expands usability to a larger population. Those who believe that accessibility is a necessary but not a sufficient condition for usability argue that accessibility is required for users to access data in the first place but that this technical accessibility alone is not sufficient to produce a usable product. Others, primarily practitioners, argue that strict technical requirements for accessibility often conflict with more general usability principles (Alexander, 2004).

Ultimately, no definitive explanation has been agreed upon to describe the relationship between usability and accessibility. However, common threads in the literature suggest that a relationship exists, accessibility benefits all users, and usable sites offer an improved experience to all users (Alexander, 2004; Nielsen, 2000; Vanderheiden, 2005).

The Role of Guidance In Designing Usable Web Sites

Since usability and accessibility are widespread and potentially damaging problems for web-based interfaces, it is reasonable to ask why and to explore what can be done to address this issue. One of the most likely reasons for the limited usability of many web-based interfaces is that they are being developed by designers with limited usability or user interface design knowledge (Borges et al., 1996). However guidelines provide a method to address this knowledge shortfall. HCI guidelines are a mechanism

for transferring human factors knowledge to designers and can play a valuable role as references during interface design (de Souza and Bevan, 1990).

Unfortunately, guidelines used in web page design are typically not on equal footing with established HCI guides. Ratner reviewed a set of common WWW guidelines and found that of 270 HTML-relevant recommendations identified in HCI guidelines, only 53 appeared within the WWW guidelines (Ratner et al., 1996). One explanation for the small overlap observed is that HTML styled guides have simply developed with “less rigor and little reference to established HCI style guides and principles” (Ratner et al., 1996).

When valid HCI guidelines are available however, they can be a valuable source for improving web sites. In one experiment by Borges, three webpage designers were provided a list of 17 HCI guidelines with no additional explanation and asked to redesign an existing home page. No constraints were given other than adherence to these guidelines. Usability testing of the redesigned home pages found an 80 percent improvement in task efficiency. Borges’s work demonstrates that use of web design guidance based on established HCI principles can generate measurable improvements (Borges et al., 1998).

Previous Air Force Intranet Web Site Research

Previous AFIT students found that systems evaluated in their research efforts suffered from low usability scores when evaluated against common practice usability heuristics. More specifically, the Air Force Knowledge Now (AFKN) web site and the web-based Automated Civil Engineer System Personnel Readiness (ACES-PR STP)

module of the Global Combat Support System (GCCS) scored poorly using Peirotti's usability checklist (Felax, 2005; Kastenholz, 2005). Furthermore, the Air Force Knowledge Now web site, which was also evaluated for accessibility, was found to have a 43 percent compliance rate for Priority 1 WAI checkpoints and 47 percent for Priority 2 checkpoints (Felax, 2005). One interesting finding by Kastenholz was that despite its relatively low heuristic compliance score, ACE-PR STP did comply with applicable Air Force regulations and guidance. He also found that usability scores were high for heuristics addressed by Air Force guidance and low for those absent from Air Force guidance. Overall, this may indicate that low usability is due not to non-compliance with Air Force standards, but to shortfalls in those standards (Kastenholz, 2005).

Current Research

The purpose of this research effort is to investigate whether the findings by Felax and Kastenholz are representative of other Air Force web sites and to explore the adequacy of the applicable Air Force and Department of Defense guidance for web sites and web-based applications. Based on the preceding literature review, it is hypothesized that some, but not all usability and accessibility principles are contained in military guidance and that some overlap exists between usability and accessibility principles. It is further hypothesized that a web site may comply with some, all, or none of these standards. However, it is assumed that the nature of the military bureaucracy makes it highly unlikely that Air Force intranet web sites will exhibit significant non-compliance with military guidance. These relationships are captured in the research model in

Figure 3 which depicts overlap between the various sources of principles and guidance and shows hypothesized findings of web evaluations.

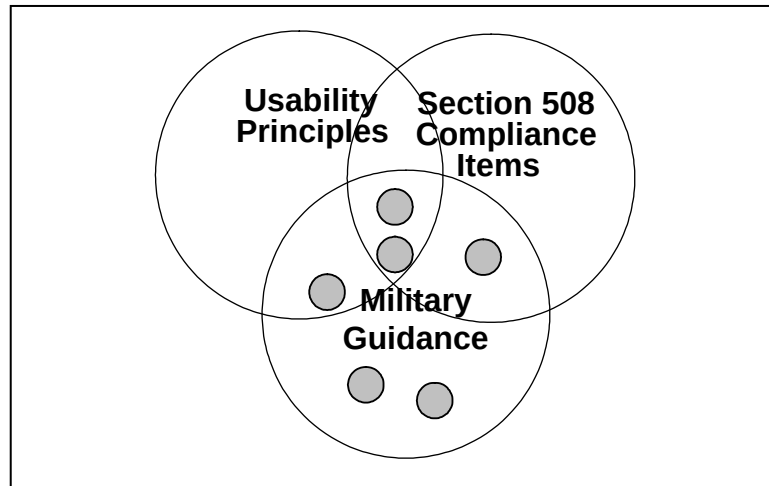


Figure 3. Current Research Model

The following investigative questions originally introduced in Chapter I are based on the findings of the literature review and this research model.

- IQ1. How well do Air Force intranet web sites follow common practice usability principles identified in the literature?
- IQ2. How well do Air Force intranet web sites adhere to the accessibility requirements of Section 508 of the Rehabilitation Act?
- IQ3. Does a relationship exist between usability and Section 508 accessibility compliance scores?
- IQ4. Are common practice usability principles and government mandated Section 508 accessibility requirements reflected in or referenced by military guidance that is relevant to Air Force intranet web sites?
- IQ5. Does a relationship exist between compliance scores and the existence of common practice usability principles and Section 508 accessibility guidelines in military guidance?

Chapter Summary

This chapter provided a review of the relevant literature. E-business and intranet concepts were discussed and described in context of the Air Force environment and ongoing DoD transformation efforts. TAM was established as a viable predictor of intended information system use and perceived usefulness and perceived ease of use were established as key determinants of intended adoption. Usability was defined in terms of ease of use and various methods of evaluating usability were discussed. Accessibility and Section 508 guidelines were described and evaluation methods discussed. Past research of Air Force web sites that found low usability and accessibility were cited as justification for the current research. A research model was then developed to visually depict this study's underlying hypotheses.

III. Methodology

Chapter Overview

This chapter presents the methodology used to pursue the investigative questions outlined in Chapters I and II of this study. First, the rationale for choosing a research design is presented. Next, specific research design issues are addressed and the research cases identified. Data collection is then discussed and the chapter concludes with an overview of the how this study exhibits the components of quality research.

Case Study Rationale

There are a number of recognized approaches to research including experiment, quasi-experiment, survey, and field study designs (Schwab, 2005). Another often used method is the case study approach. While each strategy can be used for exploratory, descriptive, or explanatory research, certain strategies lend themselves more to certain purposes. Deciding which method to employ is critical to the research effort. Yin provides three conditions for determining which method is most appropriate (Yin, 2003).

Yin's first condition for choosing a design is the form of the research question. Yin encourages discretion in development of the research question and describes it as the most important step in the research effort. Research questions have both form and substance, each of which provide important insight into the most appropriate research strategy to employ. Research questions may take the basic form of *who*, *what*, *where*, *how*, or *why*. Exploratory *what* questions can be addressed by any research strategy. However, prevalence *what* questions such as *how many* are best addressed by surveys or archival analysis. These strategies are also appropriate for *who* and *where* questions,

especially where the goal is to describe frequency of occurrence or to be predictive. *How* and *why* questions are often best addressed with case studies, histories, or experiments (Yin, 2003).

Yin's second and third conditions consider the extent of control the researcher has over behavioral effects and whether the focus is on contemporary or historical events. Experiments are appropriate when the researcher needs to have control over behavioral events while the other designs are appropriate when the research needs little or no control. Understandably, all designs except histories are potentially appropriate for the study of contemporary events. Past events lend themselves to history or archival analysis strategies (Yin, 2003). Table 4 summarizes the strategies most appropriate for each combination of conditions.

Table 4. Conditions for Different Research Strategies (Yin, 2003)

Strategy	Form of Research Question	Requires Control of Behavioral Events?	Focuses on Contemporary Events?
Archival Analysis	who, what, where, how many, how much	No	Yes / No
Case Study	how, why	No	Yes
Experiment	how, why	Yes	Yes
History	how, why	No	No
Survey	who, what, where, how many, how much	No	Yes

Following Yin's reasoning, a case study is the most appropriate strategy for the current research effort. The purpose of this research is to explore how well Air Force intranet web sites adhere to common practice guidelines and principles and how well those guidelines and principles are captured in military guidance. Furthermore, this research addresses the current state of affairs of Air Force web sites. Because the goal of

this research is to understand the “as-is” condition, the researcher neither requires nor should assert any control of behavioral events.

Case Study Design

Case studies can include either a single case or multiple cases. Furthermore, the purpose of research may be to explore, describe, or explain (Yin, 2003). These characteristics create six possible types of case studies as shown in Table 5.

Table 5. Possible Case Study Designs (Yin, 2003)

Single Case -- Exploratory	Multiple Case -- Exploratory
Single Case -- Descriptive	Multiple Case -- Descriptive
Single Case -- Explanatory	Multiple Case -- Explanatory

The current research is conducted as a multiple case, explanatory study. The goal is to explain the current status of usability and accessibility of Air Force intranet web sites. Multiple cases will provide the ability for cross-case comparisons resulting in more robust support for findings and expanded generalizability of the results.

Qualitative vs. Quantitative Analysis

All research can be described as either quantitative, qualitative, or mixed method which is essentially a combination of both (Creswell, 2003). Quantitative research involves testing hypothesized causal relationships between variables. In contrast, qualitative research assumes very little about possible relationships and instead seeks to explore what variables lead to a consequence. Creswell describes quantitative research as using primarily “postpositivist claims for developing knowledge” and qualitative research

as making “knowledge claims based primarily on constructivist perspectives” (Creswell, 2003). Mixed method approaches “base knowledge claims on pragmatic grounds” and often involve sequential collection of both quantitative and qualitative data, at the researcher’s discretion, to best understand the phenomenon (Creswell, 2003).

Yin contends that specific research designs are not inherently more appropriate for quantitative or qualitative analysis. Furthermore, he argues that neither quantitative nor qualitative analysis is stronger than the other (Yin, 2003). Indeed, Creswell acknowledges that the nature of modern research “is less quantitative *versus* qualitative and more how research practices lie somewhere on a continuum between the two” (Creswell, 2003). These arguments leave it to the researcher to determine the method of analysis that is most appropriate to the situation studied.

A mixed method approach is taken in the current study. The literature supports Nielsen’s heuristics as one of the most widely used and cost effective methods of usability inspection. A review of accessibility standards and Section 508 guidance revealed a list of mandatory compliance items created by the Access Board. Evaluations based on these heuristics and guidelines are inherently qualitative as each inspection item relies on the evaluator’s subjective interpretation (Felax, 2005). However, the resulting numeric compliance scores share some similarities with quantitative data and can be investigated using quantitative methods. Furthermore, because the current research follows past AFIT research efforts on the same subject, using similar methods as employed in those studies has the added benefit of offering findings that are more directly comparable with the findings of those studies.

The Research Design

Yin proposes five primary components of research design that are especially significant for case study research. These components are the research question, propositions, unit of analysis, logic linking the data to the propositions, and criteria for interpreting the study's findings (Yin, 2003). The following sections discuss these components and describe how the current research incorporates each.

The Research Question.

