NIST
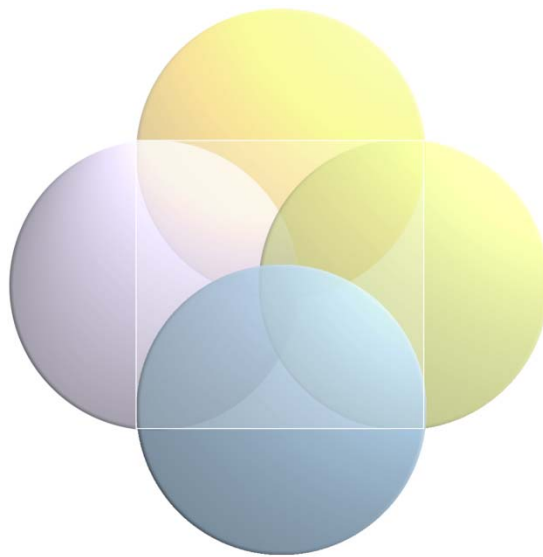National Institute of Standards and Technology

Usability & Biometrics

Ensuring Successful Biometric Systems
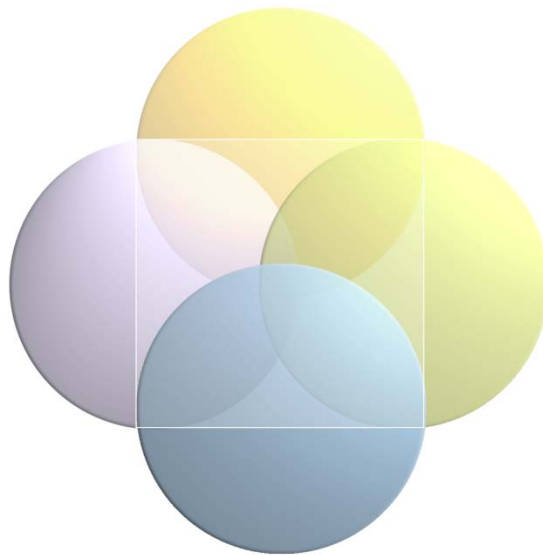
JUNE 11, 2008

ABSTRACT: This handbook provides an overview of the user-centered design process and examples of how the process can be applied to the design and development of biometric technology systems.

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KEYWORDS: Biometrics, Usability, User-Centered Design, Requirements Analysis, User and Task Analysis, User Evaluation, Usability Testing

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Purpose & Audience for This Document

This handbook is intended for use by designers and developers of biometric technologies.

The goal of this document is to provide information and resources for design teams that will ultimately improve the usability of biometric systems.

PREFACE

In a world where security is a constant concern, being able to easily and accurately ascertain the identity of individuals is of increasing importance.

"Government and industry have a common challenge in today's global society to provide more robust identity management tools and identify governance principles on how to deploy these tools intelligently to meet national and international standards." (National Science and Technology Council Subcommittee on Biometrics and Identity Management, 2006).

THE IMPORTANCE OF BIOMETRICS

The use of biometrics to confirm personal identity has become a key component to our nation's security. And, as such, there is an escalating need to design and develop biometric systems which *accurately and effectively* identify individuals.

To date, biometric technologies are the most definitive, real-time identity management tools currently available, yet according to the National Science and Technology Council (NSTC) Subcommittee on Biometrics and Identity Management, many shortcomings of these tools have yet to be addressed.

Therefore, NSTC's Subcommittee on Biometrics and Identity Management has issued the "National Biometric Challenge."

NATIONAL BIOMETRIC CHALLENGE

The National Biometric Challenge identifies known problems with current technologies and encourages government entities and industry to collaborate in resolving these issues.

Although the Challenge identifies a broad number of areas for improvement, this handbook is specifically focused on one such issue – the usability of biometric technologies.

NSTC specifically challenged technology developers to design systems which are "easy to use (intuitive to end users)" with "intuitive interfaces for the operators and end users."

Therefore, the National Institute of Standards and Technology (NIST) initiated a Usability and Biometrics effort to focus on the users and human factors of biometric systems. The goal of this effort has been to conduct research to determine how user characteristics impact biometric system performance, as well as to provide resources (such as this handbook) for designers and developers of biometric devices.

This handbook will work to introduce designers to the concept of usability and showcase the ways in which a properly implemented user-centered design process can improve a system's effectiveness, and efficiency, and user satisfaction.

For more information on this handbook and other NIST usability and biometric projects, please visit http://zing.ncsl.nist.gov/biousa/.

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FORWARD

As the NIST's Information Access Division, Visualization and Usability Group began to study the usability of biometric technologies and applications we realized that our partners in the biometric community were unfamiliar with usability terminology and methodologies. Part of fostering an effective partnership is communicating the value and benefit of the usability discipline. As the visibility and interest in our usability and biometric research increased it became clear that a handbook introducing usability would benefit the community as a whole and this document was created.

This handbook provides a common understanding and vocabulary for usability to encourage communication between usability and biometric researchers and practitioners. It begins by examining the biometric collection process and the role of the user and user characteristics. We examine the concept of usability and how it is defined. We introduce the user-centered design process and the value of the process to the development of biometrics systems. The elements of the user centered design process including context of use, user and organizational requirements, design solutions, and evaluation techniques are defined and described. Finally a list of usability methods and techniques are elaborated.

We hope that this handbook will be useful in continuing to promote a collaborate research environment between the biometric and usability research communities.

Chapter 1
The Biometric Process

THE BIOMETRIC VIEW OF THE PROCESS

To date, the design, development and evaluation of biometric technologies [1] has understandably been focused on system performance, functionality, reliability and precision including resolution of sampling, speed, accuracy, and error rates. In the beginning stages of development, it was necessary to focus primarily on the performance of biometric systems. As these new technologies mature, it's important to begin to evaluate other factors, including the usability of these systems.

One aspect of biometric systems that has not been traditionally considered is the user. The user brings innate qualities and experiences to the interaction that affect performance. Without a careful consideration of user qualities, biometric system designers and evaluators will struggle to make significant improvements, which advances in technology alone cannot achieve.

The biometric view of the process typically focuses solely on the technology. This view of the system and technology is presented in the illustration below.
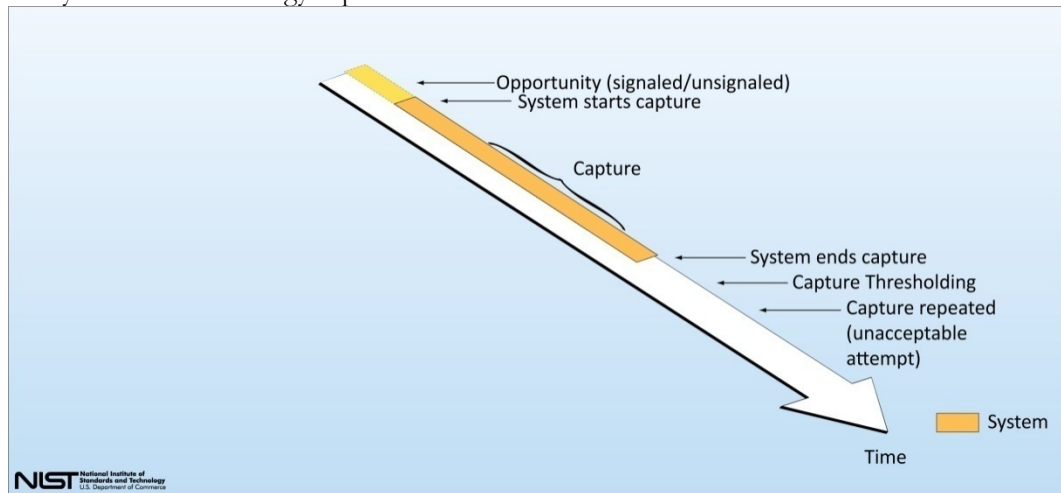
Figure 1: Biometric View of the Process

In order to make more substantial improvements to the performance of biometric technologies, it is essential to take the user into consideration.

