USABLE DESIGN OF CIVIL ENGINEER INFORMATION SYSTEMS

THESIS

GUNTHER KASTENHOLZ, Captain, USAF

AFIT/GEM/ENV/05M-07

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GEM/ENV/05M-07

USABLE DESIGN OF CIVIL ENGINEER INFORMATION SYSTEMS

THESIS

Presented to the Faculty

Department of Systems and Engineering Management

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Engineering Management

Gunther Kastenholz, BS

Captain, USAF

March 2005

AFIT/GEM/ENV/05M-07

USABLE DESIGN OF CIVIL ENGINEER INFORMATION SYSTEMS

Gunther Kastenholz, BS
Captain, USAF

Approved:

/signed/	16 March 2005
Dr. Alfred E. Thal, Jr., Ph.D., (Chairman)	date
/signed/	16 March 2005
Dr. Kevin L. Elder, Ph.D., (Member)	date
/signed/	16 March 2005
Kent C. Halverson, Maj, USAF, (Member)	date

AFIT/GEM/ENV/05M-07

Abstract

Air Force Civil Engineer information systems are subject to the same issues plaguing civilian information systems. Maximized return on information system investments is not realized due to low technology acceptance by end users. Contributing to acceptance is ease of use, and one way to raise acceptance of information systems is to increase their usability. It was proposed that low usability of these information systems resulted from non- or partial-specification of usability engineering principles in the design of Civil Engineer information systems.

A case study methodology was used in accomplishing this research. A literature review verified that usability engineering principles were, indeed, non- or partially-specified by Air Force regulations and guidance. An information system representative of other Civil Engineer information systems was inspected using the heuristic usability inspection method. The results of this inspection showed the representative system to be highly usable from the perspective of usability engineering principles specified by regulations and guidance but low in usability in all other usability engineering principles. The results of the heuristic inspection method were used to provide recommendations for improving the usability of Air Force Civil Engineer information systems in order to maximize the acceptance of these systems by end users.

Acknowledgements

Thanks be to God for helping me in ways for which I am grateful, but have yet to understand.

I would like to express my gratitude to my wife, who painstakingly endured my efforts at completing this thesis. I have asked a lot of her in the first year of our marriage, and the least I can do is mention and thank her for her patience here. My parents were always there for me as well, providing understanding and support whenever I needed them.

I also extend my gratitude to my thesis advisor and my thesis committee for providing me with the tools and guidance I needed in order to learn how to be a researcher.

Thanks go to the people at the Civil Engineer and Services School who were fast-acting and instrumental in my data collection efforts, as well as the personnel from the Air Force Civil Engineer Support Agency Technology Integration Division that pointed me in the right direction for research documents.

Thank you, Graduate in Information Resources Class 05M, for welcoming a ragged CE guy such as myself into your family. A final thanks goes to those at my previous assignment, the 5th Civil Engineer Squadron Readiness Flight, who I could always turn to for enlightening advice as well as the latest news (gossip) from the CE Readiness community.

Gunther Kastenholz

Table of Contents

Page

Page

Page

List of Figures

List of Tables

Page

USABLE DESIGN OF CIVIL ENGINEER INFORMATION SYSTEMS

I. Introduction

In today's technology-dependent business world, information system design is no longer just a means toward generating modern and effective decision aids, but a process of organizational improvement. Information systems have become so integrated into business operations that the effective design of efficient systems has become critical to maintaining a high tempo of everyday processes. Often these systems are designed with functional features in mind, yet, as important as these functional features are, there are other factors that contribute to the effectiveness of information systems. System developers and program managers must realize that the success of information systems lies not simply in function, but in the end users' ability to easily use these features. This research intends to qualify the importance of usability in information system design.

Background

A good information system is only effective if usable by people. If people cannot use the system to gather information to aid in decision-making, then the information system is irrelevant. Even if users *can* use a system, a much greater challenge is making users *want* to use a system. An entire field of research, called technology acceptance, is dedicated to this subject. In addition, another field of research, usability engineering, is dedicated to maximizing one of the main factors contributing to technology acceptance:

ease of use. Finally, a product is only as good as its design, and designs are governed by standards. This research will explore the role of standards in governing usability towards an end of maximizing technology acceptance.

Technology Acceptance

Technology acceptance is the search "to better understand why people accept or reject computers" (Davis et al., 1989:1). This field of research grew from the realization that large amounts of time and money were being spent on information systems that ultimately went unused by the intended end users. Such significant investments yielding minimal returns necessitated research into the reasons why information systems were failing (Venkatesh et al., 2003).

"Understanding and creating the conditions under which information systems will be embraced by the human organization" (Venkatesh and Davis, 2000:186) is one way of describing the goal behind the study of technology acceptance. In other words, the study of technology acceptance seeks to develop a better understanding of what it takes to encourage potential users to accept (i.e., use) information systems. By understanding what motivates users, system developers and program managers can create information system designs that cater to the factors that encourage or otherwise bolster technology acceptance. Organizations benefit from this because their technology investments do not go to waste as the result of non-usage.

Of the various technology acceptance theories available in the literature, the Technology Acceptance Model (TAM) and its derivates are some of the most researched and validated models (Venkatesh and Davis, 2000). The TAM model suggests that the acceptance of technology is based on four main elements: behavioral intentions toward the technology, attitudes toward the technology, perceived usefulness of the technology, and perceived ease of use of the technology (Davis et al., 1989). Validating studies vary in their assessments of the influences of these elements on technology acceptance, but one thing is constant: perceived ease of use has been consistently cited as a significant influence on technology acceptance (Davis et al., 1989; Venkatesh and Davis, 2000; Venkatesh et al., 2002; Venkatesh et al., 2003).

Before proceeding any further, it is important to realize the differences and similarities between the terms "ease of use" and "usability," as well as clarify how these terms will be used in the context of this research. Perceived ease of use has been established as a key factor in user acceptance of information technology. It is a measure of the user's perception that using a technology will be free from effort (Davis et al., 1989). The purveyor of this definition, Fred Davis, has been quoted defining usability as having "'…subsumed two constructs – usefulness and ease of use'" (Garcia, 2005:1). Although Davis' definition of usability includes ease of use and usefulness combined, in practice "…usability testing focuses primarily on a system's ease of use" (Davis and Venkatesh, 2004:1). As will be clarified in the following chapters, the nature of this research is not concerned with usefulness, rather the goal involves examining ease of use. Because of the nature of this research, and because of the focus of usability engineering on ease of use, it is justified, in the context of this research, to use the terms "usability" and "ease of use" interchangeably. With this in mind, the concept of usability from the perspective of usability engineering experts will be described.

Usability

Usability, as defined by Merriam Webster's Collegiate Dictionary (1994:1301), is the state of being "convenient and practicable for use." In terms of information systems, Hoffer (2002) describes three key characteristics of usability: speed, accuracy, and satisfaction. In other words, how quickly and accurately users can manipulate the system, and how satisfied they are with the output, define the usability of a system. Furthermore, Nielsen (Useit.com, 2003) breaks usability down into five characteristics: learnability, efficiency, memorability, errors, and satisfaction.

The manifestations of these characteristics can be measured with various techniques. One of these techniques is the heuristic inspection method, which will be used in this research for its ability to provide useful results with a simple, economical, and efficient procedure (Nielsen, 1994). Heuristics usability inspections involve the assessment of the system in question with principles accepted as characteristics of highly usable systems. The following ten principles form the backbone of a heuristics inspection: visibility of system status; match between the system and real world; user control and freedom; consistency and standards; error prevention; recognition rather than recall; flexibility and efficiency of use; aesthetic and minimalist design; ability to help users recognize, diagnose, and recover from errors; and system help and documentation (Nielsen, 1994).

An important thing to note is that Nielsen (1994) states that for intranet systems, which are mandated by organizational policy, user satisfaction is not as critical since employees have no other choice of systems. Since users are forced to use the system, design efforts are typically directed toward reducing errors and increasing efficiency and memorability instead of improving customer satisfaction (Nielsen, 1994). This may be true if user satisfaction is viewed as a unidirectional determinant of usability. The TAM suggests that user satisfaction cannot be ignored when roles are reversed. Usability is viewed as a factor in contributing to user attitudes, which contribute to behavioral intention to use, which ultimately leads to technology use. Thus, the full spectrum of usability characteristics should be addressed in the design process (Davis et al., 1989).

Both private and public sector organizations struggle with the balance between customer (i.e., external) and user (i.e., internal) satisfaction. This is particularly true in the Air Force, where information technology is often viewed from a mandatory use perspective and thus minimally addresses the satisfaction characteristic associated with usable systems. In addition, current Air Force standards mainly address the consistency and standards principle of usability. This is reflected in the system engineering process typical of most Civil Engineer information systems. To gain a better appreciation for design of information technology systems in the Air Force, it is useful to briefly review the existing standards.

Existing Air Force Standards

The review of existing standards involved searching through four frameworks of information system design that have been applicable to Civil Engineer information system design in recent years. One of the most recent frameworks, the Global Combat Support System, was found to focus more on integration of various combat support information systems and less on design standardization. A superseded framework, the Technical Architecture Framework for Information Management (TAFIM), was found to contain an individual volume, the Human-Computer Interface Style Guide (or simply, "Style Guide"), that was, at one time, applicable to standardization of design, and more specifically, applicable to the design of the information system used in the methodology of this research. Finally, two evolutions of frameworks, the Joint Technical Architecture (JTA) and Department of Defense (DoD) Information Technology Standards Registry (DISR), were found to be readily applicable as standards for current information system design efforts. Of these frameworks, the latter three were found to be relevant to this research and were scoured to make assessments about the extent of usability engineering principles that are specified in the design of Civil Engineer information systems.

The GCSS was developed with the overall purpose of integrating stove-piped DoD information systems such that they can be accessed by any authorized user in any location using commonly available equipment (DISA, 2005). With such a purpose in mind, it came as no surprise that the GCSS displayed a focus on integration and not on design regulations and guidance geared toward standardization. Therefore, the researcher decided that the GCSS framework was not applicable in the context of this research, since its design focus was centered on the interfaces between information systems rather than the interfaces between information systems and end users.

A review of the TAFIM Style Guide showed that this document specified primarily human-computer interface features. The recommendations in the TAFIM Style Guide are mainly directed toward ensuring consistency of design features across all information system elements. Some examples of information system elements addressed include keyboard layout, screen design, and menu appearance. The main point to realize here is that the TAFIM Style Guide was intended to maximize ease of use by minimizing the diversity of human-computer interface methods.

A review of the JTA and DISR revealed a lack of standards for usability engineering in DoD information systems. Explicit human-computer interface standards, similar to those specified in the TAFIM Style Guide, are listed for weapon system HCI and nuclear system HCI; however, no standards were found for information systems in general (Disronline.disa.mil, 2004).

The review of standards is further qualified in Chapter 2 of this research. Based on review of the four frameworks mentioned above, it was proposed that a gap could be visualized between current standards and an optimal usability standard. In the context of this research, an optimal usability standard would be written in such a manner that each of the characteristics of highly usable systems (learnability, efficiency, memorability, free from errors, and satisfaction) are maximized by addressing the ten usability principles (visibility of system status; match between the system and real world; user control and freedom; consistency and standards; error prevention; recognition rather than recall; flexibility and efficiency of use; aesthetic and minimalist design; ability to help users recognize, diagnose, and recover from errors; and system help and documentation) (Nielsen, 1994). The researcher found that applicable design standards addressing usability engineering are either non-existent or those that do exist address mainly the consistency and standards principle of usability engineering. It is this observation that led to the proposition that a gap exists between current standards and an ideal standard.

Problem Statement

Usability is a key requirement of information systems (Nielsen, 1994 and 2000). It leads to positive user attitudes, which ultimately lead to acceptance and use of information systems (Davis et al., 1989). Standards applicable to the design of Civil Engineer information systems focus on only one of the ten usability engineering principles, consistency and standards. Based on the fact that nine usability engineering principles are not required by Air Force regulation and guidance, the researcher proposes that usability of Civil Engineer information systems is not optimal. The propositions of this research are formally stated below:

1. Usability in Civil Engineer information systems is not optimal.
2. Non-optimal usability in Civil Engineer information systems can be linked to non-specification of usability engineering principles in Civil Engineer information system regulations and guidance.

While propositions serve to outline the background of a given study, research questions provide the level of detail necessary to actually implement the research methodology in order to validate the propositions.

Research Questions

To address the propositions serving as the problem statement of this research, questions must be posed that can be answered by the execution of a methodology. As related to this research, the questions are:

1. How do current standards related to the design of Civil Engineer information systems specify usability engineering principles?

2. How are gaps in existing Civil Engineer information system design standards qualified upon observation of Civil Engineer information systems through proven and accepted usability inspection methods?

3. How can improvements to usability be made as a result of any findings yielded by the usability inspection of a Civil Engineer information system?

The research questions clarify the goals that will be achieved through execution of the methodology. On overview of the methodology of this research is provided in the next section.

Methodology

The researcher considered various research methods as possible ways to answer the research questions. The methods considered were naturalistic observation, the case study method of observation, correlational research, differential methods, and experimental methods. For reasons detailed in Chapter 3 of this research, the case study research method was chosen.

As part of the case study methodology, a literature review was conducted to answer the first research question. In order to answer the remaining research questions, the methodology had to be further characterized by choosing a case study type. A holistic, single-case study type was chosen for reasons outlined in Chapter 3. In this type of case study, there is a single unit of analysis that does not have any subtypes or embedded units. The unit of analysis is then observed in order to witness any behaviors that might answer the research questions. The unit of analysis had to be carefully selected such that it would provide the opportunity to observe any effects of the non-optimal usability standards stated in the research propositions. The unit of analysis chosen was the Automated Civil Engineer System Personnel Readiness (ACES-PR) module, since it is an information system representative of other Civil Engineer information systems and has shown evidence of usability problems in the past. Equally as relevant as the unit of analysis is the method of observation. The case study instrument used in this research was the heuristic usability inspection method (Nielsen, 1994) as embodied by the checklist created by Pierotti (2002). Using the heuristic inspection method on a suitable unit of analysis allowed for the second and third research questions to be answered.

Assumptions and Limitations

One very significant assumption made in this research is that Civil Engineer information systems are subject to a global set of design standards, and that the design process of Civil Engineer information systems adhered to these standards. This assumption is important since one Civil Engineer information system was chosen as representative of other Civil Engineer information systems in order to execute the methodology and draw conclusions about Civil Engineer information system regulations and guidance documents.

Another significant limitation of this research is that the number of usability inspection methods available for this study is limited by the manpower available to perform the inspections. Some of the available methods require teams of several people to accomplish the required interviews, evaluations, and review of thousands of lines of programming code. Various time, manpower, funding, and equipment constraints make heuristic evaluation the favorable method of assessing usability.

The technology acceptance and usability engineering fields are constantly and rapidly evolving. Although recent research (Venkatesh et al., 2003) claims to be near the full capacity of understanding technology acceptance, much work is left to be done. As a result, this research will provide a point-in-time analysis, and future research will be necessary to periodically revalidate the roles of technology acceptance and usability engineering in the ACES-PR system engineering process.

Organization/Purpose of Remaining Chapters

Having generally outlined the purpose, background, and methodology of this research, a brief synopsis should be given of what remains to be discussed in the following chapters. The second chapter presents a more detailed review of the research scenario and the relevant literature. The specifics of TAM, usability engineering, and the link between the two; current DoD standards; the ACES-PR system engineering process; and the background documentation supporting the methodology used in this research are discussed. Chapter 3 will specify the details of the methodology for accomplishing this research. More specifically, heuristic inspection methods will be discussed in detail. The fourth chapter is intended to summarize the results of executing the methodology, with a focus on interpretation of the findings. Finally, Chapter 5 provides the research's conclusions and identifies areas for future research.

II. Literature Review

This chapter provides an overview of the literature pertinent to this research. The field of technology acceptance will be explored by reviewing the most prevalent and widely-recognized technology acceptance models. This will lead to an in-depth discussion of usability engineering. After reviewing the literature, the current Air Force standards related to usability will be discussed; this will include how usability can be measured and inspected. Since the Automated Civil Engineer System Personnel Readiness (ACES-PR) module will be used as the unit of analysis for the methodology of this research, a brief background of the system will be provided.

Behavioral Models

Organizations have recognized the importance of information technology (IT) and have dramatically increased IT investments (Venkatesh et al., 2003). However, performance gains resulting from such investments have been low, which Davis et al. (1989) attribute to users' non-acceptance of IT systems. To develop a better understanding of this phenomenon, researchers have developed numerous scientific models. Of the models discussed below, the Technology Acceptance Model is the most appropriate one for this research and will be explored in more detail.