The first component is the research question. The research question and investigative questions for this research were introduced in Chapters I and II, but merit additional discussion in here. The research question seeks to explain how well Air Force intranet web sites follow common practice web usability and Section 508 accessibility guidelines. The literature review detailed in Chapter II described the importance of *perceived ease of use* (PEOU) in user acceptance and identified key components of usability and accessibility that affect the user's PEOU. This serves as the foundation for IQ1 and IQ2. The literature review also established theoretical links between usability and accessibility, supporting the need for IQ3 which attempts to establish support for a relationship between usability and accessibility. The literature also validates the logical role of guidance in developing usable and accessible interfaces. This leads to the need for IQ 4 and IQ5 to assess the adequacy of DoD and AF intranet web site guidance.

Propositions.

According to Yin, study propositions are necessary to focus the research to specific areas of interest within the scope of the research. Case study research can become unwieldy if the researcher does not properly focus on specific areas. While the

form of the research question may lead to the decision to use a case study, it does not necessarily point out exactly what should be studied. Yin states that “Only if you are forced to state some propositions will you move in the right direction” (Yin, 2003).

The first proposition of this research is that it will show how well Air Force intranet web sites fair when evaluated against common practice usability and mandatory accessibility criteria. A wide variety of usability and accessibility guidelines have been developed by practitioners and academia. This first proposition focuses the research effort by limiting the scope of usability and accessibility to the subset of guidelines identified in the literature as most relevant. Specifically, this study focuses on Nielsen’s heuristics which are the most commonly applied usability principles and Section 508 guidelines for which compliance is compulsory for Federal agencies.

The second proposition is that the current research use descriptive statistics to support or fail to support the theoretical existence of a relationship between usability and accessibility. Although several theories exist regarding the relationship between usability and accessibility, limited empirical evidence exists to support a specific relationship. The second proposition provides a technique to analyze the possible existence of the relationship, addressing IQ3 using data obtained for IQ1 and IQ2. It is hoped that this will add to the body of knowledge about the relationship between usability and accessibility without expanding the scope of the current study.

The third proposition is that this research will support or fail to support that DoD and Air Force guidance adequately captures common usability and mandatory accessibility guidelines. The literature supports the role of guidance in improving usability and accessibility by providing access to basic design principles. However, this

guidance could come from a variety of sources and evaluating all possible sources is beyond the resources available for the current research. Therefore, the third proposition narrows the research to focus solely on military guidance documents, the use of which may be correlated with differences in compliance scores between different aspects of usability.

Unit of Analysis.

The unit of analysis is closely related to the definition of the case itself. According to Yin, the unit of analysis should be driven by the research question and address the entity that is the focal point of the research. It is also important that the unit of analysis remain distinguishable from the context of the study. For comparability to other studies, definition of the unit of analysis should be similar to the definition used in those studies. Once chosen, other clarifications must be made to draw clear boundaries between the unit of analysis and related units and to determine the appropriate timeframe for analysis (Yin, 2003).

This research looks at six Air Force web sites used to facilitate transactions or information exchange between a host organization and an authorized user for a business purpose other than those with the general public. The unit of analysis is the individual Air Force intranet web site. The timeframe in question is limited to the time of data collection. Data collection began in July 2005 and concluded in January 2006. All web site evaluations were performed within the time period and only guidance existing prior to the evaluation is considered by the analysis. This definition of the unit of analysis is consistent with that used in past research efforts (Felax, 2005; Kastenholz, 2005).

Logic Linking the Data to the Propositions.

Once the unit of analysis is defined, the next step is to address how the data will be used in the context of the propositions. Two common approaches are pattern matching and cross case comparisons. Pattern matching compares the research data with a predicted pattern or alternative patterns. Cross case comparisons consider how the data compare across the units of analysis from each case study.

This research study employs both techniques. Cross case comparison is used to evaluate how well Air Force web sites adhere to usability and accessibility standards. Data for each web site are compared to identify patterns in compliance. Pattern matching is then used to determine if, as theory predicts, web site usability and accessibility scores are affected by the quality of guidance. The quality of guidance is measured by the amount of overlap between military guidance and common practice usability and accessibility principles.

Criteria for Interpreting the Data.

In qualitative research, the criteria for what constitutes a significant effect is not as clear as in quantitative research. Therefore it can be difficult to ascertain specific cutoffs or to determine how well patterns must match to be considered a match. Yin cautions the researcher against establishing constraints for pattern matching that are unnecessarily restrictive. Sometimes patterns need only be visible to the eye, while other situations may call for closer scrutiny depending on the theoretical underpinnings of the research (Yin, 2003).

Criteria for Investigative Question 1.

Pierotti does not provide explicit guidance for analyzing the results of her usability heuristic checklist, located at Appendix A, which is used to answer IQ1. Rather, she encourages the researcher to use reasonable judgment in assigning a point scale to each item according to the nature of the project undertaken (Pierotti, 1996). To build on the existing body of research on Air Force web sites, this research follows the same scoring methodology used by Felax and Kastenholz (Felax, 2005; Kastenholz, 2005) which is based on concepts for evaluating homepage design outlined by Nielsen and Tahir (Nielsen and Tahir, 2002). Checklist items receive a score of “1” for applicable criteria that are met, “0” for applicable criteria that are not met, and no score for non-applicable criteria. Compliance for each heuristic is calculated as a percentage of conformance with applicable items. The overall compliance rating for each site is then calculated by giving equal weight to each section and summing the resulting scores, with a maximum possible score of 100 percent. The overall usability scores are evaluated using Nielsen and Tahir’s grading criteria, summarized in Table 6, which requires a mean usability score greater than 80 percent to be considered usable (Nielsen and Tahir, 2002).

Criteria for Investigative Question 2.

The criteria for evaluating IQ2 is similar to that used for IQ1. Cases are evaluated against the sixteen Section 508 mandatory compliance items established by the Access Board and identified in the literature review. Checklist items receive a score of “1” for applicable criteria that are met, “0” for applicable criteria that are not met, and no score for non-applicable criteria. The mean accessibility score for each web site is calculated as a percentage of applicable items meet. Based on the mandatory nature of Section 508

Table 6. Web Site Usability/Accessibility Compliance Rate (Felax, 2005; Nielsen and Tahir, 2002)

Compliance Rate	Description
90 to 95%	Perfect web site. Follows almost all usability/accessibility guidelines that apply to that particular site and does something different, but appropriate, in the remaining cases.
80 to 90%	Web site is in good shape. Consider making a few minor fixes to areas where the site violated guidelines.
50 to 80%	Start a redesign project to produce a new homepage. Your current homepage is definitely not a disaster, but it is bad enough that isolated modifications to individual areas will not suffice.
below 50%	The site is probably not serving your customers well with the current approach to web design. Most likely, you should abandon the entire current site and start over from scratch. Rethink your Internet strategy and base your new approach on studies of your customers and their real needs.

compliance for government agencies, it seems intuitive to establish criteria that web sites must score 100% to be considered fully compliant. However, opinions of what specific criteria must be met to satisfy each guideline may vary based on the context of the study and the background of the evaluator. Therefore use of a single evaluator dictates that some flexibility be used in interpreting the results. For the purposes of this study, Nielsen and Tahir's grading scale is applied to accessibility scores. An accessibility score of greater than or equal to 80 percent is considered accessible just as a usability score of greater than or equal to 80 percent is considered usable. This accessibility criteria is consistent with that used by Felax (Felax, 2005) and facilitates comparison between this study and his.

Criteria for Investigative Question 3.

Scores obtained from IQ1 and IQ2 are used to answer IQ3. Usability and accessibility scores are evaluated using descriptive statistics to identify possible correlation between the two. Due to the small number of samples used in this study,

robust linear regression cannot be used to approximate the strength of any correlation. However, descriptive methods such as comparing the mean usability and accessibility scores for each web site will provide sufficient evidence to indicate whether a strong correlation exists between usability and accessibility compliance scores.

Criteria for Investigative Question 4.

Military guidance documents are reviewed to determine whether they are applicable to Air Force intranet web site design, maintenance, and/or use and to establish whether compliance with that guidance is mandatory. Next, each relevant document is evaluated to determine which, if any, of Nielsen's heuristics it contains and whether it specifies Section 508 accessibility compliance. The number of Nielsen's heuristics that are found in military each military guidance document is reported in terms of the raw number of heuristics found and as a percentage of heuristics found in military guidance. Military guidance is given credit for including a specific heuristic if there is evidence of that heuristic in any of the mandatory guidance documents. The number of heuristics represented at least once in military guidance is divided by the total number of heuristics to establish the percentage of heuristics captured.

Higher percentages of overlap demonstrate higher potential for transferring knowledge of established design principles while lower percentages of overlap create fewer opportunities for knowledge transfer. Following Yin's guidance against being overly confined by artificial boundaries (Yin, 2003), this research establishes a threshold criteria that at least 50 percent of Nielsen's heuristics should be found in military policy. Existence of this simple majority of Nielsen's heuristics in military policy is sufficient to

establish that basic common practice guidelines are at least considered by military guidance.

Criteria for Investigative Question 5.

To evaluate IQ5, compliance scores obtained from IQ1 and IQ2 are compared against the findings of IQ 4. Descriptive methods are used to assess whether there is a correlation between the existence of common practice guidelines in military guidance and the compliance score for each heuristic and Section 508 compliance item. Due to the small number of samples used in this study, robust linear regression cannot be used to approximate the strength of any correlation. However, descriptive methods such as comparing the mean compliance score for each heuristic with the number of times a heuristic is mentioned in military guidance will provide sufficient evidence to indicate whether a strong correlation exists. Table 7 summarizes the criteria for interpreting the data for each investigative question.

Table 7. Summary of Criteria for Interpreting the Data

Investigative Question	Criteria for Interpreting the Data
IQ1	Usability compliance scores are evaluated using Nielsen and Tahir's homepage scoring guidelines. Sites that have a mean usability score greater than 80% are considered usable.
IQ2	Accessibility compliance scores are evaluated using Nielsen and Tahir's homepage scoring guidelines. Sites that have a mean accessibility greater than 80% are considered accessible.
IQ3	Usability and accessibility compliance scores appear to be correlated.
IQ4	Percent of total common practice principles that are found in military guidance. At least 50% of Nielsen's heuristics should be found in the military policy to establish that common practice guidelines are at least considered by military guidance.
IQ5	Existence of common practice principles in military policy appears to be correlated with respective compliance scores.

Case Selection

In a multiple case study approach, the motivation behind case selection is replication of results rather than traditional statistics sampling logic. Therefore, case selection must be carefully conducted and should consider prior knowledge of expected outcomes. Cases selected for literal replication should produce similar results. However, cases may be selected that produce contrasting results but for predictable reasons to establish theoretical replication. In a best case scenario, a mix of both types of cases is used to provide both literal and theoretical replication (Yin, 2003).

The goal of replication also impacts the number of cases that must be used in a study as well as which cases are used. Because sampling logic is not used to capture an entire population or a representative sample, traditional methods to determine the optimal number of cases is not applicable. Yin states that the number of cases to be used is at the researcher's discretion and depends primarily on the certainty of the results required. A larger number of cases results in greater certainty. Slight nuances in theory require more cases to detect as do a larger number of external variables that affect the outcome of the case (Yin, 2003).

Other criteria for case selection include how representative or unique a case is, a special arrangement with the case, or access to the case. Cases that are especially representative of other cases or unique from other cases are well suited for single case designs. Often a case is selected because the researcher can gain access to the necessary resources to conduct research. Regardless of the rationale for case selection, cases should be selected prior to formal data collection (Yin, 2003).

Cases for this research were selected based the purpose of the intranet site and on accessibility to the case. The literature review established that intranet web sites are used for a variety of purposes. Within the military, two basic types of intranet sites are those that facilitate a transaction and those that facilitate information exchange. Specific purposes of Air Force web sites include conducting administrative, logistical, and operational transactions, and facilitating information exchanges. A number of potential cases were randomly selected from the Air Force Portal's web links page and screened to identify several cases from each basic function. Aside from the site's purpose, primary consideration was given to accessibility to the case. Therefore the web site must exist on an unclassified network and not require special access or be willing to grant special access to evaluators.