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[1] These tests were supported by the Department of Homeland Security . Specific hardware and software products identified in this report were used in order to perform the evaluations described. In no case does such identification imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the products and equipment identified are necessarily the best available for the purpose

 "We can no longer focus on one half of the problem. It is necessary to examine the human and usability. Up to this point, the user has been in some sense forgotten from the process, yet the user is key to providing the biometric sample. The user starts the process and the user's fingerprint sample determines the success of the process and the system as a whole." (Theofanos, Stanton, Michaels, & Orandi).

USER INVOLVEMENT IN THE BIOMETRIC PROCESS

Users are a key component in the biometric process, as users begin the process with a presentation and ideally end the process by submitting a high-quality, accurate sample. Their interaction with the system is essential to a holistic understanding of the biometric process.

To date, many biometric systems have focused solely on the limitations and capabilities of a technology, without truly considering the impact a user's characteristics, experience levels and abilities will have on a biometric system.

The diagram below illustrates the two-way interaction, or relationship, between the user and the system during the biometric process.
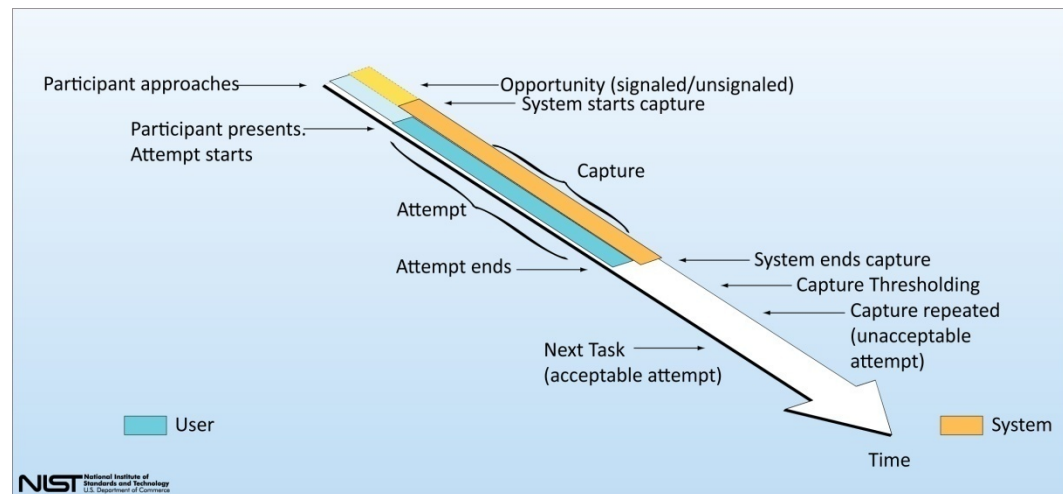
Figure 2: User Involvement in the Biometric Process

Not only does the user play an integral role in the submission of a sample, a user's innate characteristics have a substantial impact on the ultimate success of a biometric system.

DEMOGRAPHIC CHARACTERISTICS

Innate characteristics can significantly affect a user's performance and influence the ability of the system to perform successfully.   For instance, consider the impact of the following characteristics on the design of a biometric system:

- Age
- Gender
- Experience

- Ability

By designing with these characteristics in mind, developers of biometric systems can produce a system that is more effective and efficient. With a focus on users and the usability of biometric systems, design teams have the opportunity to improve image captures, increase throughput, and reduce errors.

Following is a partial list of design questions that project teams must consider in the creation of a biometric system. Please note, this list is not an exhaustive list of design considerations. Rather, it is intended to stimulate design teams to begin thinking about the needs of users and the potential impact of users' inherent qualities on the performance of a system.

Age

- How does an individual's age affect the quality of a sample?
- Does age affect users' abilities to learn and use a biometric system?
- Are younger users more successful in their attempts?
- Do older users take longer to present a sample?

Gender

- Does gender affect the quality of a sample?
- Does gender affect the accuracy of a sample?
- What role does gender play, if any, in the presentation and capture of a sample?

Experience & Ability

- What role does experience play in users' abilities to present a sample?
- Are more experienced individuals more successful?
- Do first-time users struggle more than experienced users?
- How does past experience affect a user's interaction with a system?
- How do disabilities affect the user in submitting a biometric sample?
- Which disabilities impact success in presentation and capture?

In addition to these demographic characteristics, it is also important to consider other opportunities to enhance the usability of a biometric system through the use of user-centered instructions, greater awareness of anthropometrics, enhanced affordance and improved accessibility.

To that end, we have provided some additional design questions related to these issues below:

INSTRUCTIONAL GUIDES & SYSTEM FEEDBACK

- How can designers create intuitive instructional materials (posters, signs, etc.) for end users who may not speak the same language?
- How does culture impact the understanding of symbols, colors and iconography?
- What types of cultural conventions must be considered?
- What types of instructional materials are most appropriate given the location and environment in which the biometric system is located? Where should instructional guides be positioned? At what height?
- What types of feedback should a biometric system provide to end users? Audio? Visual? Sensory?
- At what point in the process should the system provide feedback? How frequently should feedback be given? What is the most effective and efficient way to provide this feedback?

ANTHROPOMETRICS

As measurements used to describe the user of a product, anthropometrics provide data on average body dimensions that exist in the larger population. Gathered by taking measurements from a large number of users in a variety of positions, anthropometrics provide biometric designers with information needed to create more usable systems.

- How can designers use established standards to design the physical characteristics of a biometric system?
- How does an individual's height affect the quality of a sample?
- Does the height of a system affect the quality of samples?
- Can anthropometric data be used to inform the optimal height and position of a biometric system?
- How does hand geometry affect the size of the platen?

AFFORDANCE

First introduced into the world of human-computer interaction by Donald Norman in the book "The Design of Everyday Things" (Norman, 1988), affordance refers to the properties of an object that allow a user to perform an action. In designing systems, developers often look to create a sense of affordance so that users understand that they can interact with a product or system. With regard to biometric systems, this interaction may come in the form of a physical design (do users understand from the design of the hardware what actions they should take) or in the form of a systems' graphical interface (does the software interface invoke users to interact with the biometric system in an appropriate manner).

While actual affordance is a key component of any given system, it is also important for designers to consider perceived affordances. For instance, do users expect an action to

occur when in actuality the function doesn't exist? Understanding how users expect a system to perform is just as important as understanding how users interact with the intended affordances.

- Do users understand what to do when they encounter a biometric device or system?
- What actions do users perceive are available?
- What information does the biometric system provide to users to communicate the actions users should take?
    - For fingerprint readers, do users understand what actions they should take? Do they know where to place their finger(s)? Can they determine which finger(s) to use? Do they understand how to position and present their finger(s)? Do they know when the scan is completed?
    - For face recognition or iris/retina scanning, can users determine how to use these systems? Do they know how to position their bodies?
    - For voice recognition, do users know how to present their voice?
    - Etc…

ACCESSIBILITY

Accessibility refers to the ability of all types of users to successfully access and use a biometric system, including those who are visually- or hearing-impaired, individuals who use a wheelchair, and other types of individuals who may have difficulty using a product or system that doesn't take their needs into consideration.

- How can biometric designers create systems that will be usable for individuals who are visually-impaired and may have difficulty using posted instructional guides or feedback provided through a graphical interface? What other types of cues can be provided for this user population?
- What about hearing-impaired users who may have difficulty distinguishing or understanding audio cues?
- How can biometric systems be designed to accommodate users in wheelchairs, including the height of a system and allow ample area around the technology for users to access the system?
- What other types of needs should be considered? How can designers create a biometric system that is universally accessible and usable to all audiences?

By taking into consideration a users' inherent demographic characteristics, as well as instructional guides and feedback, anthropometrics, affordance, and accessibility, biometric developers have a much greater chance of producing a truly usable, user-friendly system.

USER-CENTERED VIEW OF THE BIOMETRIC PROCESS

In its entirety, the user-centered process involves all facets of the biometric system. This holistic view involves not only the system and its response to a presentation, but also the inherent qualities of users and their interaction with the biometric system.