Theory of Reasoned Action (TRA)

The basic tenets of the TRA are a person's attitude toward a target behavior and the concept of subjective norm. The TRA maintains that a person's positive or negative feelings about a behavior determine their likelihood to perform the behavior. In addition, this likelihood is affected by their perception of the subjective norm – whether or not people important to the person think the person should perform the behavior (Venkatesh et al., 2003).

Motivational Model

The motivational model is based on the concept of what motivates people to perform a given activity. It qualifies motivation in two forms, extrinsic and intrinsic. Extrinsic motivation is the idea that people are enticed to perform a particular activity by something other than the activity itself. Intrinsic motivation is the idea that people are motivated by the activity itself. An example of an extrinsically motivated behavior is increased performance at work as the result of a pay raise, whereas an intrinsically motivated worker needs no pay raise because his motivation derives from the work itself (Venkatesh et al., 2003).

Technology Acceptance Model (TAM) Overview

The TAM asserts that technology usage is determined by two major factors: perceived usefulness and perceived ease of use. Perceived usefulness describes a person's perception that a given technology will increase the person's job performance. Perceived ease of use describes a person's perception that a technology will be free from effort. Both of these factors have been widely validated as having a positive correlation with technology usage (Venkatesh et al., 2003).

Theory of Planned Behavior (TPB)

The TPB is an extension of the TRA. It adapts the factors of TRA but includes one more, perceived behavioral control. The TPB holds that, in addition to a person's attitude and perception of the subjective norm, the person's perception of the ease or difficulty of an activity also determines their likelihood to perform the activity (Venkatesh et al., 2003).

Combined TAM and TPB

The Combined TAM and TPB model is exactly that, a combination of the factors from the TAM and TPB to model a person's behavior toward technology. Thus, attitude, subjective norm, perceived usefulness, and perceived ease of use are all determinants of behavior toward technology in this model (Venkatesh et al., 2003).

Model of PC Utilization

This model predicts that six factors contribute toward a person's usage of technology: job-fit, complexity, long-term consequences, affect towards use, social factors, and facilitating conditions. Job-fit describes a person's perception that a given technology will enhance job performance. Complexity is the technology's perceived level of difficulty in being understood. Long term consequences describes the perception that a technology will pay off in the long term. Affect toward use is the concept of feeling human emotion toward a technology. Social factors are those cultural and interpersonal internalizations that the person has made in regard to the technology.

Facilitating conditions are those objective environmental factors that contribute to a system's actual, and not simply perceived, ease of use (Venkatesh et al., 2003).

Innovation Diffusion Theory

Innovation diffusion theory, geared toward acceptance of new technology, involves seven factors: relative advantage, ease of use, image, visibility, compatibility, results demonstrability, and voluntariness of use. Relative advantage is achieved if a person perceives a new technology as better than its predecessor. Ease of use describes the perception that a technology's use will be free from effort. The image factor is the perception that a technology will increase a person's status in a social system. A technology has visibility if people can visually perceive other people in their organization using the technology. Compatibility is the perception that a given technology is consistent with a person's existing values, needs, and past experiences. Results demonstrability is the degree to which the person can tangibly observe the outcomes of the technology. Voluntariness of use is the concept describing a person's perception that a technology's use is on terms of the person's own free will (Venkatesh et al., 2003).

Social Cognitive Theory (SCT)

The SCT is a theory of human behavior based on performance outcome expectations, personal outcome expectations, self efficacy, affect, and anxiety. In regards to technology, performance outcome expectations are those expectations people have about an activity that is related to their performance at a job. Personal outcome expectations are those expectations people have about an activity that is related to their individual self esteem or sense of accomplishment. In the context of technology, self efficacy is the perception a person has about his or her own ability to use the technology to accomplish their job. Affect describe's a person's like or dislike of a given activity. Anxiety is a concept describing the degree to which a person experiences emotional reactions toward an activity (Venkatesh et al., 2003).

Technology Acceptance Model Detailed Perspective

Although all of the models seek to explain important factors related to user acceptance of information technology, the TAM was found to be most relevant to this research since it has been widely validated in terms of information technology. Many of the other models were derived in response to needs in the fields of sociology or psychology, and validated in those contexts. The rest of this section is dedicated to further explaining the concepts that form the TAM.

The TAM maintains that performance gains for the organization will not be realized if employees do not make use of the purchased IT. However, for the IT systems to be used, the systems must first be accepted by the users on a behavioral level (Davis et al., 1989). Given an ideal situation where a system is in the early stages of the design process, discovering and understanding the factors that contribute to user acceptance can help system developers create more effective IT systems. Alternately, if a system is already deployed, understanding user acceptance factors can lead to better redesign efforts in future versions of the system. Two major user acceptance factors, perceived usefulness and perceived ease of use, were identified in the beginning of the TAM research (Davis et al., 1989) and have consistently been included in many prominent studies validating the TAM (e.g., Adams et al., 1992; Hendrickson et al., 1993; Szajna, 1994; Agarwal and Prasad, 1999; Malhotra and Galetta, 1999; Venkatesh and Davis, 2000; Venkatesh et al., 2002; Venkatesh et al., 2003; McFarland and Hamilton, 2004; and Venkatesh and Davis, 2004). In these studies, perceived usefulness and perceived ease of use were found to have a significant positive correlation with technology acceptance (i.e., actual system use). Additionally, most of the listed studies accept the core factor relationships outlined by Davis et al. (1989) during the development of the TAM.

As shown in Figure 1, the original TAM model defines five core factors and their relationships contributing to technology acceptance. Perceived usefulness is a subjective factor describing the perception of a user that a particular IT system will increase job performance as a result of its use. Perceived ease of use is also a subjective factor; it describes the user's perception that using a particular IT system will be free from effort. Theses two factors are influenced by external variables, which include such things as "system design characteristics, user characteristics, nature of the development or implementation process, political influences, [and] organizational structure" (Davis et al., 1989:984). The interactions of these factors impact the user attitudes factor, which describes the positive or negative feelings a user has toward the technology. Finally, behavioral intention describes how strong a user's intentions are to actually use the system.

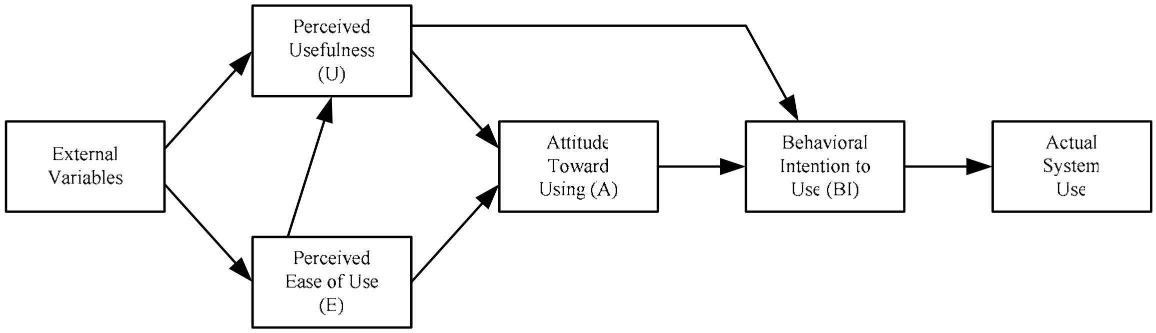

Figure 1. Technology Acceptance Model Relationships (Davis et al., 1989)

Included in the Davis et al. (1989) study was a validation of the interaction between the different factors in the TAM. Business administration master's degree students were surveyed on their usage of a word processing software package. The results verified that the proposed relationships shown in Figure 1 all had positive correlations. The two most significant factors affecting technology acceptance were found to be perceived usefulness and perceived ease of use. While usefulness was found to be significant, the intent of this research was not to suggest more features or functions that will make IT systems more useful. Therefore, usefulness issues are not addressed. Instead, this research focused on the ease of use factor. The corresponding field of study that seeks to maximize IT system ease of use is called usability engineering.

Usability Engineering

Usability can be defined in various ways. International Standards Organization (ISO) Standard 9241, Part 11 (1998:2), defines it as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use." Effectiveness is subsequently defined as the "accuracy and completeness with which users achieve specified goals" (ISO, 1998:2). Similarly, efficiency is defined as the "resources expended in relation to the accuracy and completeness with which users achieve goals" (ISO, 1998:2). Context of use is defined as the "users, tasks, equipment (hardware, software and materials), and the physical and social environments in which a product is used" (ISO, 1998:2). Finally, satisfaction is "the extent to which the user finds the use of the product acceptable" (ISO, 1998:2). Nielsen (Useit.com, 2003), often referred to as "the reigning guru of web usability" and "the world's leading expert on user-friendly design," defines usability in terms of five attributes: learnability, efficiency, memorability, errors, and satisfaction.

Learnability

The learnability attribute describes how quickly, given no previous exposure to it, users become proficient with an IT system. Beginner users can become expert users quickly in a system with high learnability (Useit.com, 2003). An example of a system with relatively high learnability is Microsoft Windows XP. The first time an individual uses a Windows XP computer, an easily understandable tour program is presented to introduce the new user to the system's features. When the tour is complete, a "tooltips" box appears whenever the computer mouse is dragged over icons appearing on the screen. This "tooltips" box tells the user the function of each icon. If a user has further questions, a product support feature called "Windows Help" allows plain text questions to be entered by the user; relatively clear and descriptive solutions are then provided by the system. Features such as the tour, tooltips, and a help database are not sufficient by themselves to consider Windows XP learnable; however, they are significant initial contributors to the learnability of the system.

Efficiency

An efficient IT system provides relevant output without requiring excessive input. Once a user has learned the system, an efficient system should operate in a manner requiring minimal inputs for desired outputs (Useit.com, 2003). One example of an efficient IT system can be found in the internet gaming community, Team Warfare League (Teamwarfare.com, 2004). Almost any feature the website has to offer can be reached within two to three clicks on hyperlinks. In this way, system users receive desired outputs with a minimal amount of inputs.

Memorability

The memorability attribute relates to how readily an infrequent user can return to the IT system after an extended period of non-use and remember how to use it. Systems with high memorability do not require extended re-learning periods for infrequent users (Useit.com, 2003). One way to increase memorability is to adopt standards in system design. For example, the icons used in the Microsoft Internet Explorer web browser (Figure 2) are similar to the icons used in the Linux operating system's Galeon web browser (Figure 3). Since these icons adhere to the industry standard, they are standardized, simple, and intuitive. This allows users to easily re-learn one operating system's browser even though another operating system might be used more often. In other words, an individual may use Microsoft Windows on a daily basis and the Linux operating system infrequently. When returning to the Linux Galeon web browser after an extended period of non-use, the individual is able to quickly re-learn how to use the Galeon browser.

Figure 2. Microsoft Internet Explorer Web Browser

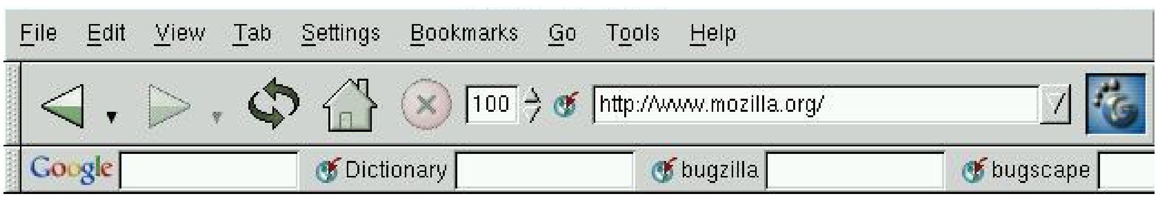

Figure 3. Linux Galeon Web Browser

Errors

An IT system with low errors is not prone to a high frequency or severity of errors. A low-error system is relatively free of bugs and is structured so that it does not lead a user toward committing an error (Useit.com, 2003). Microsoft Windows XP is much less prone to committing errors, and recovers from errors much better, than its previous versions. In these earlier versions, errors were frequent and often resulted in the “blue screen of death.” When this occurred, users were provided a rather cryptic message and two options, as shown in Figure 4. The attempt to continue usually failed and users were forced to restart their computers, thus losing unsaved work. Windows XP usually alerts users to the error that occurred and almost always allows them to continue, as shown in Figure 5. For this reason, earlier versions of Windows were considered less usable from an errors standpoint.

Satisfaction

User satisfaction describes how pleased users are with the operation of the IT system (Useit.com, 2003). As outlined in the TAM, positive user attitudes (i.e., satisfaction) contribute to technology acceptance (Davis et al., 1989). Users with negative attitudes toward an IT system will most likely not accept the system and may not use it. An example of this can be found in search engines. A study published by “PC Magazine” (Searchengineguide.com, 2004) showed that Google had the highest customer satisfaction, followed by the Yahoo and MSN search engines. This satisfaction is probably responsible for, or at least related to, usage statistics which show that Google leads in searches per day, again followed by Yahoo and MSN (1cog.com, 2004).

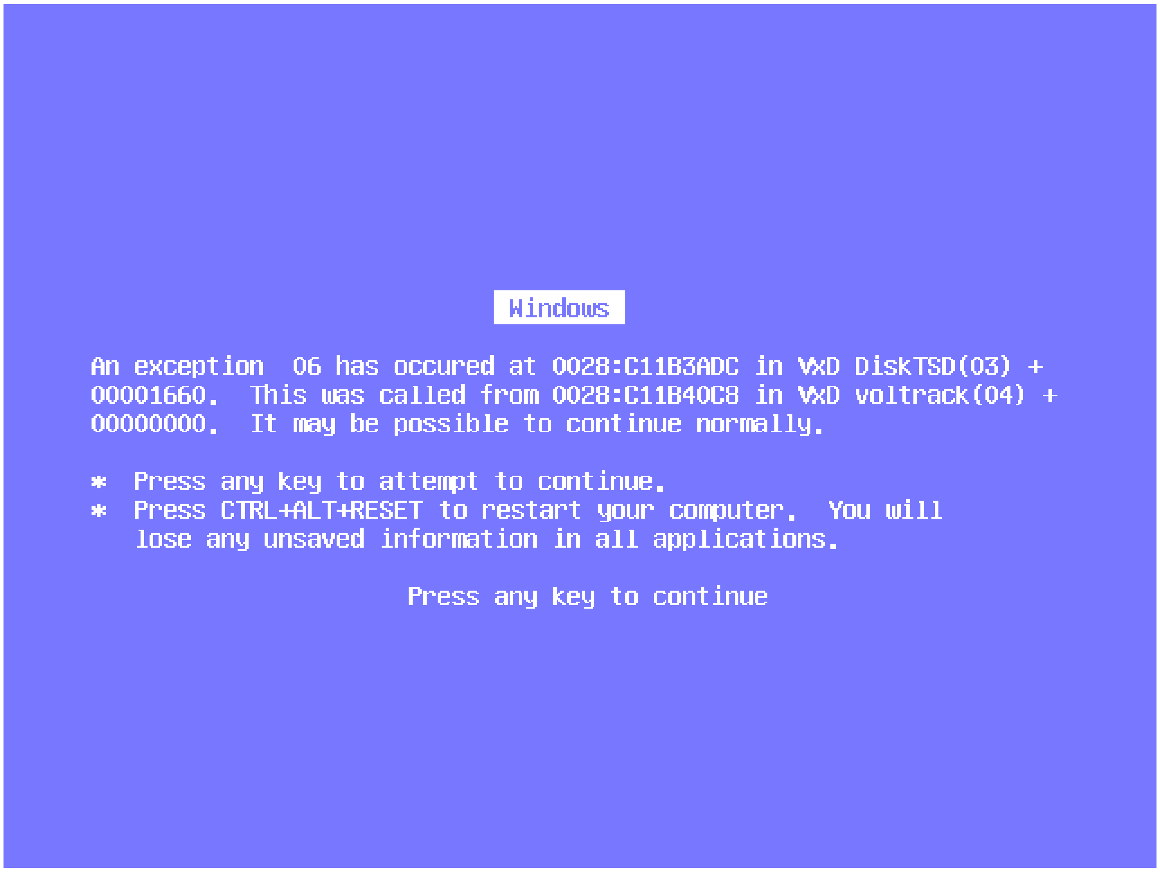

Figure 4. Early Microsoft Windows Error Screen

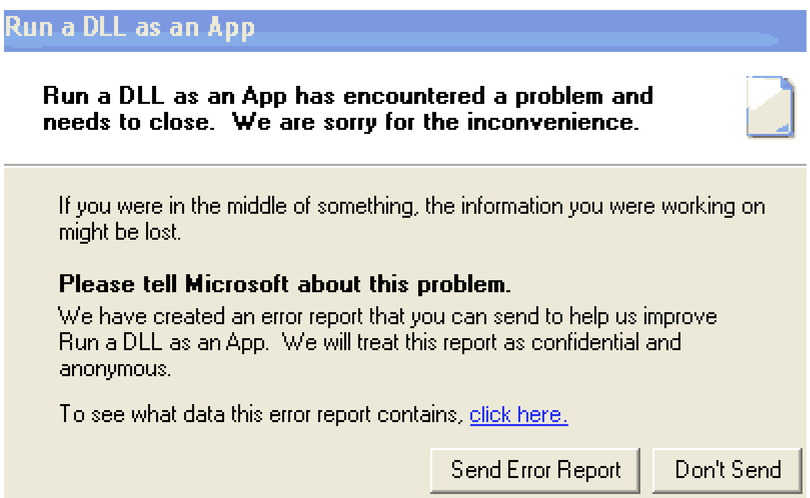

Figure 5. Windows XP Error Screen

Usability Inspection

Understanding the five attributes of usable systems is only one aspect of the usability engineering field. Another key aspect is usability inspection – the quantifiable assessment of how usable a system actually is. Many methods exist for usability inspection. Some of the more prevalent of these methods are guideline reviews, pluralistic and cognitive walkthroughs, consistency and standards inspections, formal usability inspections, feature inspections, and heuristic inspections. Of these, the most applicable to this research is the heuristic usability inspection method.