Official points of contact were reached at twenty potential cases. Of these, eight positive responses were received. One was removed from consideration because it was identified as a subset of a web site evaluated in a previous research effort. A second was removed due to the organization's limited ability to support the research. The remaining six web sites are included in this research. Anonymity was promised as a condition of participation. The cases are described in Table 8.

Data Collection

Usability scores were obtained by several evaluators for each web site. Evaluators were selected based on participation in an electronic business class taught at AFIT. All evaluators were Master's level students. Each evaluator received four hours of instruction in usability principles and heuristic evaluation techniques. A pilot study

Table 8. Research Cases Used in This Study

Case	Description
A	Intranet site offering functional area guidance, forms, and best practices
B	Intranet site offering functional area guidance, best practices, and information exchange
C	Interactive intranet site for transactions and updating information
D	Intranet site offering wide-range a of information and guidance for download
E	Intranet site offering interactive, user configurable warfighter support information
F	Interactive intranet site for transactions and updating information

was then conducted using the Air Force Knowledge Know web site. Each evaluator's results were compared to the results of Felax's previous heuristic evaluation of the same web site (Felax, 2005). Evaluators then received two hours of additional instruction focused on weak areas identified during the pilot study.

Following training, each evaluator was assigned two intranet sites. With the exception of the primary researcher who inspected all six web sites, evaluator to web site assignments were made randomly with the only constraint being that no combination of inspectors was repeated for any two web sites. Each site was evaluated by at least two evaluators and the primary researcher, resulting in a minimum of three inspectors per web site. Each evaluator was given a six-week window to complete his inspections. Completed inspections were held by the thesis advisor until the primary researcher completed inspections of all six web sites.

Due to the more technical nature of the accessibility guidelines over usability heuristics, accessibility inspections were performed only by the primary researcher. Accessibility inspections were performed following completion of usability inspections. A list of applicable military guidance documents was developed by reviewing available military guidance. The resulting list of relevant guidance was then reviewed for overlap

with Nielsen's usability heuristics and the Access Board's Section 508 compliance guidelines for web sites.

Review of military guidance was performed by the primary evaluator following completion of the usability and accessibility inspections. Military policy documents were pulled from publicly available information sources and do not include any limited distribution documents. The findings were compiled in a database that is located at Appendix B.

Research Quality

To be considered high quality, research efforts must maximize for conditions -- construct validity, internal validity, external validity, and reliability (Yin, 2003). This is as true for case study designs as for other research methods. The following discussion describes how the current research effort addresses each of these conditions.

Construct Validity.

Construct validity refers to how well the measured constructs accurately capture the theoretical construct it represents (Schwab, 2005). The literature review for this research validated the widespread consensus among experts that Nielsen's heuristics satisfactorily capture the primary tenants of usable HCI design. In addition, the literature review clearly creates and maintains a chain of evidence that supports the need for usability based on PEOU as a determinant of technology acceptance, the importance of accessibility as mandated by Federal law, and the role of intranets in the Air Force environment. Furthermore, Borges's research validates the role of guidance in developing usable and accessible web sites.

Internal Validity.

Internal validity occurs when scores on the independent variable are correlated with scores on the dependent variable, indicating the ability of the independent variable to predict changes in the dependent variable (Schwab, 2005). Case study methodology addresses internal validity during data analysis. As discussed above in *Logic Linking the Data to the Propositions*, the multi-case design of this research provides the ability for pattern matching and cross case comparisons. This creates two sources evidence supporting the link between the dependent and independent variables.

External Validity.

External validity refers to the appropriate generalization of findings to cases outside those studied. In case study research, external validity is established by replicating the results in similar circumstances and environments where theory suggests the same findings will occur (Yin, 2003). This research effort applies well established usability and accessibility theory to a range of Air Force intranet web sites. The mix of theoretical and literal replication used to compare and contrast the cases in this study extends the generalizability of the findings. However, discretion must be used so as not to overreach the extent of generalization that is appropriate.

Reliability.

Reliability is a primary goal of all high-quality empirical research. Reliability refers to the amount of variance in the research and other researchers' ability to replicate research findings (Schwab, 2005; Yin, 2003). Two sources of reliability are use of a case study protocol and a case study database. This effort clearly outlines the protocol used. Furthermore, all relevant data each web site is included in the main chapters, tables, and

Appendix B of this effort. Every effort has been taken to make this research transparent for future researchers to understand, duplicate, and reference with confidence.

Chapter Summary

This chapter explained the rationale for using a case study approach and outlined the research design. The unit of analysis was clearly defined as the individual intranet web site and the cases used in this study were introduced. Criteria for interpreting the findings were developed based on the literature review summarized in Chapter II. The chapter concluded with a discussion of the steps taken to ensure that the research effort is of high quality.

IV. Results

Investigative Question 1: Air Force Web Site Usability Inspection Results

Initial inspection of the data revealed that evaluator 5 and the primary evaluator tended to give higher usability compliance scores than other evaluators as shown in Table 9. It was also noted that evaluators 4 and 7 gave somewhat lower usability scores. These nuances contribute to a range of usability scores for each web site. However this is not an unexpected outcome but rather is a result of evaluators placing different emphasis in different areas. Indeed, this is the crux of Nielsen's *discount usability* method. His research indicates that at least three evaluators are needed for a thorough usability inspection (Nielsen and Mack, 1994).

Table 9. Usability Scores by Case and Evaluator

Evaluator	Case A	Case B	Case C	Case D	Case E	Case F
1	--	0.56	--	--	0.59	--
2	--	0.55	--	0.57	--	--
3	0.71	--	--	0.80	--	--
4	--	--	0.36	--	0.44	--
5	--	0.77	--	0.83	--	--
6	--	--	0.62	--	--	0.70
7	0.58	0.43	--	--	--	--
8	--	0.68	--	--	--	0.68
9	--	--	0.55	0.49	--	--
Primary Evaluator	0.75	0.67	0.69	0.77	0.63	0.68

Figure 4 visually depicts the mean usability scores given by each evaluator for each web site inspected. The graph shows that the mean usability score for each case is centered within the individual evaluator scores for that web site. This indicates that no evaluator's data is exerting an undue influence on the mean usability score for any case.

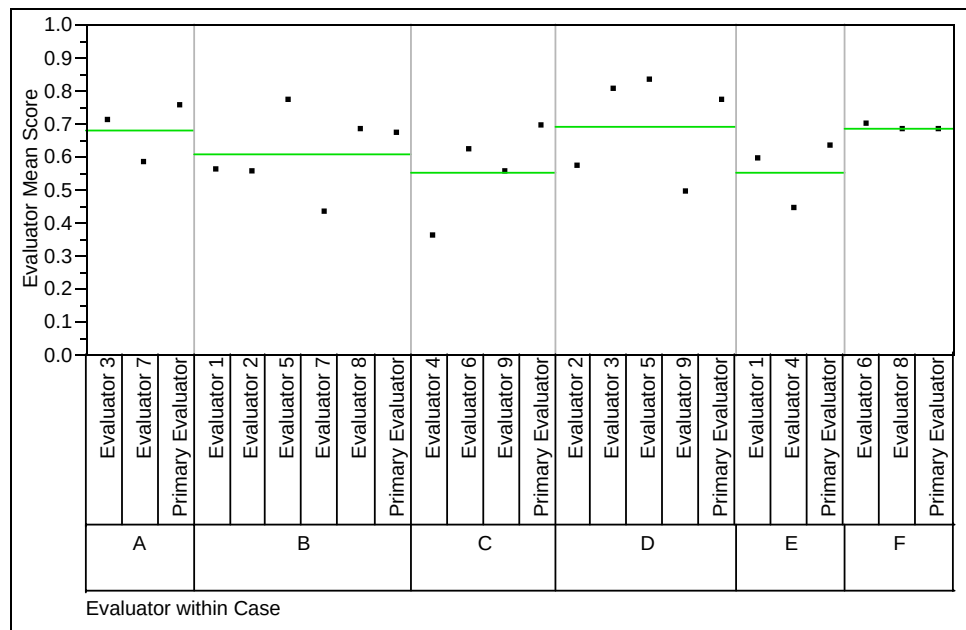


Figure 4. Average Usability Score by Case and Evaluator

It is also noted that the number of evaluators varies across each cases. This variation is due to incomplete and highly erratic data provided by two of the evaluators which prevented their inspections from being included in this study. Removal of these two evaluators resulted in an unbalanced number of evaluators per case. However, the minimum number of three evaluators per case recommended by Nielsen is met for all cases.

Cross Case Comparisons.

The following paragraphs describe the results of the web site usability inspections. Results are detailed first by heuristic and then summarized in a collective discussion of the findings.

Visibility of System Status.

The first heuristic, *visibility of system status*, posits that the system should keep users informed about what is happening. As shown in Table 10, the average score for this heuristic is .68 with a high score of .87 for Case F and a low score of .50 for Case C. Failing to keep the user informed of system status when observable delays exist was the checklist item requiring the greatest attention for this heuristic.

Table 10. Average Usability Scores for Each Case by Heuristic

Heuristic	Case A	Case B	Case C	Case D	Case E	Case F	Overall
1 Visibility of System Status	0.74	0.63	0.50	0.78	0.56	0.87	0.68
2 Match Between System and the Real World	0.78	0.70	0.64	0.75	0.69	0.85	0.73
3 User Control and Freedom	0.57	0.68	0.60	0.71	0.66	0.61	0.64
4 Consistency and Standards	0.84	0.63	0.70	0.79	0.74	0.85	0.76
5 Help Users Recognize, Diagnose, and Recover From Errors	0.79	0.78	0.54	0.75	0.44	0.77	0.68
6 Error Prevention	0.68	0.46	0.41	0.61	0.26	0.72	0.52
7 Recognition Rather Than Recall	0.66	0.54	0.46	0.65	0.54	0.65	0.58
8 Flexibility and Efficiency of Use	0.20	0.49	0.41	0.31	0.32	0.50	0.37
9 Aesthetic and Minimalist Design	0.74	0.79	0.56	0.71	0.69	0.76	0.71
10 Help and Documentation	0.43	0.24	0.50	0.70	0.17	0.30	0.39
11 Skills	0.58	0.63	0.58	0.69	0.55	0.56	0.60
12 Pleasurable and Respectful Interaction with the User	0.83	0.67	0.72	0.68	0.75	0.61	0.71
13 Privacy	1.00	0.72	0.58	0.92	0.83	0.89	0.82
Overall	0.68	0.61	0.55	0.69	0.55	0.69	0.63
Indicates scores lower than .50 Indicates scores higher than .80							

Match Between System and the Real World.

The second heuristic, *match between system and the real world*, suggests that the system interface should use conventions that are familiar to the user. The average score for this heuristic is .73 with a high score of .85 for Case F and a low score of .64 for Case C. Failing to follow a natural sequence for menu choices was the most duplicated violation across all evaluators and web sites.

User Control and Freedom.

The third heuristic, *user control and freedom*, recommends that users be provided an easy mechanism to back out of mistakes including *undo* and *redo* functionality. The average score for this heuristic is .64 with a high score of .71 for Case D and a low score of .57 for Case A. The most common problems involve failure to provide an *undo* capability and no ability for users to set their own system, session or screen defaults.

Consistency and Standards.

The fourth heuristic, *consistency and standards*, advocates use of platform-wide conventions that prevent user confusion by providing consistent meaning for words and actions. The average score for this heuristic is .76 with a high score of .85 for Case F and a low score of .63 for Case B. Lack of consistency in the location and format of online instructions was the most frequently identified problem.

Help Users Recognize, Diagnose, and Recover From Errors.