The diagram below integrates these essential usability components to illustrate a truly user-centered process that takes into consideration the needs and characteristics of users instead of simply regarding users as inactive participants in the process.
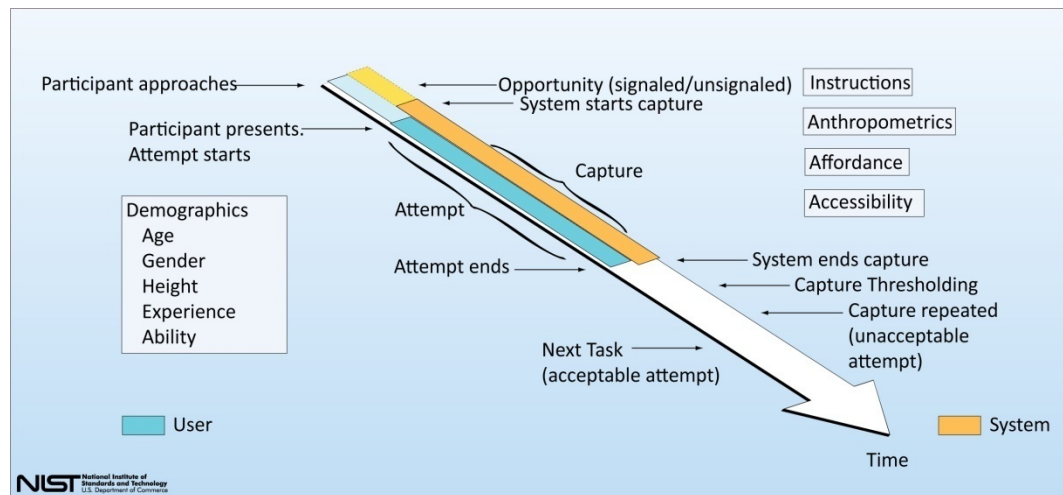
Figure 3: User View of the Biometric Process with User Attributes and Characteristics

By understanding the essential role a user plays in the biometric process and viewing the process as a two-way relationship in which the system and user are partners with the same goal in mind, we can begin to have a substantial impact on the design and usability of these systems. By coming to terms with the inherent characteristics and interactions users have with a system, design teams can make better informed decisions, thus taking some of the guesswork out of the biometric design process.

In the next sections of this handbook, we'll discuss a proven user-centered design process that will help designers and developers of biometric systems focus on the needs and characteristics of users in order to build a truly successful product.

CONCLUSION

In order to improve the usability of biometric systems, it is critical to take a holistic approach that considers the needs of users as well as the entire experience users will have with a system, including the hardware, software and instructional design of a system. Adopting a user-centric view of the biometric process is not only beneficial to the end users, but a user-centric view can also help to improve the performance and effectiveness of a system.

In order to understand the best way to improve the usability of a system, it is important to fully understand the components of a usable system. In the next chapter, we will take a closer look at the concept of usability and how it is defined.

Chapter 2
What is Usability

DEFINITION OF USABILITY

At its core, user-centered design is based upon the concept of developing a usable, useful system or product. To fully understand user-centered design, it is essential to understand the features inherent in a usable system.

Usability helps to ensure that systems and products are easy to learn, effective to use and enjoyable from the user's perspective. Defined 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." (ISO 13407:1999)

Looking closely at the definition, usability goals such as effectiveness, efficiency and satisfaction are specifically called out. Additional attributes of usability that you may also want to consider include:

- Effective to use (effectiveness)
- Efficient to use (efficiency)
- Enjoyable to use (satisfaction)
- Easy to learn (learnability)
- Easy to remember (memorability)

The table that appears on the next page lists each of these usability goals and provides a short description of each, along with a few questions for biometric system designers to consider.

When designing a usable biometric system, it is important to consider the various aspects of the user experience, including:

Usability Goals	Definition
Effectiveness	Measure of how well a user can perform a task: ▪ Can users *successfully* provide a high-quality sample? ▪ Can users *accurately* provide a sample?
Efficiency	Measure of how quickly a user can perform work and the error rate in doing so: ▪ Are users able to *quickly* accomplish goals? ▪ Can users perform tasks with *few errors*?
Satisfaction	Measure of user attitudes, perceptions, feelings and opinions regarding the system: ▪ How well does the interface *avoid inducing user discomfort and frustration?* ▪ Are users *intimidated* by using the biometric system?
Learnability	Measure of how rapidly a user can become productive: ▪ Can users *learn how to use* the biometric system? ▪ *How long* should it take a user *to learn* the interface? ▪ Are users able to use the system (to some defined level of competence) after instruction or training?
Memorability	Measure of how well a returning user forms a mental model of the biometric system and remembers how to use it: ▪ If a user has used the system before, can he/she *remember enough* to use it effectively the next time or does the user have to start over again learning everything? ▪ How do *experienced users* differ from infrequent/novice users? ▪ After not using the interface for a period of time, how long should it take for the user to get up to speed?

These usability goals can, and should, be translated into measureable usability objectives for your specific biometric product. Using these metrics, biometric designers and developers can assess a system's usability. Examples of commonly used usability criteria are:

Success rates: Can users successfully provide a high-quality sample? *(Effectiveness)*
Time on task: Can users quickly use the product? *(Efficiency)*
Time to learn a task: How long does it take a user to learn a product? *(Learnability)*
Number of errors made over time: Can users remember how to use it? *(Memorability)*
Users' satisfaction level: Are users uncomfortable using the system? *(Satisfaction)*

Specific metrics and ways to measure usability will be discussed in more detail in the chapter on Evaluation.

In its narrowest sense, usability involves the evaluation of a system; in its broadest sense, usability involves users throughout the requirements definition, design, development and evaluation phases of a technology to produce a system which is measurably easier to use, learn and remember.

Too often usability evaluations are carried out after a product has been designed and developed. Although, this can help to correct many of the things that should have been done right in the first place, it minimizes the impact a proven user-centered design process can have on a project. When usability evaluations are conducted at the end of a project lifecycle, recommendations and improvements are much more costly to make. By including users early on in the design lifecycle, it is possible to integrate user feedback and usability recommendations into the initial designs and draft prototypes, when it is much easier and less costly to make changes.

The importance of including users early on in the development process cannot be emphasized enough. The best and most successful systems involve users in the early stages of the design in order to continually evolve and refine the design in an iterative process.

CONCLUSION

A truly usable system takes into consideration the needs of users throughout the design, development and evaluation process. It involves:

- Analyzing the **context of use**
- Defining the **user and organizational requirements**
- Developing a **design solution** to meet those requirements
- Conducting **evaluations** to test the design against the defined requirements

The following sections of this handbook will introduce a user-centered design process that involves users throughout the product lifecycle to develop biometric systems that improve ease-of-use, reduce product complexity, enhance system performance, increase users' satisfaction, and minimize the number of errors that may occur.

Chapter 3
User-Centered Design

INTRODUCTION TO USER-CENTERED DESIGN

User-centered design is an approach to the design and development of a system or technology that aims to improve the ability of end users to effectively and efficiently use the product. It seeks to improve the user experience of an entire system from hardware design to software implementation, involving all aspects of a technology, including a system's by-products, such as help documentation and training materials.

By involving users in the design, development and evaluation of a biometric system, user-centered design works to create more usable products that meet the needs of its users. This, in turn, reduces the risk that the resulting system will under-deliver or fail.

User-centered design involves (ISO 13407:1999):
- early focus on users, tasks, and environment;
- the active involvement of users;
- an appropriate allocation of function between user and system;
- the incorporation of user-derived feedback into the (biometric) system design;
- iterative design whereby a prototype is designed, tested and modified.

This process is illustrated below:
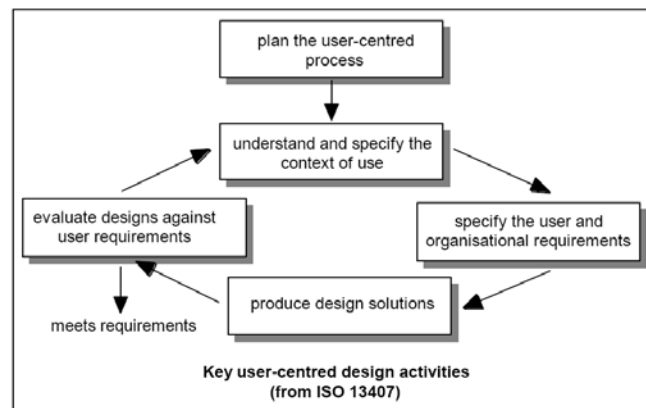
Figure 4: User-Centered Design Process (ISO 13407:1999)

Although there is a substantial body of knowledge and research regarding user-centered design and usability principles, much of this information is not yet integrated in the standard design and development processes of today's biometrics systems.