Heuristic Inspections

One reason the heuristic usability inspection method is most applicable to this research is because it is considered a "discount" usability inspection method, as referenced in the literature (Nielsen, 1994). Such a term is applied because the time, money, and resources required for performing this method are low compared to other methods (Nielsen, 1994). Given the exploratory nature of this research though, a heuristic method is considered ideal since the goal is to determine broad problem areas. More "detailed" methods can then be used to conduct more in-depth analysis in these areas.

Another reason for using a heuristic method is because Nielsen (Useit.com, 1994) found that a usability engineering intimidation barrier exists in most organizations. This barrier results from the perception that excessive amounts of funding, resources, and time are necessary for implementing usability inspection methods. For the findings and recommendations of this research to be accepted and integrated into the Air Force Civil

Engineer information system design process, it will be necessary to break through this intimidation barrier. A good way to accomplish this is through the use of usability engineering methods requiring minimal resources.

One factor in the intimidation barrier is the complexity of usability-related rules inherent in many traditional human-computer interface and usability design techniques. These techniques can often exceed a thousand rules and principles in their methods for evaluating usability. It is here that Nielsen (Useit.com, 1994) proposes the use of his ten usability principles (as outlined in the following sections) in place of the thousands of formal rules. The usability engineering stands a much better chance of being accepted by an organization if the task of ensuring usability does not seem as formidable.

Another factor is the cost associated with deluxe usability techniques. Typical cost estimates for ensuring usable designs using formal methods are on the order of $60,000 or more. Nielsen (Useit.com, 1994) provides evidence that good value usability engineering practices can cost six times less. When considered in relation to the hundreds of thousands of dollars spent on any given information system, heuristic usability engineering costs are minor.

Heuristic methods are also sometimes perceived as less effective. Nielsen (Useit.com, 1994) shows that the benefit to cost ratio of these methods are consistently higher than the ratio provided by many other methods. In addition, Nielsen shows that heuristic methods, while they may not find every single usability problem, are excellent for detecting the major usability issues in a given information system.

Finally, heuristic methods are an excellent means to open the door for future, more complex usability engineering techniques. Through Nielsen's experience

(Useit.com, 1994), he has learned that an evolutionary pattern exists for usability engineering in most organizations. Such an evolution is rooted in validated studies of organizational behavior (Useit.com, 1994) and involves starting in small steps. The small steps start with heuristic techniques, and each successive iteration convinces more organizational members of the usability engineering benefits. Gradually, the intimidation barrier is overcome and the organization fully integrates usability engineering into its information system designs. Thus, the key to acceptance of usability engineering lies in starting simple and adding complexity as the organizational environment allows.

A heuristic inspection involves observing an information system's adherence to the ten heuristic usability principles outlined by Nielsen (1994): visibility of system status; match between the system and real world; user control and freedom; consistency and standards; error prevention; recognition rather than recall; flexibility and efficiency of use; aesthetic and minimalist design; ability to help users recognize, diagnose, and recover from errors; and system help and documentation. Adherence to these principles is paramount to ensuring that the learnability, efficiency, memorability, low-error, and user satisfaction requirements of usable systems are met.

Understanding the Heuristic Principles

Visibility of System Status. Visibility of system status describes a system's ability to show the user what the system is doing. In other words, an IT system should be letting the user know it is doing something, what it is doing, and it should do this within a reasonable time span. Users should not be left wondering if the IT system has crashed or is still performing an operation (Nielsen, 1994).

Match Between the System and Real World. Match between the system and real world is the principle that requires an IT system to use terminology familiar to the users. Information and interaction dialogues created by the system should be in terms consistent with the real world and familiar to the people who will use the system. Furthermore, interactions should occur in a natural and logical order (Nielsen, 1994).

User Control and Freedom. A usable IT system should allow a sufficient amount of user control and freedom. A figurative "backdoor" should be available at any time in case the user has ventured into an unintended area and needs to back out of the unwanted transaction and return to desired territory. Navigation buttons such as "back" and "forward," and other features such as "redo" and "undo," are examples of the user control and freedom principle (Nielsen, 1994).

Consistency and Standards. Consistency and standards are necessary to ensure users do not question the meaning of identical icons or other interactive and informative objects used in different contexts. If a particular symbol has a particular meaning in one area of the IT system, it should have the same meaning in all other areas. A prime example of this is the "save" icon – the meaning of the "save" icon is universal across all Microsoft Windows-based applications (Nielsen, 1994).

Error Prevention. A usable system should have a sufficient amount of error prevention. This principle is simple. The system should be designed such that is does not contain errors, and the system should not lead users toward committing errors (Nielsen, 1994).

Recognition Rather than Recall. Recognition rather than recall is a principle describing a system's ability to make "objects, actions, and options visible" (Nielsen, 1994:30). The purpose of objects, actions, and options ideally should be intuitively obvious; if not, clear instructions should be visibly displayed or readily available through a minimal number of user actions. In other words, if a dialogue pops up on a user's screen, the user should be able to immediately figure out the purpose and usage of it; otherwise, there should be clear instructions about its purpose and the actions needed to manipulate it. If neither of these is possible, the user should be able to access a help dialogue with a minimal number of keystrokes or mouse clicks (Nielsen, 1994).

Flexibility and Efficiency of Use. A usable IT system is easy enough for a novice user to understand and operate, yet provides expert users with the flexibility and efficiency of use derived from the ability to custom-tailor the system to individual user needs. Once a novice user has become sufficiently skilled to use the system without the need for deliberate, step-by-step functioning, "accelerator" options should be available that allow the user to access frequently used features more quickly. An example of this might be the capability of creating macros for users of Microsoft Word – expert users can condense multiple function-executing keystrokes or icon selections into a single keystroke (Nielsen, 1994).

Aesthetic and Minimalist Design. Usable IT systems should be constructed in an aesthetically pleasing and minimalist design. Every item displayed to the user should be attractive, relevant, and as brief as possible so as not to waste vital screen interface space. Any extraneous items compete with and diminish the visibility of relevant items and should be avoided (Nielsen, 1994).

Help Users Recognize, Diagnose, and Recover from Errors. The ability of an IT system to help users recognize, diagnose, and recover from errors is also important to usability. Although errors should never occur under the "error prevention" principle of usability engineering, when errors do occur, messages about the error should be displayed to the user in common, understandable terms. Error messages should refrain from using diagnostic codes to describe errors; instead, they should clearly indicate the nature of the errors and suggest relevant and constructive solutions. Users should not need to consult a system administrator or system developer to determine the solution to errors that occur (Nielsen, 1994).

System Help and Documentation. System help and documentation should ideally never be needed in a fully usable system. Since this is rarely the case though, system help and documentation should be easily accessible. Additionally, it should be as concise as possible, relevant, easily searchable, and provide step-by-step instructions so users are able to solve specific problems (Nielsen, 1994).

Measuring the Principles

Understanding the principles inherent in a heuristic inspection is important, but it raises the issue of how such principles are actually measured. Typically, heuristic inspections last from one hour to half a day. The inspection consists of an evaluator going through the pages of an IT system and determining how usable the system is according to checklists designed to measure each of the heuristic principles. Results are aggregated and used to affect necessary changes to both the IT system and the associated iterative design process (Nielsen, 1994).

However, it should be emphasized that a heuristic inspection is an *evaluation* of the information system, not a repair of it. In other words, a heuristic inspection provides solutions in terms of additional insight as to which usability principles are deficient in the system. Heuristic inspection is not intended to provide system designers with software solutions or lines of machine language usability code. The inspection method will, however, provide system designers and program managers with information that can be used to improve existing design practices to facilitate usable design in future iterations of the system.

Because of their purpose, heuristic evaluations may not provide as many indications of problems as more complex methods. As a result, heuristic inspections will certainly not find every single problem in a system. They will, however, find more problems than doing nothing at all (Nielsen, 1994). Furthermore, while heuristic inspection methods may be considered “discount” usability engineering, this descriptor is relative to other inspection methods requiring more resources (i.e., people, time, funding, and equipment). There should be no misunderstanding that heuristic methods still require a significant amount of effort on the part of the evaluators and those compiling the results (Nielsen, 1994). However, because of the limited number of inspectors involved in heuristic inspections, there are some common pitfalls: biases from individual inspectors, the number of usability problems discovered in comparison to other methods, and the inability to provide specific means of solution (Nielsen, 1994).

The problems associated with having a limited number of inspectors appear to be unpredictable. Many believe that proficient inspectors may be more adept at problem-finding than others; however, some research has shown that less proficient inspectors actually identified more valid problems in some information systems (Nielsen, 1994). In other words, each inspector will be biased in some fashion to some degree, and this bias may manifest itself in inspection results.

Existing Air Force Standards

While understanding the basics of the TAM and how usability engineering contributes to technology acceptance, the regulations and guidance governing the design of Civil Engineer information systems are what ultimately dictate whether or not usability engineering principles are implemented. Therefore, this section provides an overview of usability-related Air Force standards relevant to this research. Four Air Force design frameworks of contemporary significance were examined in the course of this research, as well as more specific system-level regulations and guidance applicable to the information system used in the methodology of this research. The first standard examined was the Global Combat Support System (GCCS).

The Department of Defense (DoD) has undertaken efforts to integrate the development of information systems. The DoD recognizes that a wide variety of stove-piped, legacy information systems currently exist within its organization, each designed differently to serve different needs. Recent efforts have been undertaken to integrate all stove-piped DoD combat support information systems into a single system that can be accessed by any authorized user at any location using standardized, commonly available equipment. The hallmark of these efforts is the GCSS.

Review of literature available on the GCSS showed that this framework is intended to address the integration issues associated with combining all combat support systems into a universally compatible single system. A focus on standardization of design elements from a usability perspective was not found. Because of this, as well as the intended focus on system-to-system, rather than system-to-user interface, the GCSS was removed from consideration as an applicable framework of regulation and guidance for information system design in a usability or human-computer interface context. The next framework examined was the Technical Architecture Framework for Information Management (TAFIM).

The TAFIM was found to be comprised of several volumes, each addressing different aspects of information system design. Of these volumes, the Human-Computer Interface Style Guide (referred to in this research as simply the "TAFIM Style Guide") was the only one containing information related to usability engineering. The Style Guide addresses various aspects of human-computer interface, including hardware and software design. Relevant to this research, the software specifications consisted mainly of requirements to standardize stylistic design features. Such standardization of system features is appropriate, since the purpose of the TAFIM Style Guide (DoD, 1996) is:

> "…to provide a common framework for HCI design and implementation…interface implementation options will be standardized, enabling all DoD applications to appear and operate in a reasonably consistent manner…specifying appearance, operation, and behavior of DoD software applications will support the following operational objectives: higher productivity…less training time…reduced development time."

Further review continued to show a primary emphasis on standardizing graphical user interface components such as windows, menus, icons, and other graphical items in order to provide users a high degree of transferability of component meanings across different platforms. The TAFIM Style Guide is based on the premise that standardization will result in technology acceptance: "people will accept and use what is easy to understand if it aids them in accomplishing their assigned tasks with minimal confusion or frustration" (DoD, 1996: 1-2). Furthermore, standardization will reduce training time because users do not need to re-learn the meaning of non-standardized components: "standard training can be given once for all applications, rather than requiring users be trained when transferring to new systems" (DoD, 1996: 1-2). Finally, the guide states that system development time is reduced because system components are standardized and can be re-used for succeeding systems (DoD, 1996). The TAFIM framework, including the Style Guide, was considered contemporary until 1996, when it was replaced with the Joint Technical Architecture (JTA).

The JTA served as a framework similar to the TAFIM in many respects. In relation to this research, the key differences between the frameworks was the inclusion of commercial standards in the JTA and a focus on maximizing interoperability between information systems and technologies. Per the DoD (2003), the JTA was mandated to only include a minimum set of standards addressing such interoperability. A comprehensive review of JTA standards was not possible, since at the time of this research, the JTA had already been replaced by the DoD Information Technology Standards Registry (DISR).

The DISR is a set of standards mandated for use in the development and acquisition of any new DoD IT system; it is also applicable to all existing DoD systems. The purpose of the DISR is to provide a "minimal set of rules governing the arrangement, interaction, and interdependence of system parts or elements, whose purpose is to ensure that a conformant system satisfies a specified set of requirements" (DoD, 2004:15). In other words, DISR is meant to ensure the interoperability of DoD information systems by establishing a set of baseline standards to which all information systems must adhere. While this may sound similar to the purpose of the JTA and the TAFIM, there are two key differences. First, the DISR contains only those standards recommended by the Information Technology Standards Committee as applicable to the DoD mission. Second, the DISR is comprised of an Oracle database that can be easily queried by DoD employees as well as non-DoD organizations to quickly gain access to standards.

With each new generation of regulations and guidance, the standards have become more all-encompassing, more contemporary, and more available to users. The TAFIM Style Guide was originally available in print form, and consisted of several volumes addressing different functional standardization needs. The JTA expanded on the TAFIM by adding a wider variety of commercial standards. The DISR created an easily searchable online standards database that narrowed the standards focus to those standards recommended by the Information Technology Standards Committee, a neutral committee of information technology industry experts who convene to agree on universal information technology standards (Disronline.disa.mil, 2004).

Examination of the four frameworks (GCCS, TAFIM, JTA, and DISR) was performed to provide a perspective of high-level regulations and guidance related to Civil Engineer information system design. Of these frameworks, the TAFIM, JTA, and DISR were found to be relevant to this research. Although the TAFIM and JTA are superseded, they are relevant for the following reasons. Information systems, and more importantly, the information system used in the methodology of this research, are still in use that were constructed to the TAFIM Style Guide standard. The JTA forms the main body of standards contained within the DISR (the most recent design standard), and thus bears the importance of being mentioned. Next, an examination must be conducted of the more detailed specifications pertaining to the information system used in the methodology of this research.

The Automated Civil Engineer System Personnel Readiness System

As will be outlined in Chapter 3, the information system chosen as the unit of analysis in this research is the Automated Civil Engineer System Personnel Readiness (ACES-PR) module. Before proceeding any further, some background information about ACES-PR is required.

The ACES-PR module is an information system designed to assist Air Force Civil Engineer Readiness flights in managing flight operations and responsibilities. More specifically:

> **"**personnel training and readiness equipment management require automated information system (AIS) support, including services and preparations for wing operations during natural disasters, major accidents, war, and other base emergencies. Applications must support the planning, programming, and training for the protection of people, resources, and the environment from the effects of hazardous explosive, chemical, biological, incendiary, and nuclear ordnance. In addition, the AIS must provide for the management of information and resources for local area and areas projected for deployment. The AIS support must be fully portable in support of deployments" (AFCESA, 2003:7).