The fifth heuristic, *help users recognize, diagnose, and recover from errors*, states that errors messages should clearly state the problem and suggest a constructive solution. The average score for this heuristic is .68 with a high score of .79 for Case A and a low score of .44 for Case E. The most commonly identified problems were error messages that placed blame on the user instead of the system and failure to place the cursor in or highlight the field in which the error occurred.

Error Prevention.

The sixth heuristic, *error prevention*, calls for the system to prevent user errors whenever possible. The average score for this heuristic is .52 with a high score of .72 for Case F and a low score of .26 for Case E. Failure to visually indicate the maximum field

length or the number of character spaces remaining in a field was the most common issue identified by inspectors.

Recognition Rather Than Recall.

The seventh heuristic, *recognition rather than recall*, recommends that the system should provide visible objects, actions, options, and instructions rather than requiring the user to remember information from screen to screen. The average score for this heuristic is .58 with a high score of .66 for Case A and a low score of .46 for Case C. Failing to make the first word in each menu choice the most important word and failure to provide an online spatial menu map were the most frequently identified problems.

Flexibility and Efficiency of Use.

The eight heuristic, *flexibility and efficiency of use*, states that the system should allow users to tailor frequent actions and provide accelerators for expert users. The average score for this heuristic is .37 with a high score of .50 for Case F and a low score of .20 for Case A. The most commonly identified issue was no provision for keyboard shortcuts.

Aesthetic and Minimalist Design.

The ninth heuristic, *aesthetic and minimalist design*, recognizes that limited screen space is available and only the most relevant information to the task at hand should be presented. The average score for this heuristic is .71 with a high score of .79 for Case B and a low score of .56 for Case C. Displaying more information than is essential to decision making was the most commonly identified problem.

Help and Documentation.

The tenth heuristic, *help and documentation*, recommends that help should be readily available, useful, and task focused. The average score for this heuristic is .39, with a high score of .70 for Case D and a low score of .17 for Case E. The most frequently identified shortcomings were lack of context-sensitive help and no ability to change the level of detail available.

Skills.

The eleventh heuristic, *skills*, states that the system should augment and leverage user skills rather than attempt to replace them. The average score for this heuristic is .60 with a high score of .69 for Case D and a low score of .55 for Case E. Not automatically focusing the cursor on the field users are most likely to need was the most commonly identified problem.

Pleasurable and Respectful Interaction with the User.

The twelfth heuristic, *pleasurable and respectful interaction with the user*, suggests that the user should be treated respectfully and the interface should be aesthetically pleasing in order to increase the user's quality of work-life. The average score for this heuristic is .71 with a high score of .83 for Case A and a low score of .61 for Case F. The most frequently identified issue was not using color to draw user attention, communicate organization and relationships, or indicate status changes.

Privacy.

The thirteenth heuristic, *privacy*, recognizes the importance of helping the user protect personal and private information. The average score for this heuristic is .82 with a high score of 1.00 for Case A and a low score of .58 for Case C. Problems identified by

this heuristic appeared to be randomly distributed with no single item accounting for a disproportion amount of negative findings.

Heuristic Compliance Scores Compared.

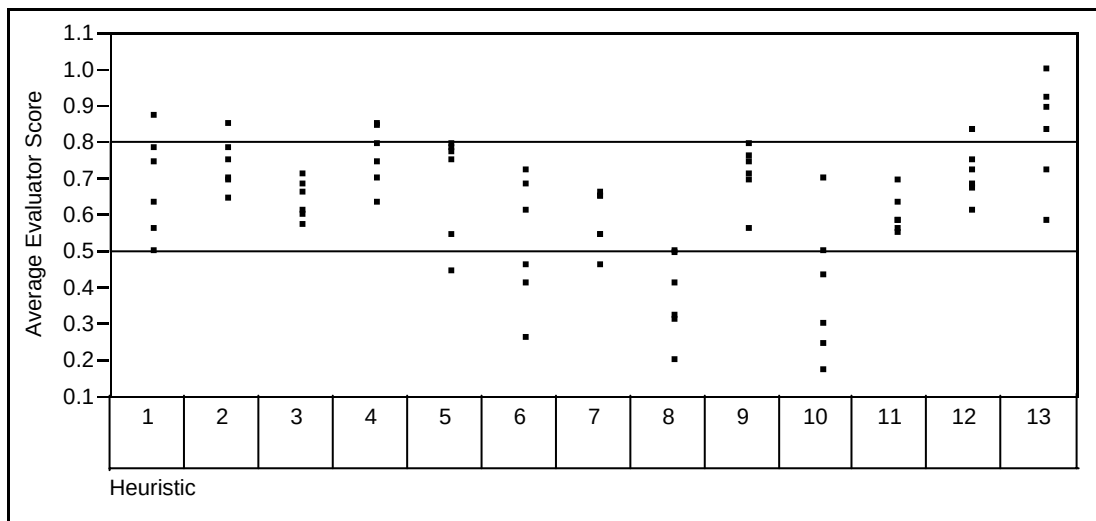
Of all thirteen heuristics inspected, only *privacy* received a mean score greater than .80 across all web sites. Two heuristics, *flexibility and efficiency of use* and *help and documentation*, received mean scores worse than .50 when averaged across all sites. *Flexibility and efficiency of use* scores were lower than .50 for all but one site while only two sites scored .50 or above for *help and documentation*.

The small number of six sample web sites for each heuristic, combined with the wide variability of evaluator scores within each heuristic makes statistical comparison difficult. However the data clearly indicates that *privacy* is the heuristic best addressed by the six web sites and that all sites performed poorly on the *flexibility and efficiency of use* and *help and documentation* heuristics. Table 11 shows that the scores for the latter are statistically different from *privacy* while all other heuristics fall within a range between .50 and .80. Figure 5 visually reinforces these findings, clearly showing that scores for the majority of the heuristics fall between .50 and .80.

Based on the established criteria, *privacy* is in good shape while *flexibility and efficiency of use* and *help and documentation* are not serving customers well. Furthermore, the remaining ten heuristics which scored between .50 and .80 are not a disaster, but are bad enough that isolated modifications to individual areas will not suffice (Felax, 2005; Nielsen and Tahir, 2002).

Table 11. Comparison of Average Usability Compliance Score by Heuristic

Heuristic	Level*			Mean
13	A			0.82333333
4	A	B		0.75833333
2	A	B		0.73500000
12	A	B		0.71000000
9	A	B		0.70833333
1	A	B		0.68000000
5	A	B		0.67833333
3	A	B		0.63833333
11	A	B	C	0.59833333
7		B	C	0.58333333
6		B	C	0.52333333
10			C	0.39000000
8			C	0.37166667
*Levels not connected by the same letter are significantly different ($\alpha = .05$)				

**Figure 5. Average Evaluator Scores for Each Case by Heuristic**

Mean Usability Compliance Score for All Cases.

Taking all cases into consideration, the mean usability score for the six web sites inspected is .63 with all six web sites falling into the scoring range of .50 to .80.

According to the established criteria, this indicates that while the current intranet web sites are not a disaster, they are bad enough that isolated modifications to individual areas

will not suffice (Felax, 2005; Nielsen and Tahir, 2002). Furthermore, the usability score of .63 is very close to the findings of past AFIT research where Felax calculated a usability score of .65 for the Air Force Knowledge Now web site (Felax, 2005) and Kastenholz calculated a usability score of .6958 for the Automated Civil Engineer System Personnel Readiness module of the Automated Civil Engineer System Personnel Readiness (Kastenholz, 2005).

Investigative Question 2: Air Force Web Site Accessibility Inspection Results

Accessibility compliance of each site was assessed by the primary researcher. The raw data is summarized in Table 12 and the following sections describe how well the cases comply with Section 508 mandatory compliance items.

Analysis of Individual Accessibility Compliance Scores by Guideline.

As shown in Table 12, guidelines 1194.22(j) and (m) received the highest scores, being met by all six cases. Additionally, guidelines 1194.22(d) and (g) were met by five of the cases. This indicates that the cases involved in this study adequately addressed the need for organizing documents so they are readable without an associated style sheet, properly identified row and column headers, avoided screen flicker greater than 2 Hz and lower than 55 Hz, and provided associated files for download in accessible formats. In contrast, only one web site met guideline 1194.22(o) by providing a method that permits users to skip repetitive navigation links. In addition, two cases failed to adequately address guidelines 1194.22(a), *provide a text equivalent for all non-text elements*, and 1194.22(n), *use forms that are compatible with assistive technologies*.

Table 12. Accessibility Compliance Scores by Case and Guideline

Guideline	A	B	C	D	E	F	Compliance Score
1194.22 (a)	1	1	1	1	0	0	0.67
1194.22 (b)	--	0	--				0.00
1194.22 (c)	1	1	1	1	1	0	0.83
1194.22 (d)	1	1	1	0	1	1	0.83
1194.22 (e)	--	--	--	--	---	---	---
1194.22 (f)	1	1	--	--	1	---	1.00
1194.22 (g)	1	1	1	1	1	0	0.83
1194.22 (h)	--	--	--	--	---	---	
1194.22 (i)	--	1	--	--	---	---	1.00
1194.22 (j)	1	1	1	1	1	1	1.00
1194.22 (k)	--	--	--	--	---	---	---
1194.22 (l)	1	1	--	1	0	1	0.80
1194.22 (m)	1	1	1	1	1	1	1.00
1194.22 (n)	1	0	1	1	0	1	0.67
1194.22 (o)	0	--	0	1	0	0	0.20
1194.22 (p)	--	--	--	--	---	---	---
Compliance Score	0.90	0.82	0.88	0.89	0.60	0.56	0.77
(1) Complies (0) Does not comply (--) Not applicable							

Guideline 1194.22(b) which requires synchronized captions for multimedia files was only applicable to one case and that case did not comply with the guideline.

Analysis Web Site Accessibility Across all Cases.

The average accessibility compliance score across all web sites included in this study is .77. Case A received the high score of .90 and Case F received the low score of .56. In all, three web sites scored greater than .80 while two scored lower. Based on the established grading criteria, the three sites scoring higher than .80 are in good shape regarding accessibility and should consider making a few minor fixes to areas where the site violated guidelines. However, the two cases scoring lower than .80 but above .50 should consider starting a redesign project to produce a new web site. While neither of

these sites is a disaster, they are bad enough that isolated modifications to individual areas will not suffice (Felax, 2005; Nielsen and Tahir, 2002).

Additional inspection of the data reveals that the accessibility scores calculated in this study greatly exceed those found in previous studies of the accessibility of government web sites (Ellison, 2004; Felax, 2005; Jackson-Sanborn et al., 2002). This may be due to better compliance by the sample of web sites used in this study or to a more liberal grading standard used by the primary researcher in this study. No assumption is made about which explanation is more accurate and it is noted that this issue warrants additional research.

Investigative Question 3: Analysis of the Relationship Between Usability and Accessibility Scores

Usability and accessibility compliance scores obtained from IQ1 and IQ2 were used to answer this investigative question. These scores were charted on a single graph with usability compliance scores on the y-axis and accessibility compliance scores on the x-axis. If the scores are related, a visible pattern should appear in the graph. However as shown in Figure 6, there appears to be no direct linear relationship between usability and accessibility compliance scores. Based on the overall compliance scores for each web site, heuristic compliance scores are not correlated with accessibility compliance scores.