USER-CENTERED DESIGN FOR BIOMETRIC SYSTEMS

This handbook will outline a user-centered design methodology for the development of biometric technologies. This process is based on the International Organization for Standardization (ISO) standard mentioned above.

The user-centered design process outlined in this handbook includes:

- Defining the **Context of Use**
  Including operational environment, user characteristics, tasks, and social environment

- Determining the **User & Organizational Requirements**
  Including business requirements, user requirements, and technical requirements

- Developing the **Design Solution**
  Including the system design, user interface, and training materials

- Conducting the **Evaluation**
  Including usability, accessibility, and conformance testing

This handbook will outline each of the steps illustrated below in order to enable developers and designers of biometric systems to implement this proven process on their own projects.
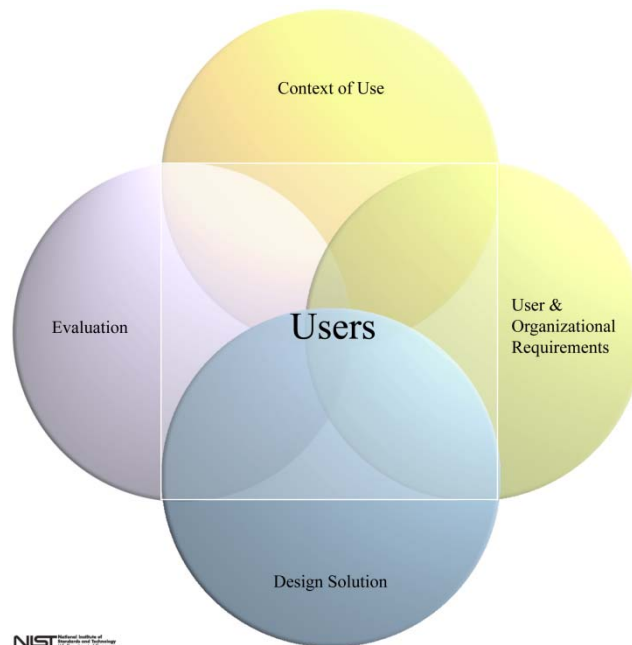
Figure 5: Biometric User-Centered Design Process

The key to this iterative process is that it is **User-Centered, Research-Based, and Performance-Driven.**

User-Centered:	▪ Identifies the types of users who will be using the system, including end users, system operators, and system analysts.
	▪ Ensures that the needs of users are considered in the design and development of the biometric device.
	▪ Includes users' feedback through user research and evaluation.
Research-Based	▪ Employs research to learn about users, their needs, their tasks, their environment, their level of experience, etc.
	▪ Conducts on-going research with users of biometric devices by observing users interacting with the actual system or product and identifying areas for improvement.
Performance-Driven	▪ Utilizes information gathered from users in the development to ensure that design decisions are data-driven.
	▪ Elicits continual feedback from users and measures user performance to ensure that design improvements have a measureable impact on users' effectiveness, efficiency and satisfaction (ISO 13407:1999) with a biometric system.

Independent of any product design lifecycle, user-centered design works as part of other development lifecycles, including waterfall, spiral and agile models. It is an evolutionary process in which project teams design, test and continually refine a system.

By following this iterative, user-centered design process, biometric development teams can have a measurable impact on the usability and ease-of-use of their systems.

BENEFITS OF USABILITY

Not only do usability improvements lead to better, easier-to-use products, they also lead to improved user performance and satisfaction as well as substantial cost savings. By designing a biometric system with usability in mind, development teams can enhance ease of use, reduce system complexity, improve user performance and satisfaction, and reduce support and training costs. Additionally, improved usability can result in a significant return on investment, including:

- Improved system performance, greater accuracy, and fewer attempts required
- Decreased time to capture an acceptable sample and increased efficiency
- Improved productivity and fewer errors
- Reduced need for assistance from system operators
- Decreased support and training costs
- Increased user acceptance

CONCLUSION

In this section, the various facets of the user-centered design lifecycle were introduced, including four main components:

- Defining the **Context of Use**
- Determining the **User & Organizational Requirements**
- Developing the **Design Solution**
- Conducting the **Evaluation**

In the next chapter, we will take a closer look at the context of use and how it is defined. The remaining chapters of this handbook will discuss each of the user-centered design phases outlined above. Additionally, a chapter on Usability Methods has also been included to describe some of the methods discussed in this handbook.

Chapter 4
Context of Use

DEFINE CONTEXT OF USE

The first stage of the user-centered design process involves defining the "context of use."

The use of all products, including biometric technologies, takes place within a context. The actual conditions under which a biometric system is used must be considered at the forefront of any project to ensure that the design of the system will meet the needs of users and the objectives of the organization once the system is implemented in a real-world environment.

Awareness of contextual factors is important throughout the development process. Context of use does not simply involve the users' context of use, it involves a much broader view of context, including the *business environment* in which the biometric system is being developed, the *operational environment* in which the system will be used, and the *social environment* in which the system will be implemented. For purposes of this document, we will focus mainly on the user environment and discuss the business environment more in the following chapter on User and Business Requirements.

To develop a usable product, the context in which the biometric system will be used should be considered from the very early stages of product design lifecycle.
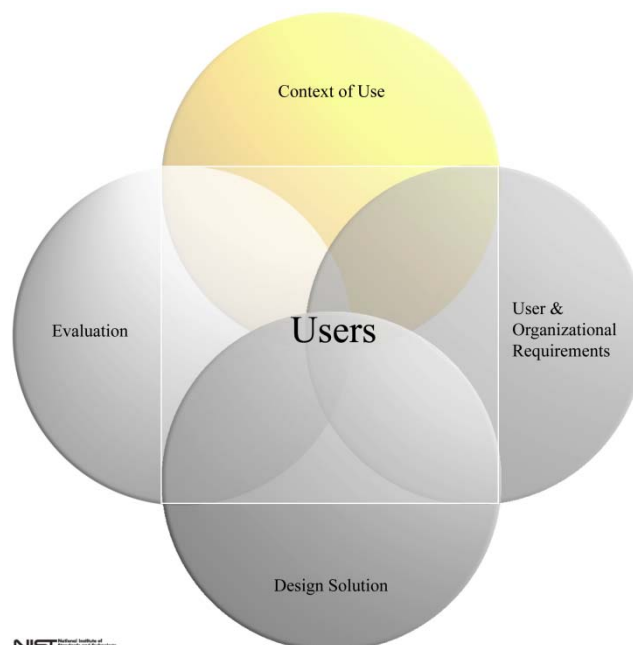
Figure 6: Context of Use within the User-Centered Design Process

Defining Your Users

The central objective of designing a usable system is to meet the needs of users within their operational context. To do this, it is imperative that users are involved throughout the biometric design process. The design of the system should:

- Focus on users' needs and expectations
- Involve users throughout
- Integrate feedback from users into the design

But before you can focus on users' needs and expectations, you must first identify who your users are. There are several different ways to categorize user groups, including:

Primary users: End users for whom the biometric system is primarily designed.

Secondary users: End users who interact with the biometric system, but not for its primary purpose or users who interact with the system infrequently.

OR

Direct stakeholders: End users who interact directly with the biometric system.

Indirect stakeholders: Individuals who may not directly interact with the biometric system but their performance is affected by the interaction of the direct stakeholders with the system.

To begin, simply identify your audiences.

Think about all of the types of users who may interact with your system on a regular basis and then create a list of these users. If your user population contains groups of people who use the system to perform different sets of tasks, or who have considerable differences in ability or experience, then divide them into separate user types.

Next, group the users into categories, such as primary or direct stakeholders and secondary or indirect stakeholders. In doing this exercise, consider the relative importance of each group and begin to create prioritized lists of user groups.

Primary or Direct Stakeholders: **Secondary or Indirect Stakeholders**

1. End User _____   1. System Analyst _____

2. System Operator _____   2. _____

3. _____   3. _____

4. _____   4. _____

5. _____   5. _____

Once this process is complete, begin to define the role each user will have with the biometric system. See below for an example.