It is established in the ACES Concept of Operations (AFCESA, 2003) that all components of ACES should be easily manipulated by end users. The ACES information system is intended to "establish a user-friendly…online transactional processing…and online analytical processing environment for Air Force warfighters" (AFCESA, 2003:13), while modules of ACES should be "engineered to provide 'common' look and feel to users to the maximum extent possible while still providing a desired functional product" (AFCESA, 2003:13).

The design of the ACES-PR module was guided by the ACES-PR Command, Control, Communications, Computers, and Intelligence Support Plan (C4ISP) (AFCESA, 2003). This document mandated the use of the TAFIM Style Guide for all design of human-computer interface features in the ACES-PR system. This fact is relevant because ACES-PR was designed after the TAFIM Style Guide had already been superseded by the JTA.

Another standard governing the design of the ACES-PR system is the Headquarters Standard Systems Group (HQ SSG) System Engineering Process (SEP). The SEP provides a framework for system planning, analysis, design, implementation, maintenance, and closure; its existence and use are mandated (DoD, 2004). The overarching purpose of the SEP is to "lay out a plan that should guide all technical aspects of an acquisition program" (DoD, 2004:1). The core documents are available to designers on the HQ SSG website and are intended to be custom-tailored to each application's development process. Customer requirements are solicited as part of the SEP. Surprisingly, a customer must express usability requirements in order for usability requirements to be included in the system design specifications. In other words, usability is not a default focus of the SEP, rather it must be explicitly requested by customers. Various sections of the SEP are applicable to usability, including the System Design Document and the Software Test Plan. Below are reviews of those sections containing references to usability, as applied to the ACES-PR module SEP.

The ACES-PR System Design Document (SDD) includes the technical details of the design process. Its purpose is to describe "the structure and relationships of the data required to manage the ACES-PR system. It documents the design decisions that will show in the application such as screen shots and interface requirements" (HQ SSG, 2001(b):1). From a usability perspective, this document contains the main specifications for the functional operation of each screen that the user sees. In terms of the TAM, the document primarily addresses the usefulness of ACES-PR by specifying the functional requirements that must be met by the system.

The SEP Software Test Plan (STP) template specifies several types of testing. Integration, interface, or interoperability testing measures the system's capability of interacting with other necessary systems. Stress testing involves measuring system capability to withstand various extremes such as a large number of users or large numerical input values. Performance testing focuses on network throughput capability, and network risk assessment deals with the security of the system (HQ SSG, 2001(a)). Similar to the SEP, customers desiring usability testing must specifically request that it be included in the software test plan.

The majority of the tests specified in the ACES-PR STP are functional in nature and meant to evaluate whether or not the system produces desired outputs. The components of the STP pertaining to usability include tests to measure how well the system meets graphical user interface standards and evaluate error messages. The primary methods of testing include entering correct and incorrect data into the system to see if the system responds with the proper output for a given input and to determine if error messages are meaningful and correct. System testing is performed by human testers using a predetermined list of test actions.

Chapter Summary

The literature review was necessary to gain an understanding of the two major fields of study pertinent to this research: technology acceptance and usability engineering. The heuristic usability inspection method was reviewed to provide a background on the instrument to be used as part of the methodology. An examination of the standards governing the usability of Civil Engineer information systems was conducted. Finally, an understanding of the ACES-PR module and documents relevant to its design was provided to familiarize the reader with the unit of analysis to be observed in the methodology of this research.

III. Methodology

This chapter describes the methodology used in this research. This chapter will include a discussion of the different research methods considered, the reasoning behind choosing the case study method, generalized and research-specific descriptions of the initial case study design steps, as well as more advanced case study design, protocol, and data gathering procedures.

Research Methods

The scientific method involves the expansion of knowledge through the use of accepted and proven research methods. This research is no exception to the scientific method and, thus, requires the selection and implementation of an accepted and proven method to answer the research questions. Therefore, before focusing on the methodology used in this research, a broad overview will be provided of the different research methods considered.

Methods Considered

In many ways, the types of scientific research methods available can be distinguished by their levels of constraint. In the field of scientific research, constraints are defined as “restrictions placed on the researcher in an effort to increase the precision of the research and enhance the validity of conclusions” (Graziano and Raulin, 2004:413). Furthermore, levels of constraint are the degree to which a researcher “imposes limits or controls on any part of the research process” (Graziano and Raulin, 2004:49). Although research methods are often labeled as either being high or low constraint, the levels of constraint are not always categorical. For a given research method, the levels of constraint may overlap or may be atypical for a particular type of research. For example, a case study, typically considered a low constraint form of research, may in some cases have a high level of constraint.

Levels of constraint are often placed on what is termed the "unit of analysis." The unit of analysis is the item being studied and analyzed in order to answer the research questions. For example, if a researcher was trying to compare the standardized test performance of two demographics of people, the unit of analysis would be the individual person belonging to a specific demographic (Graziano and Raulin, 2004). The levels of constraint placed on the unit of analysis often differentiate types of research methods.

Five types of research methods were considered and are listed below in order of increasing levels of constraint. Each is ordered according to the levels of constraint typically assigned to that particular research method.

<u>Naturalistic Observation</u>. This method involves observation of the unit of analysis in its natural environment. Researchers place no constraints on the unit of analysis and only constrain themselves in regards to interaction with the unit of analysis. The low level of constraint typical of naturalistic observation provides the benefit of high flexibility in observation. If the behavior of the unit of analysis changes during the course of observation, the researcher has the freedom to alter research strategies to best address the research questions. Research questions are also permitted to evolve with the situation. Since the researcher minimally interferes with the unit of analysis, the unit of analysis is observed in its natural environment, making results of this research method

highly applicable in the real world. The main disadvantage of this method is that results are not given as much credibility as a high constraint method, since the observation environment is not strictly controlled. Although there are exceptions, the naturalistic method is generally regarded by scientists as exploratory in nature, requiring further explanatory validation (Graziano and Raulin, 2004).

Case Study Method of Observation. This research method is similar to naturalistic observation in that the researcher tries to observe naturalistic behavior of the unit of analysis. This method differs, however, in that the researcher is given more freedom to interact with the unit of analysis. Benefits of this method are similar to the naturalistic observation method: flexibility in observation and high real-world applicability. Disadvantages are also similar, as case studies are also usually regarded as exploratory (Graziano and Raulin, 2004).

Correlational Research. The correlational research method involves higher levels of constraint than case studies or naturalistic research. The goal in this type of research is to observe the behavior of two variables to discover or validate a correlation between the two. The higher level of constraint arises from the need to strictly control the measurement techniques of the observers to ensure consistent observation of the variables. The advantage of this method is that, if researchers discover a correlation, results allow for predicting the behavior of one variable based on the behavior of the other. The tradeoff, however, is that researchers lose the flexibility of changing observation methods to evolving research questions. Although this method is explanatory, it does not prove causality. In other words, correlational methods can prove that given one variable's behavior, the other variable will behave a certain way, but the results cannot indicate that one variable actually caused the other variable's behavior (Graziano and Raulin, 2004).

Differential and Experimental Research. Differential and experimental research are two methods in which high levels of constraint are applied to the observers, the observation methods, and the units of analysis. These methods involve controlling groups of analysis units such that all units are isolated from the environment in order to observe specified behaviors. Observers are constrained by strictly defined observation methods to meet the goal of identical observation methods across all units and groups of units. The main advantage of these high constraint methods is that results are regarded by scientists as having high credibility and validity. Differential and experimental research methods are explanatory and may prove causality. The disadvantage of these methods is that results may not be applicable in the real world. Since observation takes place in an isolated environment, the environmental factors present in the real world (and not in an isolated environment) may invalidate results (Graziano and Raulin, 2004).

Method Selected

After reviewing the research methods available, the case study research method was chosen. The reason this method was chosen is twofold: the levels of constraint applied to observers needed to be minimal and the results of the methodology needed to be applicable in a real-world environment. The researcher wanted few constraints on observers. In order to make pertinent observations, observers needed the ability to freely interact with the unit of analysis. The nature of the unit of analysis was such that behaviors would not be exhibited without observer input. In addition, observers would not be able to qualify behaviors without the freedom to vary their inputs to the unit of analysis. Results of this research required a high level of applicability in a real-world setting. Strictly controlling the environment in which the unit of analysis was observed would have made results less relevant, since the unit of analysis was selected as an information system representative of other systems. Controlling the environment of the unit of analysis would have made the system less representative. Upon choosing a method, it was necessary to define the layout of the chosen methodology. To accomplish this, a five-step approach was used.

Step One: Determine Research Questions

The initial step in the case study research approach was to determine the questions the research intended to address. The questions needed to be carefully formulated such that their nature could be accurately portrayed in the form of who, what, when, where, how, or why (Yin, 2002).

Step Two: Formulate Research Propositions

The second step in the case study research approach was to develop propositions that directed "attention to something that should be examined within the scope of study" (Yin, 2002:22). This step forced the researcher to develop propositions about what the research questions implied. While the research questions were important, the substance of the research was defined by the propositions. As applicable to this research, the following propositions were made:

1. Usability in Civil Engineer information systems is not optimal.

2. Non-optimal usability in Civil Engineer information systems can be linked to non-specification of usability engineering principles in Civil Engineer information system regulations and guidance.

Step Three: Determine Unit of Analysis

The next step involved "…the fundamental problem of defining what the 'case' is" (Yin, 2002:22). This statement implied that the nature of the unit of analysis to be studied required selection in a fashion that allowed the research questions to be answered. However, the case would still remain flexible and its definition was allowed the freedom to change as relevant observations were made during the course of the study (Yin, 2002). The research questions involved characterizing the effects of specification or non-specification of usability engineering principles by Civil Engineer information system regulations and guidance. The effects were to be qualified by observation of a unit of analysis representative of Civil Engineer information systems. As such, the ACES-PR module was chosen as the unit of analysis.

The ACES-PR module can be considered representative of other Civil Engineer information systems because it was constructed to the same standards as other systems. As outlined in Chapter 2, ACES-PR was designed according to the Headquarters System Support Group system engineering process. In addition, the ACES-PR module design process made use of the Technical Architecture Framework for Information Management, and continuing design iterations are subject to the Department of Defense Information Technology Standards Registry.

Step Four: Logic Links Data to Propositions

The fourth step in the case study research approach was to determine the logic that would link the research data to the propositions. In other words, how would the researcher show that the results of the research indicate agreement or disagreement with the research propositions (Yin, 2002)? As applied to this research, the research data would be linked to the propositions as outlined in the "Case Study Protocol" section of this chapter. Usability would be assessed according to a checklist that assessed the usability of information systems according to the principles of usability engineering (Pierotti, 2002). To address the first research proposition, the case study unit of analysis (i.e., the ACES-PR module), as outlined earlier, would be considered representative of many other Civil Engineer information systems, since most Civil Engineer information systems are designed to the same set of standards. To address the second research proposition, data gathered during the research would be referenced back to existing (in the case of favorable usability measurements) or non-existing (in the case of non-favorable usability measurements) regulations and guidance related to the design of Civil Engineer information systems.

Step Five: Criteria for Interpreting Findings

The final step in designing the case study was defining the criteria to be used to interpret the research findings. The rules had to be defined that determine whether the occurrence of a particular observation indicated a particular finding. For this research, the criteria for measuring usability were provided by the usability checklist. Checklist items (observed behaviors) were grouped according to the usability engineering principle they measured. A certain number of usability-favorable checklist items per group would yield a favorable usability result for the respective principle (Pierotti, 2002). More details of this aspect of the methodology are outlined in “Case Study Protocol” section of this chapter, as well as in Chapter 4 of this research.

Detailed Case Study Design

After the initial layout of the case study approach was determined, the detailed case study design had to be accomplished. The following sections explain the detailed design and actual procedures of the case study. The first step in formulating the explicit design of the case study was to determine which of the four standard design types to use: single-case (holistic), single-case (embedded), multiple-case (holistic), or multiple-case (embedded) (Yin, 2002).

The literature provided several scenarios in which a single-case design would be appropriate. The scenario applicable to this research was to choose a single-case design if the unit of analysis could be considered representative or typical of many similar units of analysis. This was the situation with this research; as previously stated, the ACES-PR system was considered representative of other systems in the Civil Engineer career field because of common design regulations and guidance.

At this point, whether the case study design was to be holistic or embedded still had to be determined. A holistic design approach meant using a single, stand-alone unit of analysis for the research, whereas an embedded design would have involved two or more of the same types of analysis units, or units of analysis that contained subunits (Yin, 2002). Though the goal of this research involved making generalizations about many information systems, this was to be done through exploration of a single information system. In addition, the information system chosen to be examined was not comprised of differentiable subunits. Since the target of this research was a single information system, the ACES-PR module, and this information system contained no subunits, the holistic approach was more appropriate. An embedded approach would have been suitable only if the research methodology was to be executed on multiple related information systems or a single information system with multiple subsystems.

Case Study Protocol

Choosing a type of design was important, but just as important was the design of the case study execution itself or rather, how data was to be acquired to answer the research questions. The case study protocol provided the framework for accomplishing this. A case study protocol "contains the instrument as well as the procedures and general rules to be followed in using the protocol" (Yin, 2002:67). Its purpose is to facilitate the research by providing guidelines for data collection (Yin, 2002), and it should contain four key elements.

1. An overview of the case study explains the purpose of the research and provides pertinent background information.

2. Field procedures represent an administrative guide to prepare the researcher for the proper collection of data.

3. Case study questions include not only the research questions, but specific questions intended to elicit appropriate data.

4. A case study report guide provides instructions on how to report the results, to include format and presentation requirements (Yin, 2002).

The specific protocol used in this research is included as Appendix A. It consists of excerpts from the first and second chapters of this research, as well as the Pierotti (2002) checklist used as the instrument for data collection.

The checklist designed by Pierotti (2002) is intended to assess the usability of information systems. The checklist contains fourteen sections designed to measure the usability principles of visibility of system status; match between system and the real world; user control and freedom; consistency and standards; error prevention; recognition rather than recall; flexibility and efficiency of use; aesthetic and minimalist design; helping users recognize, diagnose, and recover from errors; help and documentation; flexibility and minimalist design; skills; pleasurable and respectful interaction with the user; and privacy (Pierotti, 2002).

Upon initial observation, the heuristic principles of this checklist appear to be different than those specified by Nielsen (2004). The areas in Pierotti's checklist that differ from Nielsen's usability principles are: flexibility and minimalist design, skills, pleasurable and respectful interaction with the user, and privacy. Though titled differently, the measured areas in the Pierotti (2002) checklist adhere to the general idea of a heuristic inspection and measure essentially the same characteristics that contribute to the usability of an information system. The only exception to this is the category of privacy, which is a subject area not covered by the intentions of this research. As a result, the privacy measured area was not included in the case study protocol or final results of this research.

The choice to use Pierotti's (2002) checklist in lieu of a checklist provided by Nielsen was based on the fact that Pierotti's checklist was openly available at no cost to the researcher. Nielsen's checklist was available for purchase at a rate consistent with Nielsen's fee for consultation services. Thus, in order to continue the purpose of breaking the usability engineering organizational intimidation barrier, it was appropriate to choose the openly available checklist although it did not share the exact form as Nielsen's usability principles. In addition, the idea of altering the checklist to align with Nielsen's principles was considered. This option was eliminated for two reasons. The first reason was to preserve the consistency between data gathered for this research and data gathered by other researchers using the Pierotti (2002) checklist. The second reason was to ensure the measurement instrument remained in a form as intended by Pierotti (2002). Alterations may have tainted the essence of each measured category as validated by Pierotti.

Each checklist item was answered by the observers on a "yes, no, or not applicable" scale. The "not applicable" rating was used if the research participant did not understand the checklist item or believed the checklist item to be irrelevant in the context of the observed system. In addition, each item on the checklist provided space for observers to add comments. These comments were provided at the observers' discretion to qualify responses or to include any other information relevant to a checklist item.

To use the checklist and execute the protocol, two observers were chosen. This number of observers was based on the number of people available to the researcher that possessed enough of a background in usability engineering and information systems to understand the concepts and terminology associated with the case study instrument. Observer 1 was a web administrator with one year of experience in Windows- and Linux-based website and graphical design using multiple programming languages including

HTML and PHP. Observer 1 also had experience with content management systems and database management, and spent two years as a workgroup administrator. Observer 1 had limited experience using the ACES-PR module, including a command-sponsored training course and management oversight of ACES-PR end users. Observer 2 had over 19 years total experience working with mainframe and desktop computers. In the last five years, Observer 2 had acquired software programming experience in the Perl, HTML, and JavaScript programming languages and had worked as a project manager and system administrator. Observer 2 had no prior experience using the ACES-PR module.