Investigative Question 4: Analysis of Military Policies

A list of military guidance documents relevant to web site development, maintenance, and use was compiled and reviewed for overlap with common practice usability heuristics and mandatory Section 508 compliance guidelines. This review

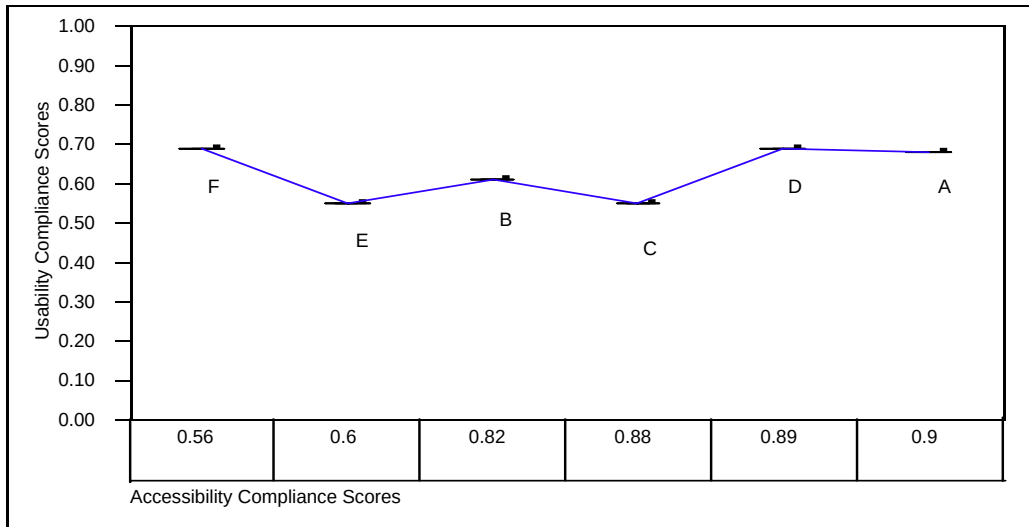


Figure 6. Graph of Usability Scores as a Function of Accessibility Scores

identified eleven military guidance documents with which compliance is mandatory for Air Force organizations. Of these eleven documents, three are Air Force publications focused on Internet use and web site development, maintenance, and use. Six include guidance that is mandatory for all Air Force web sites but does not elaborate on site development, maintenance, or use. The remaining two documents are DoD publications that provide mandatory guidance that is relevant to web sites. The results of this review are shown in Tables 13 and 14.

Of the thirteen common practice heuristics used in this study, five were found to be represented in mandatory military guidance, a total of 38 percent. In total, these five heuristics were mentioned 12 times with *privacy* receiving eight of those mentions. One document, Air Force Instruction 33-129 *Web Management and Internet Use*, contained references to four of the five heuristics mentioned.

Meanwhile, statements mandating Section 508 compliance were found four times in these same military guidelines. However only six of the sixteen individual

Table 13. Number of Occurrences of Each Heuristic in Military Guidance

Publication	Heuristic													Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Air Force Mandatory Internet Guidance														
AFI 33-117														0
AFI 33-129				X					X			X	X	4
AFI 35-101*													X	1
Air Force Mandatory non-Web Specific Guidance														
AFI 33-219													X	1
AFMAN 33-326		X												1
AFI 33-332													X	1
AFMAN 37-104													X	1
AFPD 37-1													X	1
DoD Reg 5400.7/AF Sup													X	1
DoD Mandatory Guidance														
DODD 8000.1														0
Web Site Admin Policies and Procedures													X	1
Available Reference but not Mandatory Guidance														
AF Content Publishing Guide for Publishing Center v1.1	X	X	X	X			X	X	X					7
AF Portal Style Guide	X			X			X					X		4
# Occurrences in Mandatory Guidance	0	1	0	1	0	0	0	0	1	0	0	1	8	

Table 14. Number of Mentions of Mandatory Section 508 Compliance and Occurrences of Individual Section 508 Guidelines in Military Guidance

Publication	508	Specific 1194.22 Paragraph																Total Individual
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	
Air Force Mandatory Internet Guidance																		
AFI 33-117	X																	0
AFI 33-129	X																	0
AFI 35-101*	X	X	X	X	X	X		X										6
Air Force Mandatory non-Web Specific Guidance																		
AFI 33-219																		0
AFMAN 33-326																		0
AFI 33-332																		0
AFMAN 37-104																		0
AFPD 37-1																		0
DoD Reg 5400.7/AF Sup																		0
DoD Mandatory Guidance																		
DODD 8000.1	X																	0
Web Site Admin Policies and Procedures																		0
Available Reference but not Mandatory Guidance																		
AF Content Publishing Guide for Publishing Center v1.1	X	X	X			X		X	X	X								6
AF Portal Style Guide																		0
# Occurrences in Mandatory Guidance	4	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	

accessibility compliance items mandated by the Access Board were expressly mentioned, a total of 38 percent. All six of these mentions occurred in the same document, Air Force Instruction 35-101 *Public Affairs Policies and Procedures*.

Based on these findings, the majority of common practice usability guidelines are not found in mandatory military guidance. Likewise, the majority of specific

accessibility compliance guidelines outlined by the Access Board are absent from military guidance documents. However the overarching principle that web sites must be Section 508 compliant appears to be adequately addressed, being clearly stated in four military policy documents, three of which are specific to web site development, maintenance, and use.

Investigative Question 5: Analysis of the Relationship Between Military Guidance and Compliance Scores

The number of times that common practice usability heuristics and Section 508 compliance is discussed in military guidance is compared with the compliance scores to answer this investigative question. In the first step, data was charted on a single graph with mean compliance scores for each heuristic (including one data point representing Section 508 compliance) on the y-axis and the *number of occurrences in the military guidelines* on the x-axis. If the scores are related to the number of occurrences in the military guidelines, a pattern should appear in the graph. As shown in Figure 7, it appears that higher occurrences of a given heuristic are correlated with higher compliance scores for that same heuristic.

To provide another perspective, heuristics were then divided into two groups. One group consisted of all heuristics not represented in military guidance and the other group consisted of all heuristics that are represented in military guidance. Again, accessibility compliance is included as a single data point. Figure 8 reveals the dichotomy in compliance scores between these groups, showing that mean scores for heuristics represented in military guidance are higher than for non-represented heuristics.

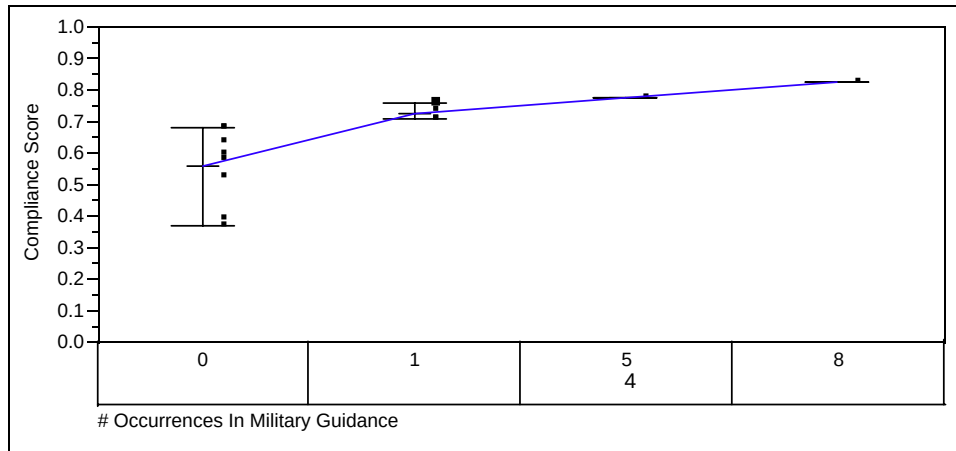


Figure 7. Graph of Compliance Scores as a Function of the Number of Occurrences of Each Heuristic in Military Guidance

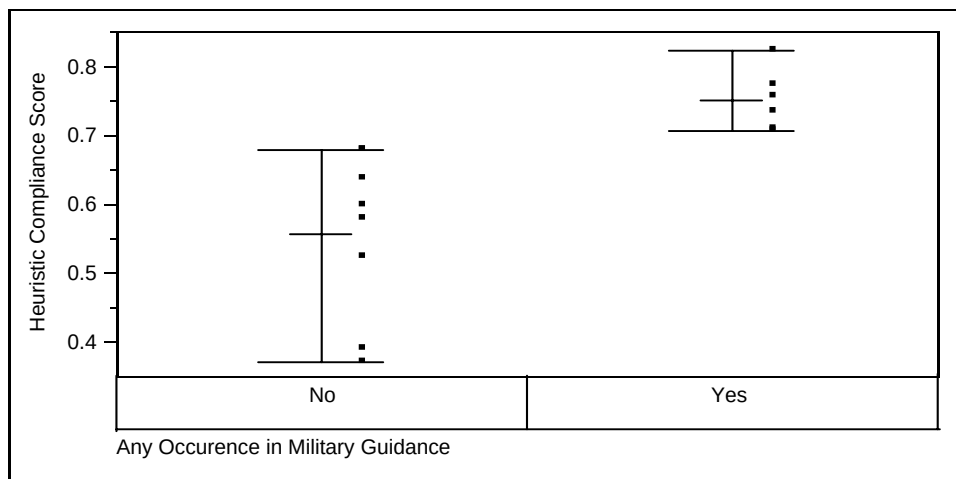


Figure 8. Graph of Compliance Scores Grouped by Occurrences in Mandatory Military Guidance

Based on these comparisons, it appears that a correlation exists between the existence of heuristics in military guidance and the compliance scores associated with those heuristics.

Ad Hoc Analysis

Although additional analysis is not required to answer the investigative questions, several findings warrant additional analysis. This ad hoc analysis looks at what might

happen to the compliance scores if the best or worst heuristics were removed from the analysis and what effect additional mandatory guidance could have on the overall quality of military guidance.

IQ1 revealed that *privacy* was the heuristic best addressed by the sites studied and that *flexibility and efficiency of use* and *help and documentation* were the worst areas. If *privacy* is removed from the analysis, the overall compliance score drops from .63 to .61. On the other hand removing either of the two lowest scoring heuristics raises the overall compliance score from .63 to .65 while removing both raises the overall score to .68. This analysis shows that neither the highest or lowest scoring heuristics are strongly influencing the overall mean usability score. Without the highest score the mean does not fall below the next cutoff of .50 nor does it rise above .80 if the lowest scores are removed. This reinforces the finding that isolated modifications to individual areas will not suffice to raise the average usability of these sites to an acceptable level.

IQ4 found that only five of Nielsen's thirteen usability heuristics were found in military guidance documents. Aside from the mandatory guidance already discussed, the review of military guidance also identified two additional documents that are relevant to some Air Force intranet web sites (also detailed in Appendix B). These documents were specifically targeted at sites appearing on the Air Force Portal and, although compliance with these guidelines is not mandatory for non-Portal web sites, these documents could serve as an additional reference for non-Portal sites. These two guidelines capture eight of Nielsen's heuristics, four of which are not otherwise found in the military guidance. Simply adding these documents to the list of mandatory guidance would raise the number of usability heuristics contained in military policy from 38 percent to 69 percent.

In addition, these two documents also provide specific guidance for six Section 508 compliance items, four of which are unique from those found already present in mandatory guidance. Adding these documents to the list of mandatory guidance would raise the average number of Section 508 compliance items contained in military guidance from 38 percent to 63 percent. These findings highlight the fact that more robust military guidance could be easily developed by simply integrating the principles found in those two documents into mandatory compliance documents.

Chapter Summary

This chapter summarized the findings of this study's five investigative questions. The average compliance rate for the web sites evaluated was found to be 63 percent. The average accessibility score was 77 percent. Furthermore, accessibility compliance was found to have no correlation with usability compliance. A review of mandatory military guidance found that only 38 percent of usability heuristics and 38 percent of mandatory accessibility requirements are captured in military guidance. In addition, a correlation was found between the existence of usability and accessibility principles in military guidance and compliance scores for those principles.

In answer to the primary research question, Air Force intranet web sites in this study did not adequately comply with basic common practice usability guidelines and compliance with mandatory Section 508 compliance items varied among sites with four of six sites receiving acceptable accessibility compliance scores.

V. Discussion

Introduction

This chapter provides discussion on the findings presented in the Chapter IV and makes recommendations based on those findings. Limitations are summarized and suggests for future research are offered.