Defining Users for a Fingerprint Reader

In considering the design of a fingerprint reader, there are at least three basic types of users:

USER GROUP	ROLE
▪ The end user	The person who provides the fingerprint
▪ The system operator	The person who operates the device
▪ The system analyst	The person who interprets the results

The end users and the system operators are *direct* stakeholders, in that they interact directly with the fingerprint reader. The system analysts are *indirect* stakeholders, in that they may not directly interact with the system but their performance is affected by the interaction of the direct stakeholders with the biometric device.

While this analysis defines, at a high-level, the types of users who use the system (both from the front-end and the back-end perspective), it is critical to define these audiences even more. For instance, within the End User group, there may be several subgroups, such as:

▪ First-time users	**OR**	▪ Younger users
▪ Frequent users		▪ Older users

While this is just a beginning, the tools and resources on the following pages will help biometric teams to better define and identify their user groups.

Understanding Your Users

Once you have identified and prioritized your users, the next step is to *understand* your users, their needs, interests and goals. Start by learning everything you can about your user audiences, including:

- Demographics and physical attributes
- Knowledge level, familiarity with the product, and skills
- Users' tasks and goals
- Users' environment and context in which they interact with the system
- Social and organizational environment

USER DEMOGRAPHICS

First consider the demographic and anthropometric characteristics of your users. The following list of characteristics is a sample list of attributes to consider. As you contemplate your design, take care to include any characteristic which may influence or affect the usability of your product, including:

- Age
- Gender
- Height
- Ethnicity, Nationality, Language and Culture
- Education
- Experience and Knowledge Level
- Attributes Regarding Accessibility

DO DEMOGRAPHIC DIFFERENCES AFFECT A DESIGN?

A recent study conducted by NIST to determine if experience and habituation would impact users' behavior and success with a fingerprinting device found that factors such as age and gender had an immediate impact on users' performance. (Theofanos, Micheals, Scholtz, Morse, & May, 2006)

How do you define user demographics?

- ☑ The User Demographics Table on the following page will help you identify the demographic characteristics of your users and will also be used in the next phase of the process User and Organizational Requirements to define possible user requirements.
- ☑ At this stage of the process, it is not necessary to define the user requirements, although a sample set of design questions have been provided in the following table.
- ☑ Please note, this exercise should be conducted *for each group of users* you identified in the previous section.

User Type: End User or Presenter

Characteristics	Questions to Consider: Defining the Characteristics	Questions to Consider: User Requirements
Age	*What is the average age range of this user group?* – *For example: 18-75.*	– *Do older users require larger text or louder audio cues?* – *Are younger users more successful?*
Gender	*What is the gender distribution?* – *For example: 50% Male/50% Female*	– *Is one gender more successful?*
Anthropometrics	*What is the average height of the population? What is the range?*	– *How does a user's height affect his/her ability to present?* – *Does the height of the system affect users' abilities to present?* – *Can the user reach the system?*
Ethnicity, Nationality, Language, Culture	*What kinds of users will access the biometric system? From which ethnicities and nationalities? Is there a common language or culture?*	– *If no common language exists, how does this impact the design of system feedback and instructional guides?*
Education	*What is the typical education level of your users?* – *For instance: Less than high school, high school diploma, college degree, advanced degree, etc.*	– *How does education affect system usage? Does the biometric system need to accommodate users with limited or no reading skills?*
Experience and Knowledge Level	*How many of the users will have experience with this system or a similar type of system?* *How many of the users will be new or first-time visitors?* *What is users' familiarity level with the biometric system?* *Have users had any type of training on the system?* – *For instance: Novice (Infrequent users), Intermediate (Moderate users), Advanced (Frequent users)*	– *Do the needs of first-time visitors differ from those of more frequent or regular users?*
Attributes regarding Accessibility	*Are there other characteristics that have not been considered?* – *For instance: Individuals with vision or hearing impairments, individuals who use a wheelchair, etc.*	– *How do these attributes affect the design of a biometric system? What design requirements must be considered to make the system universally accessible?*

Table 1: User Demographics

USER ENVIRONMENT

Once the user characteristics have been defined, begin to consider the context of use, including environmental factors, such as:

- When and where will users access the biometric system?
- What is the environment like?
  - Placement of device?
  - Height, angle and distance from portal?
  - Lighting?
  - Noise levels?
  - Temperature? Humidity?
  - Placement, type and format of instructions (signs, labels, icons)?
  - Assistance/Help? Will the devices be staffed or unstaffed? What types of help are available?

How do you define the user environment?

- ☑ The User Environment Table on the following page will help you identify the context of use and will also be used in the next phase of the process User and Organizational Requirements to define possible user requirements.
- ☑ At this stage of the process, it is not necessary to define the user requirements, although a sample set of design questions have been provided in the following table.
- ☑ Please note, this exercise should be conducted *for each type of environment* the biometric system will be available in.

User Environment: _____

Characteristics	Questions to Consider: Defining the Characteristic	Questions to Consider: Potential Effects
Location	*In what environment will the device be located?* *What are the physical characteristics of this location?* – *For example: Airport, Border Crossing, etc.*	– *How does the physical environment of this location affect or influence the design and usage of the system (i.e. Are sounds audible in an airport environment)?*
Placement of Device	*in what physical location (within in the environment) will the device be placed?* *What is the height of the device?* *Is there ample space for an individual in a wheelchair to maneuver?* *How will users access the device? Will there be waiting lines?* *Where is the device situated? On a desk? Table? Etc.*	– *How does the placement of the biometric device affect users' ability to use and access the system?* – *What types of spatial requirements are necessary to facilitate frequent use by a large number of users?* – *How does a user's height or the height of the system affect a user's ability to use the device?*
Temperature / Humidity	*What the average temperature for the device location? What are the extreme temperatures? Is the area humid?*	– *How does the outside environment affect the performance of a system?* – *How does temperature and humidity affect the capture of a high-quality sample?*
Lighting	*What types of lighting are utilized?* *Will the system be utilized at night as well as during the day?* – *For instance: Low light, florescent lighting, natural light (sunlight), night light, etc.*	– *How does the level of lighting affect the readability or visibility of graphical displays?*
Noise	*What is the noise level?* – *For instance: Quiet, noisy, etc.*	– *How does the noise level affect an individual's ability to hear audio cues and feedback provided by the system?*
Instructions	*Where are instructions placed?* *What is the format of instructions (signs, labels, icons)?* *Are users supposed to review instructions prior to presenting (i.e. while waiting in line)?* *What size are the instructions?*	– *If instructions are posted, are the icons and lettering large enough for all to see?* – *Are the instructions obstructed?* – *What is the appropriate height to place instructional guides?*
Assistance / Help	*What types of help and assistance is provided?* *Is the device staffed or unstaffed?*	– *Given the environment, what is the best way to present error feedback and help information?*

Table 2: User Environment

USER GOALS & TASKS

Once the user characteristics have been identified, it is time to turn your attention to conducting a user and task analysis, including answering questions such as:

- Why will these stakeholders use your system? What is the user's purpose?

- What are the needs, interests and goals of your users?

- Are users cooperative or not cooperative?

- How will users interact with the system?

- What are the key tasks a user must perform?

- Which tasks will users perform frequently?

- Which tasks are critical to a user's success with the biometric system?

- Which tasks are critical to the success of the organization?

How do you define user goals and tasks?

- ☑ The User Tasks & Prioritization Table on the following page will help you define the tasks that users will need to perform and rate the task based on:
  - o Frequency of use *(How frequently will users perform this task?)*
  - o Importance *(How critical is this task to users? To the organization?)*
  - o Feasibility *(How feasible is it to include this function in the design?)*
  - o Vulnerability *(If this is an existing system, is there reason to believe that this task is prone to usability issues?)*

- ☑ At this stage of the process, it is not necessary to define the importance of a task to the organization, the feasibility of a task, or the vulnerability of a task to usability issues.

- ☑ During the User and Business Requirements phase, you will re-visit this table to prioritize users' tasks with regard to the organization's objectives.

- ☑ During the Design phase, you will evaluate the feasibility of each task to determine which tasks should be translated into biometric system requirements.

- ☑ During the Evaluation phase, you will consider the vulnerability of a task to usability issues. Tasks that are susceptible to usability issues and are also important to users and the organization should be at the top of the list of things to evaluate.

- ☑ Please note, this exercise should be conducted *for each group of users* you identified in the previous section.