Both observers had research experience in usability engineering and technology acceptance concepts. In addition, both were familiar with the case study methodology as outlined by Yin (2002). Finally, both observers were graduate students enrolled in information technology course sequences involving the study of contemporary and historical management information system and information technology topics. The observers executed the case study protocol on an ACES-PR module demonstration database and not an active database containing actual user data. This demonstration database was identical to the fielded system except that the data was fictional rather than actual.

Chapter Summary

This chapter outlined the general approach to this research and specifically explained the development of the case study protocol and usability checklist. Discussion also included a review of available research methods and a description of the rationale for the selected methodology. The following chapter will discuss the findings of the case study approach used in this research.

IV. Results

To meet the original research objectives, this chapter discusses the existing level of usability standards specified for the design of a representative information system, the Automated Civil Engineer Personnel Readiness (ACES-PR) module. The majority of the chapter provides the results of an assessment on the ACES-PR module to qualify the existence of any possible gaps in existing standards.

Existing Usability Standards

Chapter 2 provided a discussion of the general contents of regulations and guidance associated with the design of Civil Engineer information systems. Further discussion of these standards is required in order to answer the first research question, "How do current standards related to the design of Civil Engineer information systems specify usability engineering principles?" The standards found to be applicable in answering this question were the Joint Technical Architecture (JTA), Department of Defense (DoD) Information Technology Standards Registry (DISR), Technical Architecture Framework for Information Management (TAFIM), Headquarters System Support Group (HQ SSG) System Engineering Process (SEP), and the Automated Civil Engineer System Personnel Readiness (ACES-PR) module Software Test Plan (STP). As outlined in previous chapters, the Global Combat Support System and ACES-PR System Design Document were found to not be applicable to questions about usability engineering, since the intent of these documents was to facilitate integration and usefulness features rather than usability engineering.

As stated in Chapter 2, comprehensive analysis of the JTA was not possible since this framework had already been absorbed into the DISR at the time of research. As such was the case, the DISR was examined instead. Within the DISR, evidence could not be found of usability-related standards related to general information system design. There were standards listed in the registry addressing nuclear weapon human-computer interfaces and conventional weapon system human-computer interfaces (Disronline.disa.mil, 2004); however, no standard was listed for general information system (non-nuclear, non-weapon systems) human-computer interfaces or usability engineering in any other form. Thus, in the case of currently applicable high-level information system design guidance, no specification existed for usability engineering principles.

A previous high-level framework, the TAFIM, contained one volume pertinent to the discovery of usability engineering specifications. This volume, the TAFIM Human-Computer Interface Style Guide (or simply, the "TAFIM Style Guide"), was found to contain various usability specifications. As stated in Chapter 2, these specifications mainly addressed the standardization of design elements across all systems with the goals of maximizing usability and minimizing required user learning time. Standardization of design elements falls under the "consistency and standards" principle of usability engineering (Nielsen, 1994). No specifications applicable to the other usability engineering principles could be found in the TAFIM Style Guide, and thus, the conclusion was drawn that this guide only partially addressed the principles of usability engineering.

The HQ SSG, responsible for the development of a wide variety of Civil Engineer information systems, including the ACES-PR module, mandates the use of its SEP for information system design. Within the SEP, there exists a requirement for the STP. In the realm of usability specifications, the ACES-PR STP was found to contain tests for compliance with graphical user interface requirements as well as validity and effectiveness of error messages. It was concluded that these tests pertained to the "consistency and standards" and "help users recognize, diagnose and recover from errors" principles of usability engineering. No specifications applicable to the other usability engineering principles could be found in the TAFIM Style Guide, and thus, the conclusion was drawn that this guide only partially addressed the principles of usability engineering.

Review of the regulations and guidance applicable to design of Civil Engineer information systems indicated that in some cases, applicable usability engineering standards were not specified. In the cases where usability-related standards were specified, these standards did not address all the usability principles as recommended by Nielsen (1994). Such nonexistent or incomplete specification of usability-related standards validate that, indeed, a gap exists between existing standards related to the design of Civil Engineer information systems and an optimal usability standard specifying the ten principles of usability engineering. Upon identification of a usability gap, it is pertinent to characterize the nature of the nature and effects of such a gap.

Qualifying Usability Gaps

The second research question, "How are gaps in existing Civil Engineer information system design standards qualified upon observation of Civil Engineer information systems through proven and accepted usability inspection methods?" dives further into exploring the gaps revealed by the first research question. To answer the second research question, a representative information system was evaluated using the heuristic usability inspection method. The rest of this section summarizes the results of the inspection method as applied to the ACES-PR module. The results are first summarized by usability principle and then compiled into an overall usability assessment based on the results of the individual evaluations.

For each usability principle, tables are presented to summarize the results from applying the respective portions of the checklist in Appendix A. Each table contains the individual assessments from two observers as well as the total assessment. The "not considered" field identifies how many principle evaluation areas were considered "not applicable" by either or both observers. The "yes" field indicates the number of observations in which the observer agreed that the information system met the requirements of a particular evaluation question. Conversely, the "no" field contains the number of observations in which the observer did not believe the information system met the requirements of a particular question. The "compliance" field is the percentage of "yes" responses in proportion to the number of evaluation areas considered. Finally, the "average" row provides the overall assessment results for the evaluated area.

The compliance percentage was compared to the compliance percentages categorized by Nielsen and Tahir (2001). A compliance rating above 80% indicates "a few minor fixes" (Nielsen and Tahir, 2001:5) to the system are required. A compliance rate above 50% and below 80% means that a redesign project should be undertaken to fix isolated usability problems. Below 50%, the compliance rate indicates a full redesign is necessary and implies that the redesign effort should more effectively address the strategic use of the systems as well as the users and their needs (Nielsen and Tahir, 2001).

Assessment Results by Usability Principle Group

The case study instrument used (Appendix A) was a heuristic usability checklist by Pierotti (2002). As described in Chapter 3, the Pierotti (2002) checklist measures thirteen usability heuristics, one of which, the privacy heuristic, was excluded from measurement due to non-applicability to this research. Listed below are the results of the heuristic inspection, divided into individual measured areas.

Visibility of System Status

The visibility of system status is the usability principle describing a system's ability to "keep users informed about what is going on, through appropriate feedback within reasonable time" (Nielsen, 1994:30). As shown in Table 1, The ACES-PR systems had a 47.92% compliance rate, which was a very poor rating in comparison to other measured areas. Two main factors contributed to this rating: significant delays between user input and system response and the lack of accurate and consistent visual feedback.

Table 1. Visibility of System Status

	Measured Area: Visibility of System Status				
	Considered	Not Considered	Yes	No	Compliance
Observer 1:	24	5	9	15	37.50%
Observer 2:			14	10	58.33%
Average:	24	5	11.50	12.50	47.92%

Observer 1 offered a significantly lower assessment of this measured area than Observer 2. This may have been due to biases formed through prior experience with the ACES-PR module. If Observer 1 had previous negative experiences involving this area, the observer's assessments may have been biased toward a lower assessment. Individual differences may have also played a role. If Observer 1 had a lower personal perception of what was an appropriate response time (i.e., was less patient) than Observer 2, the assessment of Observer 1 may have been more likely to be lower.

Match Between the System and Real World

The principle, match between system and real world, is described by Nielsen (1994:30) as the ability of a system to "speak the users' language, with words, phrases, and concepts familiar to the user, rather than system-oriented terms" and "follow real-world conventions, making information appear in a natural and logical order." As shown in Table 2, the system achieved a 73.33% compliance rating in this measured area, which is considered a relatively good rating. The main areas requiring improvement included the non-standard selection of function-indicative colors and the presence of similarly designed icons that performed opposite or distinctively different functions.

Table 2. Match Between the System and Real World

	Measured Area: Match Between the System and Real World				
	Considered	Not Considered	Yes	No	Compliance
Observer 1:	15	9	8	7	53.33%
Observer 2:			14	1	93.33%
Average:	15	9	11.00	4.00	73.33%

Again, Observer 1 offered a significantly lower assessment of the system than Observer 2. As with the last measured area, this may have been due in part to pre-formed perceptions about the system as a result of having prior experience with ACES-PR. In addition to this, however, Observer 1 was very familiar with the real-world functions that this system supports, while Observer 2 had little or no knowledge about such functions. As a result, Observer 1 may have discovered more issues in this area because of a more comprehensive understanding of what is necessary to provide a match between this system and the real world it supports.

User Control and Freedom

The user control and freedom usability principle describes a system's ability to provide users with an efficient "escape route" in the event that the user operates the system incorrectly. This may be caused by selecting an option by mistake or entering the wrong information. In either case, the system should provide "undo" and "redo" functions (Nielsen, 1994). The system performed relatively well from the perspective of the user control and freedom principle, with a 70% compliance rate as shown in Table 3. The most prevalent features found by observers to be missing from the system were the ability to reverse unwanted actions and a feature to cancel out of operations in progress.

Table 3. User Control and Freedom

	Measured Area: User Control and Freedom				
	Considered	Not Considered	Yes	No	Compliance
Observer 1:	15	8	11	4	73.33%
Observer 2:			10	5	66.67%
Average:	15	8	10.50	4.50	70.00%

Consistency and Standards

The consistency and standards principle is intended to ensure users "should not have to wonder whether different words, situations, or actions mean the same thing" (Nielsen, 1994:30). A system adhering to this principle will typically use standardized platform conventions. The ACES-PR systems displayed the best performance in regards to consistency and standards when compared to other measured areas; as shown in Table 4, this area had a compliance rating of 87.88%. The main issue observed under this principle was the system's color scheme. For one observer, colors did not match the color schemes that the observer was accustomed to seeing in other information systems.

Observer 1 provided a significantly lower assessment of this measured area than Observer 2. As with other measured areas, pre-formed perceptions due to previous experience with ACES-PR may have affected the assessments of Observer 1. In addition, other differences may have been due to the information technology background differences of the observers. One possible factor could have been the programming experience of the observers. Observer 2 had experience in JavaScript programming, the language that forms the elements of ACES-PR. With the perspective of a programmer, Observer 2 may have had a different, and perhaps more tolerant, perspective on what exactly comprises consistency and standards in a JavaScript-based information system.

Table 4. Consistency and Standards

	Measured Area: Consistency and Standards				
	Considered	Not Considered	Yes	No	Compliance
Observer 1:	33	18	25	8	75.76%
Observer 2:			33	0	100.00%
Average:	33	18	29.00	4.00	87.88%

Help Users Recognize, Diagnose, and Recover from Errors

A highly usable system will help users recognize, diagnose, and recover from errors. As stated by Nielsen (1994:30), "error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution." The ACES-PR system performed well in this area, achieving a 82.5% compliance rating as shown in Table 5. However, the observers were divided in their assessments; one observer felt the system was primarily in compliance while the other observed some discrepancies. Observer 1 observed that the system error messages were less directed toward user resolution of the error and more directed toward informing the user that an error had indeed occurred.

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

	Measured Area: Help Users Recognize, Diagnose, and Recover from Errors				
	Considered	Not Considered	Yes	No	Compliance
Observer 1:	20	1	14	6	70.00%
Observer 2:			19	1	95.00%
Average:	20	1	16.50	3.50	82.50%

Much like the consistency and standards assessment, this measured area was possibly affected by pre-formed perceptions of Observer 1, and the more extensive programming experience of Observer 2. Pre-formed perceptions would explain lower assessments of Observer 1. Programming experience of Observer 2 might explain a higher assessment by Observer 2, since such experience might make an observer more tolerant of error messages using the system's and not users' language.

Error Prevention

A system that assists users in recognizing, diagnosing, and recovering from errors is even better if it prevents errors from occurring in the first place (Nielsen, 1994). This measured area was observed to be 60% in compliance as shown in Table 6. Menu names were found to differ hierarchically; in other words, the menu option name differed from the name displayed on the function that operated as a result of selecting the option. Additionally, data entry fields consistently did not indicate the number of characters allowed to be entered into the field.

Table 6. Error Prevention

	Measured Area: Error Prevention				
	Considered	Not Considered	Yes	No	Compliance
Observer 1:	10	5	7	3	70.00%
Observer 2:			5	5	50.00%
Average:	10	5	6.00	4.00	60.00%

Recognition Rather than Recall

The recognition rather than recall principle relieves the user of the burden of having to “remember information from one part of the dialogue to another” (Nielsen, 1994:30). As Table 7 indicates, the system was found to be 65% in compliance with the usability heuristics for this area. One reason for the slightly lower rating was the placement of prompts, cues, and messages in unexpected areas, i.e., places on the screen where the user would probably not be looking. Another reason was the minimal use of object grouping and organizing features such as borders, blank spaces, and the separation of readable chunks in long, columnar fields. Data entry issues also included vague marking of optional and dependent entry fields.

Table 7. Recognition Rather Than Recall

	Measured Area: Recognition Rather Than Recall				
	Considered	Not Considered	Yes	No	Compliance
Observer 1:	30	10	17	13	56.67%
Observer 2:			22	8	73.33%
Average:	30	10	19.50	10.50	65.00%

Pre-formed perceptions of Observer 1 may have again contributed to lower assessments in this area; however, higher assessments of Observer 2 may have resulted from inexperience with the system. Observer 2, being inexperienced in the use of ACES-PR, may not have been aware of as many screens available to users as Observer 1. In other words, Observer 2 may not have known all the places to look for usability problems and, because of this, may not have accessed the features that indicated to Observer 1 that a lower assessment was required.

Flexibility and Minimalist Design

This measured area is described by Pierotti (2002:7) as a system's ability to provide "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 users and experienced users" as well as "alternative means of access and operation for users who differ from the 'average' user." As shown in Table 8, the system was assessed as having a 62.5% usability compliance rate in this measured area.

Table 8. Flexibility and Minimalist Design

	Measured Area: Flexibility and Minimalist Design				
	Considered	Not Considered	Yes	No	Compliance
Observer 1:	12	4	10	2	83.33%
Observer 2:			5	7	41.67%
Average:	12	4	7.50	4.50	62.50%

The main finding here was that the system did not provide many features that could be differentiated with respect to novice or expert users. There was a single level of interface language applied to either type of user. The higher assessment of Observer 1 may have been due to the observer's prior experience in using ACES-PR. Having previously used ACES-PR, Observer 1 may have formed perceptions about what types of features constitute expert or novice features in the context of this system. In addition, Observer 1 may have known where to look in order to gain access to such features.

Observer 2 may not have been familiar with the system enough to know of features available to the observer for customization.

Aesthetic and Minimalist Design

Aesthetic and minimalist design describes the exclusion of unnecessary information and dialogues (Nielsen, 1994). The system scored 60% compliance in this measured area as shown in Table 9. This was primarily due to the consistent screen presence of information unnecessary to the decision making associated with the screen, as well as the similarity of several icons that were conceptually distinct.

Table 9. Aesthetic and Minimalist Design

	Measured Area: Aesthetic and Minimalist Design				
	Considered	Not Considered	Yes	No	Compliance
Observer 1:	10	2	8	2	80.00%
Observer 2:			4	6	40.00%
Average:	10	2	6.00	4.00	60.00%

In this measured area, the higher measurements of Observer 1 were probably due to the observer's prior experience with ACES-PR. As Observer 1 was more familiar with the system than Observer 2, Observer 1 may have been accustomed to the appearance of screen elements and therefore, not as negatively affected by similarity or complexity of screen elements. Individual differences may have played a role as well, since each observer was likely to have a different perception of what constitutes an aesthetically pleasing design.

Help and Documentation

System help and documentation should be easy to search and oriented toward user tasks; it should specifically list step-by-step instructions and be concise (Nielsen, 1994). The system complied well with usability principles, scoring a 73.81% compliance rating as shown in Table 10. Detractors from the score included a lack of navigation and completion instructions on data entry screens and other dialogues. There was also a lack of explanatory information upon selection of ambiguous menu items. The help system interface was not found to be consistent with the overall system interface; it differed from the rest of the ACES-PR system in format, appearance, navigation, and other features.

Table 10. Help and Documentation

	Measured Area: Help and Documentation				
	Considered	Not Considered	Yes	No	Compliance
Observer 1:	21	2	14	7	66.67%
Observer 2:			17	4	80.95%
Average:	21	2	15.50	5.50	73.81%

Observer 1 may have provided lower results again based on pre-formed perceptions due to previous experience with ACES-PR. Observer 2, with a programming background, may have had a different perception of what is required to provide a usable help and documentation system. Having more experience in programming and information technology might have reduced the general dependence of Observer 2 on help and documentation features, regardless of information system being analyzed, and because of this, lowered the level of scrutiny applied to this element.