Usability Recommendations

This research found substantial usability problems with each web site evaluated. The cases selected for this research are representative of the types of applications being migrated to web interfaces. Therefore it is important to understand what lessons can be learned from this study to improve these sites and prevent other web applications from suffering similar usability problems.

Heuristic evaluations are traditionally recognized as a simple approach to identify the highest priority areas on which to commit limited organizational resources. However it is critical to realize that isolated changes and modifications will not suffice to correct the usability problems identified by this research. Consequently individual recommendations for quick fixes to specific problems are not appropriate and are not provided. Although the lowest compliance item(s) for each usability heuristic is identified in Chapter IV, changes must be implemented as part of a wider redesign effort focused on improving all aspects of usability. However, it is noted that extra attention should be focused on *flexibility and efficiency of use* and *help and documentation*, the two usability heuristics which received the worst compliance scores. Furthermore the

comparatively high compliance rates found for *privacy* raise concerns that the resources and attention dedicated to *privacy* may have come at the expense of other aspects of usability. Organizations are therefore cautioned to carefully evaluate the optimal balance for resource allotment to each usability area.

Accessibility Recommendations

This study identified only one Section 508 compliance item that was consistently overlooked by nearly all web sites. This item, *provide a method that permits users to skip repetitive navigational links*, is a simple update that must be made to all noncompliant web sites. Based on the other accessibility findings, organizations are encouraged to ensure that a text equivalent exists for all non-text elements and redesign all forms to be fully compatible with assistive technologies. The four cases with sites scoring above .80 should review all compliance items and take necessary actions to correct individual instances of non-conformance. The two cases with sites that received overall accessibility scores below .80 should initiate a site redesign focused on meeting all mandatory accessibility requirements.

Discussion About the Relationship Between Usability and Accessibility

This study found no evidence of a significant correlation between Nielsen's usability heuristics and government mandated accessibility compliance items. This research adds to the existing body of knowledge but should not be taken out of context. Section 508 compliance items largely address technical accessibility issues. Therefore, it is most appropriate to state that this study found no evidence of a correlation, either positive or negative, between usability and technical accessibility.

Recommendations for Military Web Site Guidance

This research supports the findings by Kastenholz that compliance with military guidelines is not sufficient to ensure creation of a usable web site (Kastenholz, 2005). Although basic usability and accessibility principles are not widely captured in military guidance, those that do appear in the guidance are correlated with higher compliance scores. This appears to be especially true for *privacy* which is a widely documented military concern and is the usability heuristic that received the highest compliance scores in this study. These findings support the need for the Air Force to develop a single, overarching web site style guide that adequately captures basic HCI design principles and fully documents the requirements for Section 508 compliance.

Research Limitations

This study was designed to address the primary limitation of past research by using a minimum of three evaluators per site and providing each evaluator with usability training (Felax, 2005; Kastenholz, 2005). However, some limitations exist.

One limitation is the use of students as usability experts. Although training was provided, it is unrealistic to assert that their skills are at the same level as professional usability experts who have years of HCI experience. The most likely outcome of substituting students for experts is that students will not identify as many usability problems as experts would. This implies that compliance scores would be lower if experts were used.

Another limitation is that the use of a single accessibility evaluator provides weaker support for accessibility findings than would the use of multiple evaluators.

However, accessibility evaluations are more technical in nature and the additional evaluators available for this effort did not possess the technical skills required to conduct accessibility inspections.

Two other limitations are the limited availability of relevant, web specific military guidance and the unknown degree to which individual military units comply with that guidance. This study focused solely on general guidance such as DoD Regulations and Air Force Instructions that were readily available for evaluation. This approach excluded the large body of program specific design documents used for development and acquisition of web-based applications. Likewise, organizational guidance produced for use on at the local unit level was not included. Furthermore, although military guidance can easily be qualified as mandatory or optional, cases were not questioned to determine their knowledge or use of mandatory guidance.

Recommendations for Future Research

The relatively high compliance rate for *privacy* may indicate that an inverse relationship exists between *privacy* as implemented by Air Force web sites and the other heuristics. One possibility is that *privacy* is given preferential treatment and allowed to take precedence over other aspects of usability when conflicts exist. Another possibility is that more resources are spent on *privacy* leaving fewer resources for other aspects of usability. Future research could investigate possible covariance between *privacy* and the other usability heuristics.

Regarding accessibility, future research may benefit from the use of an automated accessibility inspection tool. The findings of an automated tool would be more objective

and arguably more rigorous by ensuring a more consistent evaluation across web sites than is possible with a human evaluator. Additionally, an automated tool could easily evaluate accessibility against Section 508 compliance items and against WAI Web Content Accessibility Guidelines to provide a deeper understanding of overall accessibility.

A study should be conducted to perform a comprehensive review of all military web site development guidance and handbooks across programs and functional areas. Such a review should include the design documents used for system development and acquisition as well as guidelines produced below the Air Force level such as Major Command and local unit guidance. This review could also follow Ratners's work by evaluating the military guidance against the 270 HTML-relevant recommendations she identified in HCI guidelines (Ratner et al., 1996).

Although the applicability of TAM is strongly supported in web based and mandatory adoption environments, the question of exactly how much usability is sufficient has not been definitively answered. Indeed, there is ongoing discussion in both academic and practitioner circles as to how much should be invested in usability. Therefore, future research could compare usability compliance to a web site acceptance construct to identify trends and attempt to quantify the level of usability required for specific web site functions.

Chapter Summary

This chapter provided a discussion of the results documented in Chapter IV. The web sites evaluated by this study faired poorly against Nielsen's usability heuristics but

most met mandatory accessibility standards. These sites should consider redesign projects to develop more usable sites and address any outstanding accessibility problems. The results of this study present a learning opportunity for Air Force organizations responsible for web site design and maintenance and provide evidence of the value of creating a single, robust, program-independent Air Force web style guide that adequately captures basic HCI design principles and fully documents the requirements for Section 508 compliance.

Appendix A. Usability Heuristic Checklist

The following checklist comes from Pierotti and is based on Nielsen's usability heuristics (Nielsen and Mack, 1994; Pierotti, 1995).

1. Visibility of System Status

The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

#	Review Checklist
1.1	Does every display begin with a title or header that describes screen contents?
1.2	Is there a consistent icon design scheme and stylistic treatment across the system?
1.3	Is a single, selected icon clearly visible when surrounded by unselected icons?
1.4	Do menu instructions, prompts, and error messages appear in the same place(s) on each menu?
1.5	In multi-page data entry screens, is each page labeled to show its relation to others?
1.6	If overtype and insert mode are both available, is there a visible indication of which one the user is in?
1.7	If pop-up windows are used to display error messages, do they allow the user to see the field in error?
1.8	Is there some form of system feedback for every operator action?
1.9	After the user completes an action (or group of actions), does the feedback indicate that the next group of actions can be started?
1.10	Is there visual feedback in menus or dialog boxes about which choices are selectable?
1.11	Is there visual feedback in menus or dialog boxes about which choice the cursor is on now?
1.12	If multiple options can be selected in a menu or dialog box, is there visual feedback about which options are already selected?
1.13	Is there visual feedback when objects are selected or moved?
1.14	Is the current status of an icon clearly indicated?
1.15	Is there feedback when function keys are pressed?
1.16	If there are observable delays (greater than fifteen seconds) in the system's response time, is the user kept informed of the system's progress?
1.17	Are response times appropriate to the task?
1.18	Typing, cursor motion, mouse selection: 50-150 milliseconds
1.19	Simple, frequent tasks: less than 1 second
1.20	Common tasks: 2-4 seconds
1.21	Complex tasks: 8-12 seconds

1.22	Are response times appropriate to the user's cognitive processing?
1.23	Continuity of thinking is required and information must be remembered throughout several responses: less than two seconds.
1.24	High levels of concentration aren't necessary and remembering information is not required: two to fifteen seconds.
1.25	Is the menu-naming terminology consistent with the user's task domain?
1.26	Does the system provide <i>visibility</i> : that is, by looking, can the user tell the state of the system and the alternatives for action?
1.27	Do GUI menus make obvious which item has been selected?
1.28	Do GUI menus make obvious whether de-selection is possible?
1.29	If users must navigate between multiple screens, does the system use context labels, menu maps, and place markers as navigational aids?

2. Match Between System and the Real World

The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

#	Review Checklist
2.1	Are icons concrete and familiar?
2.2	Are menu choices ordered in the most logical way, given the user, the item names, and the task variables?
2.3	If there is a natural sequence to menu choices, has it been used?
2.4	Do related and interdependent fields appear on the same screen?
2.5	If shape is used as a visual cue, does it match cultural conventions?
2.6	Do the selected colors correspond to common expectations about color codes?
2.7	When prompts imply a necessary action, are the words in the message consistent with that action?
2.8	Do keystroke references in prompts match actual key names?
2.9	On data entry screens, are tasks described in terminology familiar to users?
2.10	Are field-level prompts provided for data entry screens?
2.11	For question and answer interfaces, are questions stated in clear, simple language?
2.12	Do menu choices fit logically into categories that have readily understood meanings?
2.13	Are menu titles parallel grammatically?
2.14	Does the command language employ user jargon and avoid computer jargon?
2.15	Are command names specific rather than general?
2.16	Does the command language allow both full names and abbreviations?
2.17	Are input data codes meaningful?
2.18	Have uncommon letter sequences been avoided whenever possible?
2.19	Does the system automatically enter leading or trailing spaces to align decimal points?

2.20	Does the system automatically enter a dollar sign and decimal for monetary entries?
2.21	Does the system automatically enter commas in numeric values greater than 9999?
2.22	Do GUI menus offer activation: that is, make obvious how to say “ <i>now do it</i> ”?
2.23	Has the system been designed so that keys with similar names do not perform opposite (and potentially dangerous) actions?
2.24	Are function keys labeled clearly and distinctively, even if this means breaking consistency rules?

3. User Control and Freedom

Users should be free to select and sequence tasks (when appropriate), rather than having the system do this for them. Users often choose system functions by mistake and will need a clearly marked “emergency exit” to leave the unwanted state without having to go through an extended dialogue. Users should make their own decisions (with clear information) regarding the costs of exiting current work. The system should support undo and redo.

#	Review Checklist
3.1	If setting up windows is a low-frequency task, is it particularly easy to remember?
3.2	In systems that use overlapping windows, is it easy for users to rearrange windows on the screen?
3.3	In systems that use overlapping windows, is it easy for users to switch between windows?
3.4	When a user's task is complete, does the system wait for a signal from the user before processing?
3.5	Can users type-ahead in a system with many nested menus?
3.6	Are users prompted to confirm commands that have drastic, destructive consequences?
3.7	Is there an "undo" function at the level of a single action, a data entry, and a complete group of actions?
3.8	Can users cancel out of operations in progress?
3.9	Are character edits allowed in commands?
3.10	Can users reduce data entry time by copying and modifying existing data?
3.11	Are character edits allowed in data entry fields?
3.12	If menu lists are long (more than seven items), can users select an item either by moving the cursor or by typing a mnemonic code?
3.13	If the system uses a pointing device, do users have the option of either clicking on menu items or using a keyboard shortcut?
3.14	Are menus broad (many items on a menu) rather than deep (many menu levels)?

3.15	If the system has multiple menu levels, is there a mechanism that allows users to go back to previous menus?
3.16	If users can go back to a previous menu, can they change their earlier menu choice?
3.17	Can users move forward and backward between fields or dialog box options?
3.18	If the system has multi-page data entry screens, can users move backward and forward among all the pages in the set?
3.19	If the system uses a question and answer interface, can users go back to previous questions or skip forward to later questions?
3.20	Do function keys that can cause serious consequences have an undo feature?
3.21	Can users easily reverse their actions?
3.22	If the system allows users to reverse their actions, is there a retracing mechanism to allow for multiple undos?
3.23	Can users set their own system, session, file, and screen defaults?