User Type: Operator of a Fingerprint Device

Task	Frequency of Use?	Importance to User?	Importance to Business Objectives?	Feasibility?	Vulnerability to Usability Issues?
1. Collect demographic data from each user, including: gender, date of birth, and country of origin.	*High*	*High*	*To be completed in the User and Business Requirements Phase*	*To be completed in the Design Phase*	*To be completed in the Evaluation Phase*
2. Collect biometric sample (fingerprint).	*High*	*High*			
3. Assist users with questions about the system.	*High*	*High*			
4. Troubleshoot system errors.	*High*	*High*			
5. Register each individual user and establish user identity within the database.	*High*	*High*			

Table 3: User Tasks and Prioritization

Once these high-level tasks have been defined, development teams should break each task down into its subcomponents. Many teams find that the development of use cases can be a particularly effective way to document this step-by-step process. Use cases are used by many software development teams to document the way a user interacts with a system, under various conditions. A use case is usually a text document (but it can be in the form of a process diagram) that describes the steps a user takes to accomplish a goal. For each step the user takes, a use case documents the system's response to the user's action. By documenting a user's interaction and the associated system response, use cases can be a very effective way to document system requirements that take into consideration a user's needs and interactions when accomplishing a task.

Researching Your Users

In the midst of defining, understanding and documenting user characteristics, the question usually arises, "What if I don't know who my user audience is?" or "What if I know who my audience is, but I don't know very much about them?"

When this occurs, there are several ways to go about learning about your users:
1. Begin by interviewing key stakeholders within the organization. Ask leadership and managers who they believe the target user audiences are.
2. Review existing data about your user population, including past results from surveys, focus groups, interviews, etc.
3. Conduct new research to learn about your audience.

Conducting research with users is an essential step in the user-centered design process. There are numerous ways to learn about your users at this stage of the process, including[2]:

- ☑ User Surveys
- ☑ Focus Groups
- ☑ User Interviews
- ☑ Contextual Inquiry / Naturalistic Observation
- ☑ Cognitive Walkthroughs
- ☑ Usability Testing

While primary research directly with users is far superior to the opinions of colleagues and management, it is not always feasible to conduct this type of research. Sometimes access to users of biometric systems can be limited or resources/time do not allow for primary research to be performed. In these instances, it is best to talk with stakeholders within your organization who have had direct contact with users and to learn all that you can through this second-hand interaction.

Remember, time spent in the early planning phases learning about users generally saves time and development costs in the later phases, when usability issues are much more costly and time-consuming to fix.

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[2] Please see the section on Usability Research Methods for more detail on each of the methods listed above.

CONCLUSION

A thorough analysis of your existing biometric system and users' interaction or context of use with that system is a critical first step to designing a truly usable system. By understanding your users and their tasks with a system, including how their demographics, abilities and environment affect the use of a biometric system, and its eventual success, your project team will be better positioned to develop a successful product.
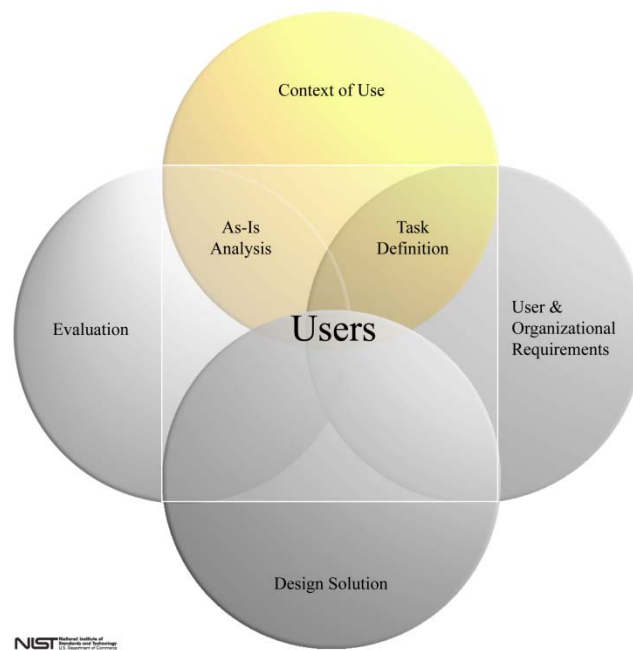
Figure 7: Components of the Context of Use Phase

This in-depth understanding of a biometric system's context of use is key to identifying the user and organizational requirements that will ultimately impact the design and development. The following chapter will discuss how to use the information analyzed in the Context of Use phase to develop user requirements that will ultimately impact the performance of the system and the resulting success of the organization.

Chapter 5
User & Organizational Requirements

DETERMINE REQUIREMENTS

The requirements phase of the development lifecycle typically occurs after the product team has established a thorough understanding of the biometric system's context of use and users.

The goal of any requirements analysis phase is to create clear, unambiguous requirements for a biometric system so that the entire development team thoroughly understands what the system should do and how it should work. There are many types of requirements including:

- Business and Organizational Requirements
- Environmental and Physical Requirements
- Functional Requirements
- Nonfunctional Requirements
- Technical and System Requirements
- User Requirements

Each of these types of requirements may have usability components, in addition to other requirements. The requirements suggested in this document are not meant to be all-encompassing, but simply highlight some of the potential usability issues that may be documented.
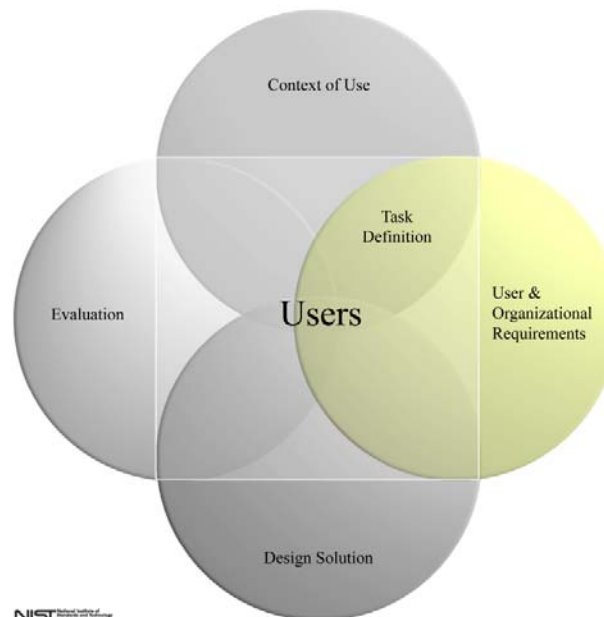
Figure 8: User & Organizational Requirements within the User-Centered Design Process

Understanding Different Types of Requirements

Requirements analysis can be quite detailed with varying levels of complexity.

Many teams may find themselves with several types of requirements documents, while other teams may only have one requirements document.

No matter the number of requirements documents, it's important that your requirements address the key factors affecting your design. In the following section, we will discuss some of the types of requirements you may want to consider for your biometric project.

> ***User Requirements*** are requirements that are based on the needs of the users.

> ***Business and Organizational Requirements*** are requirements that the organization has for a product or system. These requirements are typically established to help the organization achieve its business goals and are usually focused on high-level business objectives.

> ***Environmental and Physical Requirements*** are requirements about the physical environment that the system will be used in, or the context of use. These requirements are established to ensure that design teams take into consideration the physical attributes of the environment, including location, lighting, noise levels, etc.

> ***Functional Requirements*** are requirements that specify the features and functions that the system will support. In short, the functional specifications identify the tasks necessary to fulfill the business requirements. While, the high-level business requirements specify the "why," the detailed functional specifications identify the "what." It is important to note that functional requirements do *not* specify the "how." Determining how to fulfill a requirement is something that is determined during the design phase.

> ***Nonfunctional Requirements*** are requirements that cannot be described by a single feature or function. They are broader requirements for the product/system and may include things such as look and feel requirements, usability requirements, performance requirements, social requirements, legal requirements, etc. Although nonfunctional requirements are not tied to a specific feature or function and are used to describe the overall attributes and characteristics of a system, they can lead to more specific functional requirements.

> ***Technical and System Requirements*** are requirements that detail the technical environment that the system will be built on, including hardware and software requirements. These requirements may also include items such as security needs, database structures, supported platforms, etc.

The following sections will describe each of these types of requirements in greater detail.