Skills

Pierotti (2004:11) describes this area as the ability of a system to "support, extend, supplement, or enhance the user's skills, background knowledge, and expertise—not replace them." As shown in Table 11, the system was assessed as having a 60% usability compliance rating. The main feature in this category that was not observed was the ability for the user to specify iconic or textual display of information. In addition, the amount of information displayed per screen was not varied in response to a user's skill level, system usage frequency, or system response times.

Table 11. Skills

	Measured Area: Skills				
	Considered	Not Considered	Yes	No	Compliance
Observer 1:	15	6	9	6	60.00%
Observer 2:			9	6	60.00%
Average:	15	6	9.00	6.00	60.00%

Pleasurable and Respectful Interaction with the User

This measured area describes a systems ability to provide users with enhancement to their work-life, as well as the ability of the system to treat users with respect (Pierotti, 2002). The ACES-PR module was assessed relatively high in this category, with a usability compliance rating of 78.57% as shown in Table 12. Reasons for this included an icon scheme that was friendly and familiar as well as the discretionary use of color.

Varying observations in this measured area were likely attributable to individual differences. It can be reasonably assumed that each observer has a unique perception of what can be considered pleasurable or respectful user interaction. In addition, the possibility of pre-formed perceptions existed for Observer 1 as this observer had previous experience in using the ACES-PR module.

Table 12. Pleasurable and Respectful Interaction with the User

	Measured Area: Pleasurable and Respectful Interaction with the User				
	Considered	Not Considered	Yes	No	Compliance
Observer 1:	7	7	4	3	57.14%
Observer 2:			7	0	100.00%
Average:	7	7	5.50	1.50	78.57%

Assessment Overall Results

The final overall usability assessment was determined by adding the average "yes" responses and dividing by the total number of "considered" responses. The average “yes” responses refer to the averaged value between the observers. Overall, the ACES-PR system was considered to be 69.58% compliant with heuristic usability principles. According to Nielsen and Tahir (2001), this indicates a need to redesign isolated parts of the system to ensure a high level of usability. The overall results are summarized in Table 13.

Table 13. Overall Usability Observations

	Overall Heuristic Usability Inspection Results				
	Considered	Not Considered	Yes	No	Compliance
Observer 1:	212	77	136	76	64.15%
Observer 2:			159	53	75.00%
Average:	212	77	147.50	64.50	69.58%

Consolidating the results allows a better view of which areas, in particular, were found to be least in compliance with usability heuristics. Table 14 summarizes the results, ranking the measures least compliant to most compliant. The results of the heuristic inspection indicate that the ACES-PR system is most compliant with the “consistency and standards” as well as the “help users recognize, diagnose, and recover from errors” usability principles. Due to the emphasis of Civil Engineer information system regulations and guidance on these usability principles, the high level of compliance in these areas was not unexpected. However, the observed lack of design standards and guidance documents specifying the inclusion of other usability principles may have contributed to lower compliance ratings in the other heuristic inspection areas.

Table 14. Summary of Heuristic Inspection Observations

	Considered	Not Considered	Yes	No	Compliance
Visibility of System Status	24	5	11.50	12.50	47.92%
Error Prevention	10	5	6.00	4.00	60.00%
Aesthetic and Minimalist Design	10	2	6.00	4.00	60.00%
Skills	15	6	9.00	6.00	60.00%
Flexibility and Minimalist Design	12	4	7.50	4.50	62.50%
Recognition Rather Than Recall	30	10	19.50	10.50	65.00%
User Control and Freedom	15	8	10.50	4.50	70.00%
Match Between the System and Real World	15	9	11.00	4.00	73.33%
Help and Documentation	21	2	15.50	5.50	73.81%
Pleasurable and Respectful Interaction with the User	7	7	5.50	1.50	78.57%
Help Users Recognize, Diagnose, and Recover from Errors	20	1	16.50	3.50	82.50%
Consistency and Standards	33	18	29.00	4.00	87.88%

Thus, to answer the second research question, the gaps in existing Civil Engineer information system design standards (the nature of which were determined in answering the first research question) are qualified as corresponding to the measured usability compliance of a representative information system. Low-measured areas in the ACES-PR module corresponded to usability principles not specified by regulations and guidance. High-measured areas in the ACES-PR module corresponded to those principles specified by regulations and guidance. Furthermore, given the representative nature of the ACES-PR module, the statement can be made that all Civil Engineer information systems are likely to exhibit this same compliance behavior. What can be learned from this finding is discussed in more detail in the following section.

Improvement

Identifying and qualifying gaps in usability standards allow for answering the third research question, "How can improvements to usability be made as a result of any findings yielded by the usability inspection of an Civil Engineer information system?" The first recommendation for improvement is to address the root cause of usability problems and not necessarily the symptoms alone. The research results are general in nature and the intent is not to address usability problems in any specific system. Recommendations will then be provided for improving usability from the perspective of the proposed root cause, the regulations and guidance governing Civil Engineer information system design.

Addressing the Cause, not the Symptoms

The results presented in this chapter were not specific in nature. That is, the researcher did not provide highly detailed references to causes of usability problems within the evaluated system; instead, general assessments of usability from the perspective of the ten usability heuristics (Nielsen, 1994) were provided. To further clarify, outlining a specific cause of usability problems might be to point out the need for a desirable feature such as a specific button title on a specific page. Such specific results were not provided because the intent of this research was not to point out specific details in any given information system. Instead, the goal was to qualify, categorically, any lack of usability regulations or guidance, validate the effects of missing regulations or guidance in a representative Civil Engineer information system, and, based on research results, provide recommendations to system designers and program managers for improving usability. Pointing out specific feature issues would only encourage the focus of improvement efforts on the inspected system's usability problems, when the results of this research have revealed usability issues on a larger scale. Thus, by revealing specific research results, the researcher would be promoting efforts toward fixing the symptoms, and not the cause, of usability problems.

Regulations and Guidance

The results of the heuristic usability inspection indicate that Civil Engineer information systems, including ACES-PR, exhibit usable behavior concurring with the level of specification provided in applicable regulations and guidance. Because of this, it needs to be noted that these systems are not low in usability compliance due to violation of Air Force standards, but rather, it is the standards that require improvement.

The results of this research indicated that ACES-PR exhibited high usability from the perspective of the "consistency and standards" usability principle as this measured area was shown to be more than 80% compliant with heuristic usability measurements.

Such a high rating may indicate that the focus of regulations and guidance on consistency and standards in the design of Civil Engineer information systems, as shown in the literature review, provided the ACES-PR module with high usability in this area.

With the exception of the "help users recognize, diagnose, and recover from errors" heuristic principle, all other usability principles measured showed low ratings. The high (over 80% compliance) rating of the "help users recognize, diagnose, and recover from errors" measured area can be explained by specifications for error message testing in the ACES-PR STP.

One recommendation for improvement in the low-measured usability principles is for the testing and evaluation component of the information system engineering process to include a usability measurement tool such as the checklist used in the case study protocol (Appendix A) of this research. Contrary to the methodology of this research however, very specific details should be recorded about each measured area for use by system designers in rectifying discovered usability issues. Use of such a measurement tool would provide designers and program managers with valuable feedback on a system's level of usability while still in the design stages, allowing changes to be made before the information system is fielded to end users. In this way, designers, and not end users, discover usability issues. As a result, end users may not exhibit low technology acceptance behavior attributed to low usability.

A regulation governing usable information system design should be included in the DISR. As previously stated, the DISR contains regulations for nuclear and weapon system design, but not for general information system design. The TAFIM Human

Computer Interface guide could be updated to contain usability engineering, and then placed in the DISR.

Further study and managerial attention should be focused on this issue to provide a more widespread perspective on the detailed issues surrounding usability engineering in the Civil Engineer information system design environment. Undoubtedly there will be resistive forces (Useit.com, 1994), and for usability engineering to maximize technology acceptance, such resistance will need to be addressed from the highest levels of management.

Chapter Summary

The purpose of this chapter was to summarize the results obtained in this research. The first question was, “How do current standards related to the design of Civil Engineer information systems specify usability engineering principles?” This was answered through further examination of the relevant Air Force standards found in Chapter 2. The result of this examination showed that Air Force standards in some cases do not specify usability engineering principles at all, and in other cases emphasize the “consistency and standards” and “help users recognize, diagnose, and recover from errors” usability principles.

The second question was, “How are gaps in existing Civil Engineer information system design standards qualified upon observation of Civil Engineer information systems through proven and accepted usability inspection methods?” By evaluating a representative information system, it was shown that the emphasis of Civil Engineer standards on particular usability principles was reflected in current information systems.

The results of the evaluation of the ACES-PR module, being a system representative of other Civil Engineer information systems, indicate that gaps in existing usability standards contribute to low compliance with heuristic usability principles.

The third question was “How can improvements to usability be made as a result of any findings yielded by the usability inspection of a Civil Engineer information system?” This question was answered by proposing improvements to the root cause of usability problems, the regulations and guidance documents, and the nature of these proposed improvements was characterized.

V. Discussion

While Chapter 4 presented results and recommendations based on this research, this chapter discusses the boundaries of this research, future areas of study, and other research efforts related to this research. The boundaries are explained through a discussion of limitations, while future areas of study are those suggested to further the efforts in this research. Finally, concurrent research efforts by other Air Force Institute of Technology researchers are discussed.

Limitations of Research

As with any research, this research has its limitations. The main limitations of this study concern its scope and its methods. The scope of this research was limited by manpower, funding, and time.

Manpower limitations were one factor leading to the selection of the heuristic method of evaluating usability of the Automated Civil Engineer System Personnel Readiness (ACES-PR) module. The heuristic method is, however, a valid and accepted method of assessing usability, and was suitable for the purposes of the case study methodology of this research. Thus, manpower's effect as a limitation in conducting the methodology, from this perspective, was minimal.

Funding was another reason for choosing the heuristic method, since only a few observers are required to accomplish the heuristic method. Other methods exist for evaluating usability, but these methods require more money to purchase or lease sophisticated evaluation hardware and software. Again, from the perspective of conducting the methodology of this research, the effect of funding as a limitation on research was minimal.

Of more significance was time. Since this research was limited to 18 months, explicit results yielded from recommendations in this research, and thus, practical validation of this research, have yet to be achieved. Given more time, more complex and widespread research could have been conducted on more information systems, in more depth. Results of a longer research period could be more applicable on an overall Air Force-wide scale, as discussed further in this section.

Limitations exist in the methods used to conduct this research. These limitations primarily concerned the quantity and nature of observers and quantification of system user perceptions. A limitation in the heuristic method is created when less than three evaluators are used to assess a system's usability. According to Nielsen (1994), using two evaluators will generally only discover approximately half of the usability problems in any given evaluated system. Using five or ten evaluators will result in discovery of approximately 75 percent and 90 percent, respectively, of usability problems. It should be noted, however, that since the goals of this research were exploratory in nature, that the effect of this limitation is minimal. The purpose was not to detect every single usability problem in a particular system; instead, the goal in using the heuristic method was to validate the existence of any usability issues at all. Thus, the detection of usability issues to any degree, regardless of the percentage of total problems found, is satisfactory in meeting the goals of this research.

Another limitation of the observers in this research was their background. As stated in Chapter 3, Observer 1 had mild technical experience in the field of information technologies, as well as previous experience using and managing the use of the ACES-PR module. The extent of the technical knowledge of Observer 1, as well as prior experience with ACES-PR, may have influenced assessments during the heuristic inspection, as outlined in depth in Chapter 4. Observer 2 had a wealth of technical experience, including programming experience, but had no prior experience with ACES-PR. Both conditions may have affected assessments during the heuristic inspection, as described in Chapter 4. Helping to offset the limitations of the observer's backgrounds was their research experience. Comprised of studies of usability engineering, technology acceptance, and case study methodologies, both observers were aware of the importance of impartial observations in performing the heuristic inspection.

This research could have benefited from an initial survey of ACES-PR end users. The initial proposal that a low usability issue existed was made based on archival, personal, and anecdotal evidence. A survey to end users, consisting of questions designed to assess the users' perspective on usability levels of, and satisfaction in using the ACES-PR module, could have helped explicitly determine an initial level of technology acceptance. This same survey could then be administered at a later point in time to quantify any increases in the level of technology acceptance resulting from system engineering process improvements and ultimately, system usability improvements. Such a survey could serve to validate the results and importance of this research.

Suggested Future Research

The results of this research are, by no means, the final step in researching Civil Engineer information system usability. The results of this research are only a minute step toward further usability research in the Air Force, DoD, and other federal agencies. This section will summarize the researcher's thoughts on ideas for future research.

The research results could be further validated by more studies similar in nature, but using other information systems as analysis units. Future researchers, perhaps with career field backgrounds besides Air Force Civil Engineering, could perform an identical holistic single-case study using another information system that is relevant to their career field, or perhaps, to remove any researcher bias, perform the study on an information system in which they have no previous experience. Another option could be to perform a similar study using a different approach such as an embedded multiple case study, in which the results of this research could be used as one of the cases. Such a methodology would provide improved research credibility through revelation (or non-revelation) of regulation- and guidance-rooted usability issues across multiple, unrelated, yet representative, information system platforms.

Future research could also be performed on a larger scale. This research focused on Civil Engineer information systems, but the issue of usability engineering can be applied at higher levels such as the Air Force, Department of Defense, or even the entire United States federal government. A foreseeable issue would be finding a single information system representative of all information systems contained in the scope of the proposed research. In this case, a multiple-case study methodology involving information systems from various government agencies might be appropriate.

Undoubtedly there will be resistance to usability improvement efforts. To assist in dealing with such resistance to change, research should be conducted to identify the key factors contributing to and mitigating resistance to usability improvement efforts. Usability engineering, if not already a part of the system engineering process, will require time, manpower, and resources. To address time, manpower, and resource problems, it may be beneficial to conduct a cost and benefits analysis of improving usability to quantify tangible effects of making usability improvements. Such an analysis might be directed toward quantifying the effects of low technology acceptance as the result of poor usability. As stated in previous chapters, there is a correlation between usability and technology acceptance that has been repeatedly validated, and analysis of the effects of low technology acceptance might reduce managerial resistance to directing effort toward usability engineering. Additionally, it is recommended that any efforts to overcome organizational resistance begin with heuristic usability engineering methods. As stated in Chapter 2, such methods help to ease the process of breaking through the usability intimidation barrier (Useit.com, 1994).

Although the use of heuristic methods is prescribed for initial usability efforts, the benefits of more formal methods are also great. Because of this, it may be beneficial to perform research using other inspection methods aside from the heuristic method used in this research. Many more costly methods are available to researchers (Nielsen, 1994), but if a sponsor can provide time, manpower, and resources to a future researcher, these methods have many benefits that can contribute to research validity and credibility.

Training and education of system developers and program managers was not addressed in this research. Future research should examine the training and education process to determine the level of usability engineering taught to people associated with the information system engineering process. If the level of usability engineering training is minimal, it may be beneficial to study the potential benefits of exposing system designers and program managers to usability engineering concepts and practices.

Air Force usability engineering efforts could benefit from a research duration longer than that of this research. A longitudinal study of information system usability would add more weight to the argument for usability engineering practices. By performing the same methodology at successive points in time, it could be demonstrated that low usability is consistently a behavior exhibited by organizational information systems. Another benefit of taking several snapshots in time is that program managers and decision makers would receive feedback on the results of their system engineering process improvements.

Concurrent Research

For reference purposes and to benefit future researchers, it is important to note that several other related research efforts were underway at the Air Force Institute of Technology during the execution of this research. One study, involving technology acceptance, applied the Davis et al. (1989) model of technology acceptance to the Communities of Practice concept implemented in the Air Force Knowledge Now website. Also involving the Air Force Knowledge Now website, a second study was underway that examined the website's usability and accessibility.

The first study, applying the Technology Acceptance Model, is relevant because it examined the factors in an Air Force information system that contributed to its acceptance or non-acceptance. The findings of this study can be referenced by future researchers to assist in developing their research of usability engineering, since ease of use is a key factor in technology acceptance. This research thesis, by 1st Lt John Tate, was to be completed in March 2005.

The second study, involving usability and accessibility, is particularly applicable to usability engineering researchers expanding on this research because it includes the use of the heuristic inspection method as well as Yin (2002) case study methodology. This study also looks at accessibility, a factor of usability not addressed by Nielsen's (1994) ten heuristic principles. Accessibility is important because it ensures that, through assistive technologies, people with disabilities are able to use information systems. This research thesis, by Capt Gary Felax, was to be completed in March 2005.