4. Consistency and Standards

Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

#	Review Checklist
4.1	Have industry or company formatting standards been followed consistently in all screens within a system?
4.2	Has a heavy use of all uppercase letters on a screen been avoided?
4.3	Do abbreviations not include punctuation?
4.4	Are integers right-justified and real numbers decimal-aligned?
4.5	Are icons labeled?
4.6	Are there no more than twelve to twenty icon types?
4.7	Are there salient visual cues to identify the active window?
4.8	Does each window have a title?
4.9	Are vertical and horizontal scrolling possible in each window?
4.10	Does the menu structure match the task structure?
4.11	Have industry or company standards been established for menu design, and are they applied consistently on all menu screens in the system?
4.12	Are menu choice lists presented vertically?
4.13	If "exit" is a menu choice, does it always appear at the bottom of the list?
4.14	Are menu titles either centered or left-justified?
4.15	Are menu items left-justified, with the item number or mnemonic preceding the name?
4.16	Do embedded field-level prompts appear to the right of the field label?
4.17	Do on-line instructions appear in a consistent location across screens?
4.18	Are field labels and fields distinguished typographically?
4.19	Are field labels consistent from one data entry screen to another?
4.20	Are fields and labels left-justified for alpha lists and right-justified for numeric lists?

4.21	Do field labels appear to the left of single fields and above list fields?
4.22	Are attention-getting techniques used with care?
4.23	Intensity: two levels only
4.24	Size: up to four sizes
4.25	Font: up to three
4.26	Blink: two to four hertz
4.27	Color: up to four (additional colors for occasional use only)
4.28	Sound: soft tones for regular positive feedback, harsh for rare critical conditions
4.29	Are attention-getting techniques used only for exceptional conditions or for time-dependent information?
4.30	Are there no more than four to seven colors, and are they far apart along the visible spectrum?
4.31	Is a legend provided if color codes are numerous or not obvious in meaning?
4.32	Have pairings of high-chroma, spectrally extreme colors been avoided?
4.33	Are saturated blues avoided for text or other small, thin line symbols?
4.34	Is the most important information placed at the beginning of the prompt?
4.35	Are user actions named consistently across all prompts in the system?
4.36	Are system objects named consistently across all prompts in the system?
4.37	Do field-level prompts provide more information than a restatement of the field name?
4.38	For question and answer interfaces, are the valid inputs for a question listed?
4.39	Are menu choice names consistent, both within each menu and across the system, in grammatical style and terminology?
4.40	Does the structure of menu choice names match their corresponding menu titles?
4.41	Are commands used the same way, and do they mean the same thing, in all parts of the system?
4.42	Does the command language have a consistent, natural, and mnemonic syntax?
4.43	Do abbreviations follow a simple primary rule and, if necessary, a simple secondary rule for abbreviations that otherwise would be duplicates?
4.44	Is the secondary rule used only when necessary?
4.45	Are abbreviated words all the same length?
4.46	Is the structure of a data entry value consistent from screen to screen?
4.47	Is the method for moving the cursor to the next or previous field consistent throughout the system?
4.48	If the system has multi-page data entry screens, do all pages have the same title?
4.49	If the system has multi-page data entry screens, does each page have a sequential page number?
4.50	Does the system follow industry or company standards for function key assignments?
4.51	Are high-value, high-chroma colors used to attract attention?

5. Help Users Recognize, Diagnose, and Recover From Errors

Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

#	Review Checklist
5.1	Is sound used to signal an error?
5.2	Are prompts stated constructively, without overt or implied criticism of the user?
5.3	Do prompts imply that the user is in control?
5.4	Are prompts brief and unambiguous.
5.5	Are error messages worded so that the system, not the user, takes the blame?
5.6	If humorous error messages are used, are they appropriate and inoffensive to the user population?
5.7	Are error messages grammatically correct?
5.8	Do error messages avoid the use of exclamation points?
5.9	Do error messages avoid the use of violent or hostile words?
5.10	Do error messages avoid an anthropomorphic tone?
5.11	Do all error messages in the system use consistent grammatical style, form, terminology, and abbreviations?
5.12	Do messages place users in control of the system?
5.13	Does the command language use normal action-object syntax?
5.14	Does the command language avoid arbitrary, non-English use of punctuation, except for symbols that users already know?
5.15	If an error is detected in a data entry field, does the system place the cursor in that field or highlight the error?
5.16	Do error messages inform the user of the error's severity?
5.17	Do error messages suggest the cause of the problem?
5.18	Do error messages provide appropriate semantic information?
5.19	Do error messages provide appropriate syntactic information?
5.20	Do error messages indicate what action the user needs to take to correct the error?
5.21	If the system supports both novice and expert users, are multiple levels of error-message detail available?

6. Error Prevention

Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.

#	Review Checklist
6.1	If the database includes groups of data, can users enter more than one group on a single screen?
6.2	Have dots or underscores been used to indicate field length?

6.3	Is the menu choice name on a higher-level menu used as the menu title of the lower-level menu?
6.4	Are menu choices logical, distinctive, and mutually exclusive?
6.5	Are data inputs case-blind whenever possible?
6.6	If the system displays multiple windows, is navigation between windows simple and visible?
6.7	Are the function keys that can cause the most serious consequences in hard-to-reach positions?
6.8	Are the function keys that can cause the most serious consequences located far away from low-consequence and high-use keys?
6.9	Has the use of qualifier keys been minimized?
6.10	If the system uses qualifier keys, are they used consistently throughout the system?
6.11	Does the system prevent users from making errors whenever possible?
6.12	Does the system warn users if they are about to make a potentially serious error?
6.13	Does the system intelligently interpret variations in user commands?
6.14	Do data entry screens and dialog boxes indicate the number of character spaces available in a field?
6.15	Do fields in data entry screens and dialog boxes contain default values when appropriate?

7. Recognition Rather Than Recall

Minimize the user's memory load by making objects, actions, and options visible.

The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

#	Review Checklist
7.1	For question and answer interfaces, are visual cues and white space used to distinguish questions, prompts, instructions, and user input?
7.2	Does the data display start in the upper-left corner of the screen?
7.3	Are multiword field labels placed horizontally (not stacked vertically)?
7.4	Are all data a user needs on display at each step in a transaction sequence?
7.5	Are prompts, cues, and messages placed where the eye is likely to be looking on the screen?
7.6	Have prompts been formatted using white space, justification, and visual cues for easy scanning?
7.7	Do text areas have "breathing space" around them?
7.8	Is there an obvious visual distinction made between "choose one" menu and "choose many" menus?
7.9	Have spatial relationships between soft function keys (on-screen cues) and keyboard function keys been preserved?
7.10	Does the system gray out or delete labels of currently inactive soft function keys?
7.11	Is white space used to create symmetry and lead the eye in the appropriate direction?

7.12	Have items been grouped into logical zones, and have headings been used to distinguish between zones?
7.13	Are zones no more than twelve to fourteen characters wide and six to seven lines high?
7.14	Have zones been separated by spaces, lines, color, letters, bold titles, rules lines, or shaded areas?
7.15	Are field labels close to fields, but separated by at least one space?
7.16	Are long columnar fields broken up into groups of five, separated by a blank line?
7.17	Are optional data entry fields clearly marked?
7.18	Are symbols used to break long input strings into "chunks"?
7.19	Is reverse video or color highlighting used to get the user's attention?
7.20	Is reverse video used to indicate that an item has been selected?
7.21	Are size, boldface, underlining, color, shading, or typography used to show relative quantity or importance of different screen items?
7.22	Are borders used to identify meaningful groups?
7.23	Has the same color been used to group related elements?
7.24	Is color coding consistent throughout the system?
7.25	Is color used in conjunction with some other redundant cue?
7.26	Is there good color and brightness contrast between image and background colors?
7.27	Have light, bright, saturated colors been used to emphasize data and have darker, duller, and de-saturated colors been used to de-emphasize data?
7.28	Is the first word of each menu choice the most important?
7.29	Does the system provide <i>mapping</i> : that is, are the relationships between controls and actions apparent to the user?
7.30	Are input data codes distinctive?
7.31	Have frequently confused data pairs been eliminated whenever possible?
7.32	Have large strings of numbers or letters been broken into chunks?
7.33	Are inactive menu items grayed out or omitted?
7.34	Are there menu selection defaults?
7.35	If the system has many menu levels or complex menu levels, do users have access to an on-line spatial menu map?
7.36	Do GUI menus offer affordance: that is, make obvious where selection is possible?
7.37	Are there salient visual cues to identify the active window?
7.38	Are function keys arranged in logical groups?
7.39	Do data entry screens and dialog boxes indicate when fields are optional?
7.40	On data entry screens and dialog boxes, are dependent fields displayed only when necessary?

8. Flexibility and Efficiency of Use

Accelerators, unseen by the novice user, may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions. Provide alternative means of access and

operation for users who differ from the “average” user (e.g., physical or cognitive ability, culture, language, etc).

#	Review Checklist
8.1	If the system supports both novice and expert users, are multiple levels of error message detail available?
8.2	Does the system allow novices to use a keyword grammar and experts to use a positional grammar?
8.3	Can users define their own synonyms for commands?
8.4	Does the system allow novice users to enter the simplest, most common form of each command, and allow expert users to add parameters?
8.5	Do expert users have the option of entering multiple commands in a single string?
8.6	Does the system provide function keys for high-frequency commands?
8.7	For data entry screens with many fields or in which source documents may be incomplete, can users save a partially filled screen?
8.8	Does the system automatically enter leading zeros?
8.9	If menu lists are short (seven items or fewer), can users select an item by moving the cursor?
8.10	If the system uses a type-ahead strategy, do the menu items have mnemonic codes?
8.11	If the system uses a pointing device, do users have the option of either clicking on fields or using a keyboard shortcut?
8.12	Does the system offer "find next" and "find previous" shortcuts for database searches?
8.13	On data entry screens, do users have the option of either clicking directly on a field or using a keyboard shortcut?
8.14	On menus, do users have the option of either clicking directly on a menu item or using a keyboard shortcut?
8.15	In dialog boxes, do users have the option of either clicking directly on a dialog box option or using a keyboard shortcut?
8.16	Can expert users bypass nested dialog boxes with either type-ahead, user-defined macros, or keyboard shortcuts?

9. Aesthetic and Minimalist Design

Dialogues should not contain information which is irrelevant or rarely needed.

Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

#	Review Checklist
9.1	Is only (and all) information essential to decision making displayed on the screen?
9.2	Are all icons in a set visually and conceptually distinct?
9.3	Have large objects, bold lines, and simple areas been used to distinguish icons?

9.4	Does each icon stand out from its background?
9.5	If the system uses a standard GUI interface where menu sequence has already been specified, do menus adhere to the specification whenever possible?
9.6	Are meaningful groups of items separated by white space?
9.7	Does each data entry screen have a short, simple, clear, distinctive title?
9.8	Are field labels brief, familiar, and descriptive?
9.9	Are prompts expressed in the affirmative, and do they use the active voice?
9.10	Is each lower-level menu choice associated with only one higher level menu?
9.11	Are menu titles brief, yet long enough to communicate?
9.12	Are there pop-up or pull-down menus within data entry fields that have many, but well-defined, entry options?