USER REQUIREMENTS

First and foremost, it is essential to document user requirements. These requirements should document what the system is required to do to meet users' needs, not what the system requires of a user. It is important to note that users should not be required to have specific skills to use a system. As designers of biometric systems, it is essential that we understand our users' characteristics and any implications for biometric system requirements.

At this point in the process, re-visit the user analysis you completed for each audience and review the potential user requirements identified. Ensure that all of the requirements documents created address users' needs and requirements.

BUSINESS AND ORGANIZATIONAL REQUIREMENTS

In any technology environment, it is essential to ensure that the product developed meets the needs of the organization, as well as the needs of the users. The business requirements help to specify what the organization wants to achieve. Many times, business requirements are fairly high-level and do not address specific functionality.

Example business requirements:

- To create a system that will accurately and efficiently collect biometric samples.
- To reduce the number of system errors.
- To design an intuitive interface that will decrease the amount of assistance/help required to use the biometric device.

In order to determine the organizational requirements, begin by posing the following questions to your management team:

- What is the purpose of the system?
- What are the goals for the product?
- How would you describe the system?
    - From an organization's standpoint?
    - From a user's standpoint?
- What outcomes would you like to achieve?
- How would you define a successful system for your organization?

Once you've created a list of goals for your biometric system or product, try to see how well your organization's goals match up with the goals you identified for your users. It's is critical to the success of the product that the goals are closely aligned.

For instance:

Organization's Purpose / Goals	Users' Purpose / Goals
▪ To create a system that will collect accurate biometric samples in the most efficient manner possible, with the highest possible throughput.	▪ To quickly pass through customs and border patrols with as little inconvenience as possible.

In the example above, it's easy to see that the organization has a desire to process individuals as efficiently as possible, just as users have a desire to complete the task as quickly as they can. In this instance, both parties want an efficient system that will speed users through the process.

Mapping organizational goals to user goals is a key step in the process to ensure that the system you are designing will meet both the needs of your organization and the needs of your users.

FUNCTIONAL REQUIREMENTS

Functional requirements define what a biometric system must do; they do not specify how the system will be implemented.

In defining these requirements, it is essential to re-visit the user tasks identified in earlier stages of the user-centered design process. By considering users' tasks and their context of use, it is easier for design teams to develop workflows and requirements that will meet the needs of users and ultimately help improve the usability of a biometric system. In defining functional requirements, begin by clearly stating the goal of the system. An example:

The system shall provide feedback to a user to let him/her know when an acceptable sample is captured.

Note that the requirement states the goal of the system, but does not define how the biometric system will provide feedback. This decision is left to the design team to make once they have had an opportunity to review all of the system requirements.

Once all of the functional requirements are written down, you will want to formally document these requirements. There are several ways to document your functional requirements, including: use cases, Unified Modeling Language (UML), process diagrams, task flow diagrams, task scenarios, etc. Since many of the requirements documents are quite detailed, it is essential to document each feature step-by-step. By breaking down each task into its subparts and creating task workflows, it is easier to create a functional specification that more closely matches the needs and experiences of users.

NONFUNCTIONAL REQUIREMENTS

Nonfunctional requirements identify requirements for a system that are not specifically tied to a feature or function. They may include:

- Graphic design requirements (or look and feel) – *The design of the system must reflect the corporate branding of the organization.*

- Usability requirements – *At least 75% of users will be able to successfully use the system without assistance or help.*

- User Experience – *The system will provide users with a consistent interface, interactions and affordances.*

- Performance requirements – *The system will accurately collect samples from 90% of users on the first attempt.*

- Social requirements –*The system shall mitigate users' perceived health risks of biometric devices.*

- Legal requirements – *The system shall protect the privacy of the end users who submit samples.*

Nonfunctional requirements help to guide the development of the overall system.

ENVIRONMENTAL AND PHYSICAL REQUIREMENTS

Based on a review of the context of use, environmental requirements should be created to address the attributes and characteristics of the physical location where the system will be located.

These requirements may involve determining the optimal height of a biometric device, defining interaction styles based on noise and lighting levels, and/or specifying space and furniture requirements.

While these requirements primarily depend on an evaluation of the physical surroundings, it is also important to review how users are affected by environmental factors and adjust the physical design of a biometric system based on users' characteristics. For instance, the optimal height of a biometric device should be based upon a thorough evaluation of the physical environment where the device will be located, but also should take into consideration common anthropometrics, such as the average the height of your user population. Additionally, these decisions should also be supplemented by observation of users in real-world settings to evaluate users' posture, as well as how users of differing heights utilize the system. Based on an analysis of these factors, a suitable height should be defined and included in the requirements documentation.

Additionally, it may be necessary to develop a distinct set of environmental requirements for *each* physical location in which a product/system will be located. For instance, a noisy environment may require different requirements than a quiet location, just as a system located under low light may have different requirements than a system which is in direct sunlight.

Below are some example requirements for different types of environmental factors:

- *Noisy Environment*
  A requirement could be that the system relies on visual and other types of non-auditory feedback, as users may not be able to hear audio feedback in a noisy location.

- *Low Light*
  A requirement may specify that interaction screens, visual cues and colored displays are bright enough to be seen in locations with poor lighting. Or the requirement could require that supplemental lighting be provided to adequately light the system.

- *Natural Light*
  A requirement may stipulate that in outdoor settings, it is best to rely on audio and other types of sensory feedback as the direct sunlight might produce a glare, making it difficult to see visual feedback. Or the requirement could entail developing screens that do not reflect light and reduce the amount of glare. Another requirement could be to use screen filters as a way to reduce the potential problems of glare.

- *Temperature and Humidity*
  A requirement might state that the system is able to sustain extreme temperatures and high levels of humidity. Or the requirement may state that the system must operate within a range of temperatures and humidity.

In each of the above examples, there may be more than one way to address an issue and therefore, the implementation may vary from project to project.

Additionally, since devices may be used under a variety of conditions and in a plethora of locations, it is essential to review the physical attributes of each location and define common environmental requirements to address the differing needs.

TECHNICAL AND SYSTEM REQUIREMENTS

In developing your biometric system, it is also essential to document the hardware and software systems upon which the product will be based. The requirements should identify any issues or constraints regarding the technical environment and should also specify system requirements for the security and maintenance of the device.

Researching Your Requirements

In order to understand and document the requirements for your biometric system, you will need to have a thorough understanding of:

- Your user audience
- Your organization and management objectives
- Your current system and goals for future improvements
- Your competitors' products

Additionally, you should be aware of the environmental, physical, social, and technical factors affecting your system. Armed with this knowledge, you should be able to create clear, unambiguous requirements which will drive the design and development of a usable biometric device.

In order to ensure you have adequate information to write and develop effective requirements, consider conducting the following types of research: [3]

- ☑ User Surveys
- ☑ Focus Groups
- ☑ User Interviews (including interviews with internal leadership)
- ☑ Contextual Interviews/Naturalistic Observation
- ☑ Cognitive Walkthroughs
- ☑ Expert Reviews
- ☑ Competitive Analysis
- ☑ Usability Testing

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[3] Please see the section on Usability Research Methods for more detail on each of the methods listed above.

CONCLUSION

In order to identify and define the requirements of your system, it is essential that biometric project teams take into consideration many types of requirements, including:

- user requirements,
- business and organizational requirements,
- environmental and physical requirements,
- functional requirements,
- nonfunctional requirements, and
- technical and system requirements.