Chapter Overview

This chapter discussed the results summarized in earlier chapters. The boundaries of this research were explained in a discussion of limitations. Several ideas were described for future researchers to use in efforts to explore new areas of research and to validate and use this research. Finally, a reference list was provided of related research efforts underway at the time of this research to help future researchers in their efforts to study usability engineering and technology acceptance.

Appendix A: Case Study Protocol

Overview

The purpose of this case study instrument is to facilitate the gathering of data in order to evaluate the usability of the Automated Civil Engineer System Personnel Readiness (ACES-PR) Module.

The ACES-PR Module is a web-based information system used by Air Force Civil Engineer personnel to manage data related to the disaster preparedness and Civil Engineer world-wide mobility mission areas.

The goal of the research observer is to collect information about the usability of the ACES-PR Module using the case study instrument, the heuristic inspection checklist.

Field Procedures

The computers available for evaluating the ACES-PR module are located in Wright-Patterson Air Force Base, Area B, Building 643 (The Civil Engineer and Services School), Computer Room 227. These computers may be accessed using a standard Air Force Institute of Technology (AFIT) student user account. The availability of this computer room is listed in the AFIT email Public Folders, accessible from the highlighted Microsoft Outlook calendar as shown in the Figure on the next page. Any block of time without a class or other event scheduled for the room can be considered as available for use by case study observers.

Once logged onto an evaluation computer, proceed to the following website using Microsoft Internet Explorer web browser:

https://gupe64501.mont.disa.mil/servlet/f60servlet?config=aces

The web browser will load a login page. The user name, password, and database will be provided to you by the researcher, Capt Kastenholz. Submit the password form and the browser will load an initial page providing access to several ACES modules. Click the link button referencing ACES-PR (Personnel Readiness). Another page will load which is the initial interface for using all features of ACES-PR. At this point the heuristic evaluation begins and the case study observer is to execute the case study instrument, the heuristic checklist.

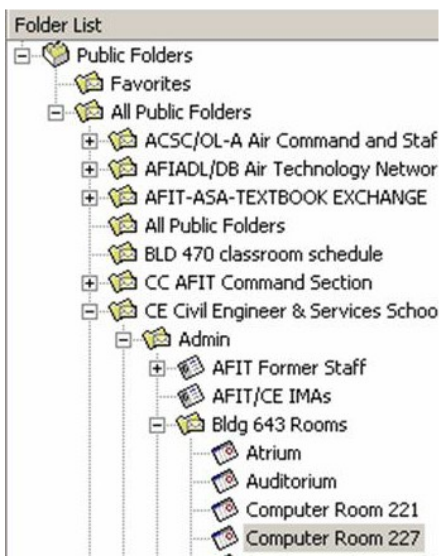

Figure. Computer Room Availability

Any questions related to execution of this case study instrument should be directed to the researcher, Capt Gunther Kastenholz, at (937) 475-9631 or via email at gunther.kastenholz@afit.edu.

Case Study Instrument (Heuristic Checklist)

The case study observer will complete the following checklist. The observer should answer each question by filling in the appropriate circle for a “yes,” “no,” or “not applicable” response, as indicated in the checklist by “Y,” “N,” or “NA,” respectively. A “yes” answer indicates that the observer agrees that the ACES-PR module generally behaves in accordance with the question. A “no” answer indicates the observer does not agree that the ACES-PR module generally behaves in accordance with the question. A “not applicable” response indicates that the observer either does not feel the question is applicable to the ACES-PR module, the observer feels the question is unclear, or the observer otherwise does not feel a “yes” or “no” answer is justified. The observer should also add any appropriate comments that the observer feels would provide value to the researcher in understanding the reasoning behind choosing the selected answer.

1. Visibility of System Status

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

#	Review Checklist	Y N NA	Comments
1.1	Does every display begin with a title or header that describes screen contents?	O O O	
1.2	Is there a consistent icon design scheme and stylistic treatment across the system?	O O O	
1.3	Is a single, selected icon clearly visible when surrounded by unselected icons?	O O O	
1.4	Do menu instructions, prompts, and error messages appear in the same place(s) on each menu?	O O O	
1.5	In multipage data entry screens, is each page labeled to show its relation to others?	O O O	
1.6	If overtype and insert mode are both available, is there a visible indication of which one the user is in?	O O O	
1.7	If pop-up windows are used to display error messages, do they allow the user to see the field in error?	O O O	
1.8	Is there some form of system feedback for every operator action?	O O O	
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?	O O O	
1.1	Is there visual feedback in menus or dialog boxes about which choices are selectable?	O O O	

1.11	Is there visual feedback in menus or dialog boxes about which choice the cursor is on now?	O O O	
1.12	If multiple options can be selected in a menu or dialog box, is there visual feedback about which options are already selected?	O O O	
1.13	Is there visual feedback when objects are selected or moved?	O O O	
1.14	Is the current status of an icon clearly indicated?	O O O	
1.15	Is there feedback when function keys are pressed?	O O O	
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?	O O O	
1.17	Are response times appropriate to the task?	O O O	
1.18	Typing, cursor motion, mouse selection: 50-1 50 milliseconds	O O O	
1.19	Simple, frequent tasks: less than 1 second	O O O	
1.2	Common tasks: 2-4 seconds	O O O	
1.21	Complex tasks: 8-12 seconds	O O O	
1.22	Are response times appropriate to the user's cognitive processing?	O O O	

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

2. Match Between System and the Real World

The system should speak the user's 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	Y N NA	Comments
2.1	Are icons concrete and familiar?	O O O	
2.2	Are menu choices ordered in the most logical way, given the user, the item names, and the task variables?	O O O	
2.3	If there is a natural sequence to menu choices, has it been used?	O O O	

2.4	Do related and interdependent fields appear on the same screen?	O O O	
2.5	If shape is used as a visual cue, does it match cultural conventions?	O O O	
2.6	Do the selected colors correspond to common expectations about color codes?	O O O	
2.7	When prompts imply a necessary action, are the words in the message consistent with that action?	O O O	
2.8	Do keystroke references in prompts match actual key names?	O O O	
2.9	On data entry screens, are tasks described in terminology familiar to users?	O O O	
2.1	Are field-level prompts provided for data entry screens?	O O O	
2.11	For question and answer interfaces, are questions stated in clear, simple language?	O O O	
2.12	Do menu choices fit logically into categories that have readily understood meanings?	O O O	
2.13	Are menu titles parallel grammatically?	O O O	
2.14	Does the command language employ user jargon and avoid computer jargon?	O O O	
2.15	Are command names specific rather than general?	O O O	

2.16	Does the command language allow both full names and abbreviations?	O O O	
2.17	Are input data codes meaningful?	O O O	
2.18	Have uncommon letter sequences been avoided whenever possible?	O O O	
2.19	Does the system automatically enter leading or trailing spaces to align decimal points?	O O O	
2.2	Does the system automatically enter a dollar sign and decimal for monetary entries?	O O O	
2.21	Does the system automatically enter commas in numeric values greater than 9999?	O O O	
2.22	Do GUI menus offer activation: that is, make obvious how to say "now do it"?	O O O	
2.23	Has the system been designed so that keys with similar names do not perform opposite (and potentially dangerous) actions?	O O O	
2.24	Are function keys labeled clearly and distinctively, even if this means breaking consistency rules?	O O O	

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	Y N NA	Comments
3.1	If setting up windows is a low-frequency task, is it particularly easy to remember?	O O O	

3.2	In systems that use overlapping windows, is it easy for users to rearrange windows on the screen?	O O O	
3.3	In systems that use overlapping windows, is it easy for users to switch between windows?	O O O	
3.4	When a user's task is complete, does the system wait for a signal from the user before processing?	O O O	
3.5	Can users type-ahead in a system with many nested menus?	O O O	
3.6	Are users prompted to confirm commands that have drastic, destructive consequences?	O O O	
3.7	Is there an "undo" function at the level of a single action, a data entry, and a complete group of actions?	O O O	
3.8	Can users cancel out of operations in progress?	O O O	
3.9	Are character edits allowed in commands?	O O O	
3.1	Can users reduce data entry time by copying and modifying existing data?	O O O	
3.11	Are character edits allowed in data entry fields?	O O O	
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?	O O O	

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

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	Y N NA	Comments
4.1	Have industry or company formatting standards been followed consistently in all screens within a system?	O O O	
4.2	Has a heavy use of all uppercase letters on a screen been avoided?	O O O	
4.3	Do abbreviations not include punctuation?	O O O	
4.4	Are integers right-justified and real numbers decimal-aligned?	O O O	
4.5	Are icons labeled?	O O O	
4.6	Are there no more than twelve to twenty icon types?	O O O	
4.7	Are there salient visual cues to identify the active window?	O O O	
4.8	Does each window have a title?	O O O	
4.9	Are vertical and horizontal scrolling possible in each window?	O O O	
4.1	Does the menu structure match the task structure?	O O O	

4.11	Have industry or company standards been established for menu design, and are they applied consistently on all menu screens in the system?	O O O	
4.12	Are menu choice lists presented vertically?	O O O	
4.13	If "exit" is a menu choice, does it always appear at the bottom of the list?	O O O	
4.14	Are menu titles either centered or left-justified?	O O O	
4.15	Are menu items left-justified, with the item number or mnemonic preceding the name?	O O O	
4.16	Do embedded field-level prompts appear to the right of the field label?	O O O	
4.17	Do on-line instructions appear in a consistent location across screens?	O O O	
4.18	Are field labels and fields distinguished typographically?	O O O	
4.19	Are field labels consistent from one data entry screen to another?	O O O	
4.2	Are fields and labels left-justified for alpha lists and right-justified for numeric lists?	O O O	
4.21	Do field labels appear to the left of single fields and above list fields?	O O O	

4.22	Are attention-getting techniques used with care?	O O O	
4.23	Intensity: two levels only	O O O	
4.24	Size: up to four sizes	O O O	
4.25	Font: up to three	O O O	
4.26	Blink: two to four hertz	O O O	
4.27	Color: up to four (additional colors for occasional use only)	O O O	
4.28	Sound: soft tones for regular positive feedback, harsh for rare critical conditions	O O O	
4.29	Are attention-getting techniques used only for exceptional conditions or for time-dependent information?	O O O	
4.3	Are there no more than four to seven colors, and are they far apart along the visible spectrum?	O O O	
4.31	Is a legend provided if color codes are numerous or not obvious in meaning?	O O O	
4.32	Have pairings of high-chroma, spectrally extreme colors been avoided?	O O O	

4.33	Are saturated blues avoided for text or other small, thin line symbols?	O O O	
4.34	Is the most important information placed at the beginning of the prompt?	O O O	
4.35	Are user actions named consistently across all prompts in the system?	O O O	
4.36	Are system objects named consistently across all prompts in the system?	O O O	
4.37	Do field-level prompts provide more information than a restatement of the field name?	O O O	
4.38	For question and answer interfaces, are the valid inputs for a question listed?	O O O	
4.39	Are menu choice names consistent, both within each menu and across the system, in grammatical style and terminology?	O O O	
4.4	Does the structure of menu choice names match their corresponding menu titles?	O O O	
4.41	Are commands used the same way, and do they mean the same thing, in all parts of the system?	O O O	
4.42	Does the command language have a consistent, natural, and mnemonic syntax?	O O O	
4.43	Do abbreviations follow a simple primary rule and, if necessary, a simple secondary rule for abbreviations that otherwise would be duplicates?	O O O	

4.44	Is the secondary rule used only when necessary?	O O O	
4.45	Are abbreviated words all the same length?	O O O	
4.46	Is the structure of a data entry value consistent from screen to screen?	O O O	
4.47	Is the method for moving the cursor to the next or previous field consistent throughout the system?	O O O	
4.48	If the system has multipage data entry screens, do all pages have the same title?	O O O	
4.49	If the system has multipage data entry screens, does each page have a sequential page number?	O O O	
4.5	Does the system follow industry or company standards for function key assignments?	O O O	
4.51	Are high-value, high-chroma colors used to attract attention?	O O O	

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

Error messages should be expressed in plain language (no codes).

#	Review Checklist	Y N NA	Comments
5.1	Is sound used to signal an error?	O O O	
5.2	Are prompts stated constructively, without overt or implied criticism of the user?	O O O	

5.3	Do prompts imply that the user is in control?	O O O	
5.4	Are prompts brief and unambiguous.	O O O	
5.5	Are error messages worded so that the system, not the user, takes the blame?	O O O	
5.6	If humorous error messages are used, are they appropriate and inoffensive to the user population?	O O O	
5.7	Are error messages grammatically correct?	O O O	
5.8	Do error messages avoid the use of exclamation points?	O O O	
5.9	Do error messages avoid the use of violent or hostile words?	O O O	
5.1	Do error messages avoid an anthropomorphic tone?	O O O	
5.11	Do all error messages in the system use consistent grammatical style, form, terminology, and abbreviations?	O O O	
5.12	Do messages place users in control of the system?	O O O	
5.13	Does the command language use normal action-object syntax?	O O O	
5.14	Does the command language avoid arbitrary, non-English use of punctuation, except for symbols that users already know?	O O O	

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?	O O O	
5.16	Do error messages inform the user of the error's severity?	O O O	
5.17	Do error messages suggest the cause of the problem?	O O O	
5.18	Do error messages provide appropriate semantic information?	O O O	
5.19	Do error messages provide appropriate syntactic information?	O O O	
5.2	Do error messages indicate what action the user needs to take to correct the error?	O O O	
5.21	If the system supports both novice and expert users, are multiple levels of error-message detail available?	O O O	

6. Error Prevention

Even better than good error messages is a careful design which prevents a problem from occurring in the first place.

#	Review Checklist	Y N NA	Comments
6.1	If the database includes groups of data, can users enter more than one group on a single screen?	O O O	
6.2	Have dots or underscores been used to indicate field length?	O O O	
6.3	Is the menu choice name on a higher-level menu used as the menu title of the lower-level menu?	O O O	

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

7. Recognition Rather Than Recall

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

7.11	Is white space used to create symmetry and lead the eye in the appropriate direction?	O O O	
7.12	Have items been grouped into logical zones, and have headings been used to distinguish between zones?	O O O	
7.13	Are zones no more than twelve to fourteen characters wide and six to seven lines high?	O O O	
7.14	Have zones been separated by spaces, lines, color, letters, bold titles, rules lines, or shaded areas?	O O O	
7.15	Are field labels close to fields, but separated by at least one space?	O O O	
7.16	Are long columnar fields broken up into groups of five, separated by a blank line?	O O O	
7.17	Are optional data entry fields clearly marked?	O O O	
7.18	Are symbols used to break long input strings into "chunks"?	O O O	
7.19	Is reverse video or color highlighting used to get the user's attention?	O O O	
7.2	Is reverse video used to indicate that an item has been selected?	O O O	
7.21	Are size, boldface, underlining, color, shading, or typography used to show relative quantity or importance of different screen items?	O O O	
7.22	Are borders used to identify meaningful groups?	O O O	

7.23	Has the same color been used to group related elements?	O O O	
7.24	Is color coding consistent throughout the system?	O O O	
7.25	Is color used in conjunction with some other redundant cue?	O O O	
7.26	Is there good color and brightness contrast between image and background colors?	O O O	
7.27	Have light, bright, saturated colors been used to emphasize data and have darker, duller, and desaturated colors been used to de-emphasize data?	O O O	
7.28	Is the first word of each menu choice the most important?	O O O	
7.29	Does the system provide mapping: that is, are the relationships between controls and actions apparent to the user?	O O O	
7.3	Are input data codes distinctive?	O O O	
7.31	Have frequently confused data pairs been eliminated whenever possible?	O O O	
7.32	Have large strings of numbers or letters been broken into chunks?	O O O	
7.33	Are inactive menu items grayed out or omitted?	O O O	
7.34	Are there menu selection defaults?	O O O	

7.35	If the system has many menu levels or complex menu levels, do users have access to an on-line spatial menu map?	O O O	
7.36	Do GUI menus offer affordance: that is, make obvious where selection is possible?	O O O	
7.37	Are there salient visual cues to identify the active window?	O O O	
7.38	Are function keys arranged in logical groups?	O O O	
7.39	Do data entry screens and dialog boxes indicate when fields are optional?	O O O	
7.4	On data entry screens and dialog boxes, are dependent fields displayed only when necessary?	O O O	