10. Help and Documentation

Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

#	Review Checklist
10.1	If users are working from hard copy, are the parts of the hard copy that go on-line marked?
10.2	Are on-line instructions visually distinct?
10.3	Do the instructions follow the sequence of user actions?
10.4	If menu choices are ambiguous, does the system provide additional explanatory information when an item is selected?
10.5	Are data entry screens and dialog boxes supported by navigation and completion instructions?
10.6	If menu items are ambiguous, does the system provide additional explanatory information when an item is selected?
10.7	Are there memory aids for commands, either through on-line quick reference or prompting?
10.8	Is the help function visible; for example, a key labeled HELP or a special menu?
10.9	Is the help system interface (navigation, presentation, and conversation) consistent with the navigation, presentation, and conversation interfaces of the application it supports?
10.10	Navigation: Is information easy to find?
10.11	Presentation: Is the visual layout well designed?
10.12	Conversation: Is the information accurate, complete, and understandable?
10.13	Is the information relevant?
10.14	Goal-oriented (What can I do with this program?)
10.15	Descriptive (What is this thing for?)
10.16	Procedural (How do I do this task?)
10.17	Interpretive (Why did that happen?)

10.18	Navigational (Where am I?)
10.19	Is there context-sensitive help?
10.20	Can the user change the level of detail available?
10.21	Can users easily switch between help and their work?
10.22	Is it easy to access and return from the help system?
10.23	Can users resume work where they left off after accessing help?

11. Skills

The system should support, extend, supplement, or enhance the user's skills, background knowledge, and expertise -- not replace them.

#	Review Checklist
11.1	Can users choose between iconic and text display of information?
11.2	Are window operations easy to learn and use?
11.3	If users are experts, usage is frequent, or the system has a slow response time, are there fewer screens (more information per screen)?
11.4	If users are novices, usage is infrequent, or the system has a fast response time, are there more screens (less information per screen)?
11.5	Does the system automatically color-code items, with little or no user effort?
11.6	If the system supports both novice and expert users, are multiple levels of detail available.
11.7	Are users the initiators of actions rather than the responders?
11.8	Does the system perform data translations for users?
11.9	Do field values avoid mixing alpha and numeric characters whenever possible?
11.10	If the system has deep (multilevel) menus, do users have the option of typing ahead?
11.12	When the user enters a screen or dialog box, is the cursor already positioned in the field users are most likely to need?
11.13	Can users move forward and backward within a field?
11.14	Is the method for moving the cursor to the next or previous field both simple and visible?
11.15	Has auto-tabbing been avoided except when fields have fixed lengths or users are experienced?
11.16	Do the selected input device(s) match user capabilities?
11.17	Are cursor keys arranged in either an inverted T (best for experts) or a cross configuration (best for novices)?
11.18	Are important keys (for example, <u>ENTER</u> , <u>TAB</u>) larger than other keys?
11.19	Are there enough function keys to support functionality, but not so many that scanning and finding are difficult?
11.20	Are function keys reserved for generic, high-frequency, important functions?
11.21	Are function key assignments consistent across screens, subsystems, and related products?
11.22	Does the system correctly anticipate and prompt for the user's probable next activity?

12. Pleasurable and Respectful Interaction with the User

The user's interactions with the system should enhance the quality of her or his work-life. The user should be treated with respect. The design should be aesthetically pleasing with artistic as well as functional value.

#	Review Checklist
12.1	Is each individual icon a harmonious member of a family of icons?
12.2	Has excessive detail in icon design been avoided?
12.3	Has color been used with discretion?
12.4	Has the amount of required window housekeeping been kept to a minimum?
12.5	If users are working from hard copy, does the screen layout match the paper form?
12.6	Has color been used specifically to draw attention, communicate organization, indicate status changes, and establish relationships?
12.7	Can users turn off automatic color coding if necessary?
12.8	Are typing requirements minimal for question and answer interfaces?
12.9	Do the selected input device(s) match environmental constraints?
12.13	If the system uses multiple input devices, has hand and eye movement between input devices been minimized?
12.14	If the system supports graphical tasks, has an alternative pointing device been provided?
12.15	Is the numeric keypad located to the right of the alpha key area?
12.16	Are the most frequently used function keys in the most accessible positions?
12.17	Does the system complete unambiguous partial input on a data entry field?

13. Privacy

The system should help the user to protect personal or private information belonging to the user or his/her clients.

#	Review Checklist
13.1	Are protected areas completely inaccessible?
13.2	Can protected or confidential areas be accessed with certain passwords?
13.3	Is this feature effective and successful?

Appendix B. Summary of Military Guidance Documents

The following information summarizes the findings of the review of military guidance. The first bullet for each document describes its relationship with web site development, maintenance, and use. The remaining bullets identify specific the usability heuristic and Section 508 references contained within each document. Reference paragraphs are provided where applicable.

Air Force Guidance

Air Force Instruction 33-117
Multimedia (MM) Management
1 April 2004

- Directly applicable to multimedia productions, including those developed for web site use, by military MM functions.
- General Section 508 compliance statement(s)
Reference paragraphs(s): 1.1

Air Force Instruction 33-129
Web Management and Internet Use
3 February 2005

- Directly applicable to web site design, maintenance, and use
- General Section 508 compliance statement(s)
Reference paragraph(s): 3.5.1, 3.9.1.3, 3.12.8, 3.14.1, 3.14.8
- Consistency and standards
Reference paragraphs(s): 3.13.1
- Pleasurable and respectful interaction with the user
Reference paragraphs(s): 6
- Aesthetic and minimalist design
Reference paragraphs(s): 6

- Privacy
Reference paragraphs(s): Paragraphs 3.9.1.3, 3.12.8, 3.12.1, 3.13.1, 3.15.3, 5.1.2, 7.1.4.9, 7.2, 12.1.1, 12.2, 12.6
- Note: references IEEE Standard 2001 as an additional information source, but does not mandate compliance with the principles contained within that document.

Air Force Instruction 33-219

Telecommunications Monitoring and Assessment Program

23 May 2002

- Does not specifically address web site development, maintenance, or use but is applicable to web sites because they are a form of telecommunications that fall under the scope of the program established by this document. At minimum, it is an additional mandatory reference.
- Privacy
Reference paragraphs(s): 21.8, A3.3.6

Air Force Instruction 33-332

Privacy Act Program

29 January 2004

- Contains multiple comments directed specifically at web site development, maintenance, and use.
- Privacy
Reference paragraphs(s): 12.8, 12.8.1, 12.8.2, 12.8.3

Air Force Instruction 35-101

Public Affairs Policies and Procedures

29 November 2005*

- Directly applicable to web site design, maintenance, and use. Provides guidance for both public and private web sites but only those paragraphs applicable to private web sites are evaluated for this study

* Previous version not available for review.

- Privacy
Reference paragraphs(s): 18.5.3, 18.8.1.3, 10.10
- Section 508 §1194.22(a)
Reference paragraphs(s): 18.7.1.1, 18.7.1.7
- Section 508 §1194.22(b)
Reference paragraphs(s): 18.7.1.2, 18.7.1.8
- Section 508 §1194.22(c)
Reference paragraphs(s): 18.7.1.3
- Section 508 §1194.22(d)
Reference paragraphs(s): 18.7.1.4
- Section 508 §1194.22(e)
Reference paragraphs(s): 18.7.1.5
- Section 508 §1194.22(g)
Reference paragraphs(s): 18.7.1.6

Air Force Manual 33-326

Preparing Official Communications

1 November 1999

- Does not specifically address web site development, maintenance, or use but could be construed as applicable to web sites that function as a form of official communication. At minimum, it is an additional mandatory reference.
- Match between the system and the real world
Reference paragraphs(s): 1.2

Air Force Manual 37-104

Managing Information to Support the Air Force Mission

1 June 1995

- Does not specifically address web site development, maintenance, or use but is applicable to web sites because they are a form of information management. At minimum, it is an additional mandatory reference.
- Privacy
Reference paragraphs(s): 4.1, 4.2

Air Force Policy Directive 37-1
Information Management
19 November 1993

- Does not specifically address web site development, maintenance, or use but could be construed as applicable to web sites that function as a form of official communication. At minimum, it is an additional mandatory reference.
- Privacy
Reference paragraph(s): 2.6

Air Force Supplement to Department of Defense Regulation 5400.7
DoD Freedom of Information Act Program
24 June 2002

- Contains one comment directed specifically at web site development, maintenance, and use.
- Privacy
Reference paragraph(s): C3.2.1.6

Air Force Content Publishing Guide for Publishing Center v 1.1
April 2004

- Addresses web site design and maintenance for sites associated with the Air Force Portal. Publication is available for other uses, but compliance with it is not mandatory for those uses.
- Guide discusses general requirements for content provided by Portal web sites, but overall themes include:
 - Visibility of System Status
 - Match between system and the real world
 - User control and freedom
 - Consistency and standards
 - Recognition rather than recall
 - Flexibility and efficiency of use
 - Aesthetic and minimalist design
- Guide discusses specific requirement to meet Section 508 standards and explicitly provides general guidance for the following Section 508 1194.22 standards:
 - Section 508 §1194.22(a)
 - Section 508 §1194.22(b)

- Section 508 §1194.22(f)
- Section 508 §1194.22(h)
- Section 508 §1194.22(i)
- Section 508 §1194.22(l)

Air Force Portal Style Guide v 2.0
October 2003

- Addresses web site design and maintenance for sites associated with the Air Force Portal. Publication is available for other uses, but compliance with it is not mandatory for those uses.
- Guide discusses specific requirements for Portal web sites, but overall themes include:
 - Visibility of system status
 - Consistency and standards
 - Recognition rather than recall
 - Pleasurable and respectful interaction with the user

Department of Defense Guidance

Department of Defense Directive Number 8000.1
Management of DoD Information Resources and Information Technology
27 February 2002

- Does not specifically address web site development, maintenance, or use but is applicable to web sites because they are a form of Information Resources and Information Technology to which this directive is applicable. At minimum, it is an additional mandatory reference.
- General Section 508 compliance statement(s)
Reference paragraph(s): 4.4.3, 4.10

Office of the Assistant Secretary of Defense
Web Site Administration Policies & Procedures
November 25, 1998 (latest corrections from 11 January, 2002)

- Directly applicable to web site design, maintenance, and use although focused more on web site content than on site design.
- Privacy
Reference paragraph(s): Part I 4.2, 4.4, 5.5.4, 5.5.10; Part II 3.6, 11.1, 12.3

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Vita

Captain Richard S. Bentley graduated from Gordon Lee High School in Chickamauga, Georgia. After three years on active duty as a vehicle operator, he entered Valdosta State University in Valdosta, Georgia under the Scholarships for Outstanding Airman to ROTC program. Captain Bentley earned a Bachelor of Business Administration degree in Management and received his commission through AFROTC Detachment 172 at Valdosta State.

His first assignment as a commissioned officer was at Charleston AFB in the 437th Communications Squadron. Since that time, Captain Bentley has served in a variety of roles including communications maintenance flight commander at Charleston and chief of computer operations, chief of space weather communications, and chief of network operations and security at the Air Force Weather Agency, Offutt AFB. While stationed at Offutt AFB, he spent four months deployed to Qatar with US Central Command Forward Headquarters supporting Operation Enduring Freedom and Operation Iraqi Freedom. Upon graduation from the Air Force Institute of Technology, he will be assigned to Headquarters Air Force Space Command.

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14. ABSTRACT The Air Force is moving to a network centric environment where information must be data visible, accessible, and understandable. This transformation has seen the adoption of the Internet web browser as a de facto standard for information access. The Technology Acceptance Model suggests that information systems must not only be useful but also be usable and a large body of usability engineering knowledge exists to support usable design. In addition, the U.S. government mandates specific minimum design features required to support disabled user access. This research effort seeks to establish an understanding of how well common practice usability design principles and government mandated accessibility guidelines are followed by Air Force intranet web sites. Heuristic evaluation is used to investigate web site usability. Accessibility is inspected against government guidelines. The results of this study suggest that Air Force intranet web sites do not adequately comply with many usability principles and that accessibility compliance varies from site to site. Furthermore, although the majority of usability and accessibility design principles are not captured in military guidance, scores were higher for those principles that are captured in the guidance than for those that are not.						
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