8. Flexibility and Minimalist Design

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	Y N NA	Comments
8.1	If the system supports both novice and expert users, are multiple levels of error message detail available?	O O O	
8.2	Does the system allow novices to use a keyword grammar and experts to use a positional grammar?	O O O	
8.3	Can users define their own synonyms for commands?	O O O	
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?	O O O	

8.5	Do expert users have the option of entering multiple commands in a single string?	O O O	
8.6	Does the system provide function keys for high-frequency commands?	O O O	
8.7	For data entry screens with many fields or in which source documents may be incomplete, can users save a partially filled screen?	O O O	
8.8	Does the system automatically enter leading zeros?	O O O	
8.9	If menu lists are short (seven items or fewer), can users select an item by moving the cursor?	O O O	
8.1	If the system uses a type-ahead strategy, do the menu items have mnemonic codes?	O O O	
8.11	If the system uses a pointing device, do users have the option of either clicking on fields or using a keyboard shortcut?	O O O	
8.12	Does the system offer "find next" and "find previous" shortcuts for database searches?	O O O	
8.13	On data entry screens, do users have the option of either clicking directly on a field or using a keyboard shortcut?	O O O	
8.14	On menus, do users have the option of either clicking directly on a menu item or using a keyboard shortcut?	O O O	
8.15	In dialog boxes, do users have the option of either clicking directly on a dialog box option or using a keyboard shortcut?	O O O	
8.16	Can expert users bypass nested dialog boxes with either type-ahead, user-defined macros, or keyboard shortcuts?	O O O	

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	Y N NA	Comments
9.1	Is only (and all) information essential to decision making displayed on the screen?	O O O	
9.2	Are all icons in a set visually and conceptually distinct?	O O O	
9.3	Have large objects, bold lines, and simple areas been used to distinguish icons?	O O O	
9.4	Does each icon stand out from its background?	O O O	
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?	O O O	
9.6	Are meaningful groups of items separated by white space?	O O O	
9.7	Does each data entry screen have a short, simple, clear, distinctive title?	O O O	
9.8	Are field labels brief, familiar, and descriptive?	O O O	
9.9	Are prompts expressed in the affirmative, and do they use the active voice?	O O O	
9.1	Is each lower-level menu choice associated with only one higher level menu?	O O O	
9.11	Are menu titles brief, yet long enough to communicate?	O O O	

9.12	Are there pop-up or pull-down menus within data entry fields that have many, but well-defined, entry options?	O O O	

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	Y N NA	Comments
10.1	If users are working from hard copy, are the parts of the hard copy that go on-line marked?	O O O	
10.2	Are on-line instructions visually distinct?	O O O	
10.3	Do the instructions follow the sequence of user actions?	O O O	
10.4	If menu choices are ambiguous, does the system provide additional explanatory information when an item is selected?	O O O	
10.5	Are data entry screens and dialog boxes supported by navigation and completion instructions?	O O O	
10.6	If menu items are ambiguous, does the system provide additional explanatory information when an item is selected?	O O O	
10.7	Are there memory aids for commands, either through on-line quick reference or prompting?	O O O	
10.8	Is the help function visible; for example, a key labeled HELP or a special menu?	O O O	
10.9	Is the help system interface (navigation, presentation, and conversation) consistent with the navigation, presentation, and conversation interfaces of the application it supports?	O O O	

10.1	Navigation: Is information easy to find?	O O O	
10.1	Presentation: Is the visual layout well designed?	O O O	
10.1	Conversation: Is the information accurate, complete, and understandable?	O O O	
10.1	Is the information relevant?	O O O	
10.1	Goal-oriented (What can I do with this program?)	O O O	
10.2	Descriptive (What is this thing for?)	O O O	
10.2	Procedural (How do I do this task?)	O O O	
10.2	Interpretive (Why did that happen?)	O O O	
10.2	Navigational (Where am I?)	O O O	
10.2	Is there context-sensitive help?	O O O	
10.2	Can the user change the level of detail available?	O O O	
10.2	Can users easily switch between help and their work?	O O O	

10.2	Is it easy to access and return from the help system?	O O O	
10.2	Can users resume work where they left off after accessing help?	O O O	

11. Skills

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

#	Review Checklist	Y N NA	Comments
11.1	Can users choose between iconic and text display of information?	O O O	
11.2	Are window operations easy to learn and use?	O O O	
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)?	O O O	
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)?	O O O	
11.5	Does the system automatically color-code items, with little or no user effort?	O O O	
11.6	If the system supports both novice and expert users, are multiple levels of detail available.	O O O	
11.7	Are users the initiators of actions rather than the responders?	O O O	
11.8	Does the system perform data translations for users?	O O O	

11.9	Do field values avoid mixing alpha and numeric characters whenever possible?	O O O	
11.1	If the system has deep (multilevel) menus, do users have the option of typing ahead?	O O O	
11.1	When the user enters a screen or dialog box, is the cursor already positioned in the field users are most likely to need?	O O O	
11.1	Can users move forward and backward within a field?	O O O	
11.1	Is the method for moving the cursor to the next or previous field both simple and visible?	O O O	
11.2	Has auto-tabbing been avoided except when fields have fixed lengths or users are experienced?	O O O	
11.2	Do the selected input device(s) match user capabilities?	O O O	
11.2	Are cursor keys arranged in either an inverted T (best for experts) or a cross configuration (best for novices)?	O O O	
11.2	Are important keys (for example, ENTER , TAB) larger than other keys?	O O O	
11.2	Are there enough function keys to support functionality, but not so many that scanning and finding are difficult?	O O O	
11.2	Are function keys reserved for generic, high-frequency, important functions?	O O O	
11.2	Are function key assignments consistent across screens, subsystems, and related products?	O O O	

11.2	Does the system correctly anticipate and prompt for the user's probable next activity?	O O O	

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	Y N NA	Comments
12.1	Is each individual icon a harmonious member of a family of icons?	O O O	
12.2	Has excessive detail in icon design been avoided?	O O O	
12.3	Has color been used with discretion?	O O O	
12.4	Has the amount of required window housekeeping been kept to a minimum?	O O O	
12.5	If users are working from hard copy, does the screen layout match the paper form?	O O O	
12.6	Has color been used specifically to draw attention, communicate organization, indicate status changes, and establish relationships?	O O O	
12.7	Can users turn off automatic color coding if necessary?	O O O	
12.8	Are typing requirements minimal for question and answer interfaces?	O O O	
12.9	Do the selected input device(s) match environmental constraints?	O O O	

12.1	If the system uses multiple input devices, has hand and eye movement between input devices been minimized?	O O O	
12.1	If the system supports graphical tasks, has an alternative pointing device been provided?	O O O	
12.2	Is the numeric keypad located to the right of the alpha key area?	O O O	
12.2	Are the most frequently used function keys in the most accessible positions?	O O O	
12.2	Does the system complete unambiguous partial input on a data entry field?	O O O	

Note to Case Study Observer

Using the space provided below, please provide information about your background and previous experience regarding information technology, information systems, and heuristic inspection methods.

____

____

____

____

____

____

____

____

____

Data Reporting Procedures

The case study observer will submit the data collected to the researcher in whichever form is most convenient for the observer. This submittal should include the case study instrument (the heuristic checklist) as well as the observer's background information related to information technology and information systems.

Bibliography

1cog.com. "Don't Say 'Search Engine' - Say 'Google'". n.pag. http://www.1cog.com/search-engine-statistics.html. November 2004.

Adams, Dennis A., Ryan R. Nelson, and Peter A. Todd. "Perceived Usefulness, Ease of Use, and Usage of Information Technology: A Replication." MIS Quarterly, 16, 2: 227-247 (June 1992).

Agarwal, Ritu and Jayesh Prasad. "Are Individual Differences Germane to the Acceptance of New Information Technologies?" Decision Sciences, 30, 2: 361-391 (Spring 1999).

Air Force Civil Engineer Support Agency (AFCESA). Automated Civil Engineer System (ACES) Command, Control, Communications, Computers, and Intelligence Support Plan (C4ISP). Tyndall AFB: HQ AFCESA, Sep 2002.

Air Force Civil Engineer Support Agency (AFCESA). Automated Civil Engineer System System Engineering Process Guide. Tyndall AFB: HQ AFCESA, Aug 2001.

Air Force Civil Engineer Support Agency (AFCESA). Concept of Operations (CONOPS) for the Automated Civil Engineer System (ACES). Tyndall AFB: HQ AFCESA, 1 May 2003.

Air Force Reserve Command (AFRC). C4 Systems Requirements Document CSO Control Number AFRC2003-006. Robins AFB: HQ AFRC, 1 Jul 2003.

Davis, Fred D., Bagozzi, Richard P., and Warshaw, Paul R., "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models". The Institute of Management Sciences. 1989, pages 982-1003.

Davis, Fred D. and Viswanath Venkatesh. "Toward Preprototype User Acceptance Testing of New Information Systems: Implications for Software Project Management." IEEE Transactions on Engineering Management, 51, 1: 31-46 (February 2004).

Department of Defense (DoD). *Department of Defense (DoD) Joint Technical Architecture (JTA) Version 6.0.* Washington, D.C. 24 November 2003.

Department of Defense (DoD). *Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS).* DoD Directive 4630.5 Washington, GPO, 5 May 2004.

Department of Defense (DoD). Technical Architecture Framework for Information Management, Volume 8: Human Computer Interface Style Guide. Washington: GPO, 30 Apr 1996.

Department of the Air Force (HQ USAF). Full Spectrum Threat Response (FSTR) Planning and Operations. AFI 10-2501. Washington: HQ USAF, 24 Dec 2002.

Department of the Air Force (HQ USAF). Prime Base Engineer Emergency Force (BEEF) Program. AFI 10-210. Washington: HQ USAF, 1 Oct 2004.

Disronline.disa.mil. "DISR Reports and Archives." n.pag. http://disronline.disa.mil/VJTA/jta_reports.jsp

Fourteen Heuristics [OCLC Heuristic Evaluation] www.oclc.org. ©2004 OCLC Online Computer Library Center. http://www.oclc.org/policies/usability/heuristic/set.htm. 30 May 2004.

Garcia, Carolyne. "Simple. Obvious. Intuitive. Impossible." n.pag. http://advancement.uark.edu/pubs/Research_Frontiers/fall_2003/08F3.html. February 2005.

Graziano, Anthony M. and Michael L. Raulin. *Research Methods: A Process of Inquiry (5th Edition).* Boston: Pearson, 2004.

Hendrickson, Anthony R., Patti D. Massey, and Timothy Paul Cronan. "On the Test-Retest Reliability of Perceived Usefulness and Perceived Ease of Use Scales." MIS Quarterly, 17, 2: 227-230 (June 1993).

Hoffer, Jeffrey A., Joey F. George, and Joseph S. Valacich. *Modern Systems Analysis and Design (3rd Edition).* Prentice Hall, 2001.

Headquarters System Support Group (HQ SSG) (a). "Automated Civil Engineer System Personnel Readiness Module Software Test Plan (Version 2.0)." Gunter Annex, HQ SSG: 2001.

Headquarters System Support Group (HQ SSG) (b). "Automated Civil Engineer System Personnel Readiness Module System Design Document (Version 2.0)." Gunter Annex, HQ SSG: 22 Feb 2001.

International Organization for Standardization. *Ergonomic requirements for office work with visual display terminals (VDTs) -- Part 11: Guidance on usability.* ISO 9241 Part 11. 1998.

Malhotra, Yogesh and Dennis F. Galletta. "Extending the Technology Acceptance Model to Account for Social Influence: Theoretical Bases and Empirical Validation." In Proceedings of the 32nd Hawaii International Conference on System Sciences. IEEE, 1999, pages 1-14.

McFarland, Daniel J. and Diane Hamilton. "Adding Contextual Specificity to the Technology Acceptance Model." Article in press, Computers in Human Behavior: 1-21 (2004).

Merriam-Webster, Incorporated. *Merriam-Webster's Collegiate Dictionary (10th Edition).* Springfield MA: Merriam-Webster, Incorporated, 1994.

Nielsen, Jakob. Designing Web Usability. Indianapolis: New Riders Publishing, 2000.

Nielsen, Jakob. "Heuristic Evaluation", in Usability Inspection Methods. Ed. by J. Nielsen and R. Mack. John Wiley and Sons, Inc. 1994, pages 25-62.

Nielsen, Jakob and Molich, Rolf. "Heuristic Evaluation of User Interfaces", in Proceedings of ACM CHI'90 Conference of Human Factors in Computing Systems. ACM, New York. 1990, pages 249-256.

Nielsen, Jakob and Tahir, Marie. "Homepage Usability 50 Websites Deconstructed". New Riders Publishing 2002.

Pierotti, Deniese. "Heuristic Evaluation – A System Checklist". n. pag. http://www.stcsig.org/usability/topics/articles/he-checklist.html. 15 December 2002.

Searchengineguide.com. "Search Engine Guide." n. pag. http://www.searchengineguide.com. November 2004.

Szajna, Bernadette. "Software Evaluation and Choice: Predictive Validation of the Technology Acceptance Instrument." MIS Quarterly, 18, 3: 319-324 (September 1994).

Teamwarfare.com. "Teamwarfare: Community Based Gaming." n. pag. http://www.teamwarfare.com. November 2004.

Useit.com. "About Jakob Nielsen." n. pag. http://www.useit.com/jakob/index.html. November 2004.

Useit.com. "Guerrilla HCI: Using Discount Usability Engineering to Penetrate the Intimidation Barrier" n. pag. http://www.useit.com/papers/guerrilla_hci.html. 1994.

Useit.com. "Usability 101: Introduction to Usability." n. pag. http://www.useit.com/alertbox/20030825.html. 25 August 2003.

Venkatesh, Viswanath and Fred D. Davis. “A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies,” Management Science, 46, 2: 186-204 (February 2000).

Venkatesh, Viswanath, Cheri Speier, and Michael G. Morris. “User Acceptance Enablers in Individual Decision Making About Technology: Toward an Integrated Model,” Decision Sciences, 33, 2: 297-316 (Spring 2002).

Venkatesh, Viswanath, Michael G. Morris, Gordon B. Davis, and Fred D. Davis. “User Acceptance of Information Technology: Toward a Unified View,” 27, 3: 425-478 (September 2003).

Yin, Robert K. Case Study Research : Design and Methods (3rd Edition). Newbury Park: Sage Publications, 2002.

Vita

Captain Gunther Kastenholz graduated from Capital High School in Olympia, Washington. He entered undergraduate studies at the University of Portland in Portland, Oregon where he graduated with a Bachelor of Science degree in Mechanical Engineering in May 2000. He was commissioned as a Second Lieutenant upon completion of the Detachment 695, University of Portland, Air Force Reserve Officer Training Corps program.

His first assignment was at Minot Air Force Base in July 2000. At this assignment he served with the 5th Civil Engineer Squadron as a mechanical design engineer, Readiness Flight officer, and personnel section commander. In August 2003, he entered the Graduate School of Engineering and Management, Air Force Institute of Technology. Upon graduation, he will be assigned to Los Angeles Air Force Base, California.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From – To)*
21-03-2005	**Master's Thesis**	Jun 2004 - March 2005

4. TITLE AND SUBTITLE

Usable Design of Civil Engineer Information Systems

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Kastenholz, Gunther (NMI), Captain, USAF

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)
Air Force Institute of Technology
Graduate School of Engineering and Management (AFIT/EN)
2950 Hobson Way
WPAFB OH 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER

AFIT/GEM/ENV/05M-07

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
N/A

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This research used a case study methodology where one instrument used to collect data was a heuristic usability inspection method. Data was collected from a literature review of pertinent Civil Engineer information system design documents, and conclusions drawn about the existing level of specification of usability engineering principles. The heuristic usability inspection method was used to validate the conclusions drawn through inspection of an information system representative of other Civil Engineer information systems, the Automated Civil Engineer System Personnel Readiness module.

15. SUBJECT TERMS
Usability Engineering, Technology Acceptance, Automated Civil Engineer System Personnel Readiness Module (ACES PR), Heuristic Inspection

16. SECURITY CLASSIFICATION OF: Unclassified			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
					Alfred E. Thal, Jr., (ENV)
REPORT	**ABSTRACT**	**c. THIS PAGE**	UU	130	**19b. TELEPHONE NUMBER** *(Include area code)*
U	**U**	**U**			(937) 255-3636, ext. 4798; e-mail: Alfred.Thal@afit.edu

Standard Form 298 (Rev: 8-98)
Prescribed by ANSI Std. Z39-18