To define these requirements, it is critical that you have a clear understanding of your users, their context of use and the tasks that they will use the system for. The design decisions that you make based upon the requirements set forth will ultimately have a great impact on the user experience of the system.
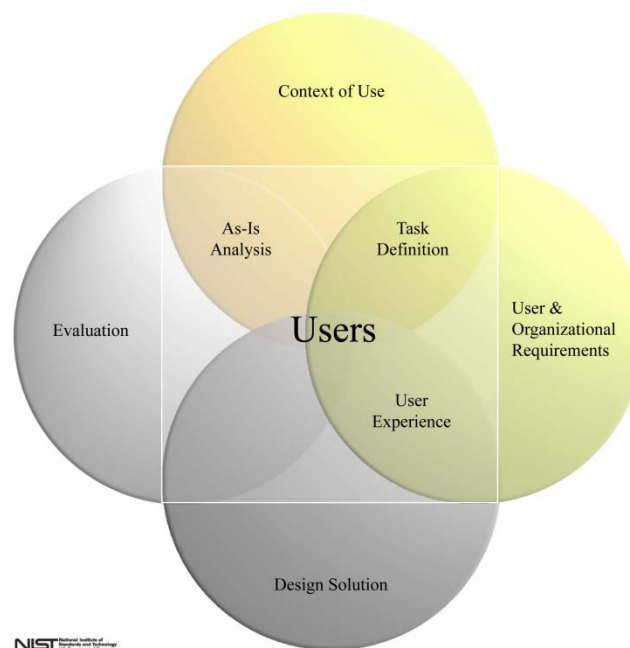
Figure 9: Components of the User & Organizational Requirements Phase

The following chapter will provide additional detail on designing a usable system that not only improves the user experience, but also improves system performance and throughput.

Chapter 6
Design Solution

DEVELOP THE DESIGN

Once the requirements have been identified, the design team can begin to evaluate ways to address each requirement and specify a design solution. The design solution should encompass the entire product/system including the design that end users will interact with, as well as the design that operators and system analysts will use. It is important to note that the design considerations should not be limited to end users, but should also take into consideration those users who will be operating the systems and analyzing the data.

When considering solutions for the system design (hardware/software), the interface design (the way the system will interact with users); instructional design (method and materials presented prior to users approaching the system); and training/support design (help materials for end users and operators to effectively use the system), consider the following two questions:

- What are the needs of my end users (or the individuals providing a sample)?
- What are the needs of the operators / analysts managing the system?

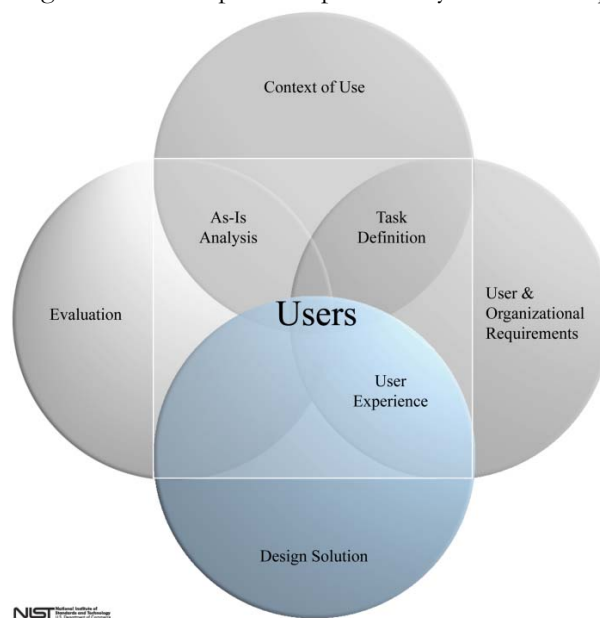Collectively, these design elements help to comprise the system's use experience..

Figure 10: Design Solution within the User-Centered Design Process

When considering the design of a solution, it is important to consider both the interaction design, as well as the interface design. Ideally, these design elements work together to provide a seamless experience for users (both end users and system users).

Interaction Design

Simply put, interaction design is a method used to define the way a system responds to a user's actions. The goal of interaction design is to define the behavior of a system, without implying any look and feel (or interface design) requirements. The interaction design is the foundation upon which the interface design will be built.

This process involves several steps that focus on the tasks a system will perform. To begin:

- Define the tasks that the system will perform, based on the task analysis conducted during the Context of Use and User and Organizational Requirements phases.
- Review each task and identify the sub-steps of each task.
- Identify user interactions for each task and the associated system response.
- Create a use case or workflow diagram to document these tasks and interactions.
- Define how the system will work for each step in your task flow or workflow diagram.

To simplify the process, begin with a very simple task and work your way to more difficult or complex tasks a system will perform. For each task, ask yourself:

- When will this process begin?
- What initiates the process? Does a user initiate a process, if so, how?
- How does the system respond to a user's action? What type of information does the system need to communicate with a user so that the user knows what to do next?
- When does the process end? How will the user know that the task is finished and that it was successful?
- If the task is not successful, how will the user know that there was an error? What types of feedback or messages will the system communicate to a user to help them correct the error and complete the task successfully?

These questions all focus on ensuring that the user and the system are working together, in a partnership, with the same end goal. Each step of the process is considered from a user's viewpoint as well as from a system viewpoint, taking care to identify the types of feedback needed to keep the interaction moving along.

Interaction design is similar to a conversation; a conversation between the user and the system. For each action a user makes, the system must respond. Thus, a solid interaction design specification is needed. This process takes into consideration how a system should

behave throughout an entire task and also tries to consider the possibility for errors along the way.

At each point in the process, an error can occur. A user may become confused and not know what to do next, a user may not be able to tell when a task is finished, or a user may prematurely think a task is completed before it actually is. Numerous types of errors may occur at any point in the process. Therefore, it is necessary to consider how a system will work to avoid errors, and when errors do happen, how the system will provide feedback to a user, so that the user may continue the task. It is this type of feedback or conversation that is necessary for the system and the user to work in partnership toward the end goal.

For instance, let's look at the task of a user providing a sample. First consider:

- When does the task begin? Does it begin when a user places his/her finger on a fingerprint reader? Or does it begin much earlier when a user, waiting in line, reads posters or other instructional guides before approaching a system?
- What types of messages does the system provide the user so that the user knows what to do? How does the system communicate to the user so that the user knows how to provide a sample?
- Once the user initiates the task, what types of feedback does the system provide to the user to let him know that he is positioning his hand/finger appropriately?
- How does the system let the user know when the sample has been successfully captured?
- If there is an error, what types of feedback are provided? Does the system let the user know that the quality is poor? Or that the positioning was off? Or that a user needs to apply more/less pressure? What types of tips or guidance are provided so that a user can correct the error?

These are the types of questions that biometric system designers need to consider when defining an interaction specification.

To create a successful interaction design for a biometric system, developers need to think of each task as a conversation between the user and the system. Each step within the process needs to be considered so that a user and a system can successfully exchange information to accomplish a task. This information should be documented in an interaction design specification which will serve as the foundation for the interface design.

Interface Design

During the interaction design stage, the team focuses on "what" the system will communicate and "when" it will communicate with users, whereas, the interface design stage defines "how" the system will communicate with the user.

At this point in the process, biometric developers begin to think about the best way to communicate with users. Designers may consider many design options, such as:

- Should the system provide a graphical interface or menu structure to users?

- Should textual messages be provided on the screen?
- Should the biometric device provide visual cues, such as lights or other cues?
- Should it provide audible cues?
- Should the hardware be shaped in a specific way (i.e. conformed to the shape of a finger to signal how a user should position her hand)?

All of these design questions are focused on the interface and how the interface will work. When considering the interface design, it is important to consider providing feedback to users in multiple ways. If a system relies on only one method to provide feedback, it may fail to meet the needs of users who cannot understand the method selected. For instance:

- If a system uses text to communicate to users, which language should be used? Will the system support multiple languages? Will Braille be provided?
- If a system provides visual cues, will those cues be visible during daylight hours if a system is used outdoors (i.e. border crossings)? How will blind or visually impaired users interact with this type of system?
- If the system uses lights or colors to signal success, are the colors chosen universally understood? For instance, if red is chosen to signal an error, does this color communicate across nationalities and cultures?
- If a system relies on audible cues, will those cues be heard in noisy environments such as airport security lines? How will hearing-impaired users interact with the system?
- If a system is shaped or contoured to help users position their hands/fingers, will that shape accommodate different hand shapes and sizes? Will it be positioned so that tall individuals as well as shorter individuals can reach it? How will individuals in wheelchairs be accommodated?

The design of a user interface is a complex process that must consider not only the content of a message, but also the most effective way to deliver that message.

CONCLUSION

Since there are so many ways to design a system, it is helpful to try out several different designs and evaluate the success of each design with users. That way, the best elements from each design can be merged into the end-resulting biometric system.

By involving users early on in this process when it is still easy to make changes to a design, biometric system designs can have a much more measurable impact on a system's usability. Waiting until the end to solicit user feedback is dangerous, as many times the feedback is received too late to make any substantial changes.
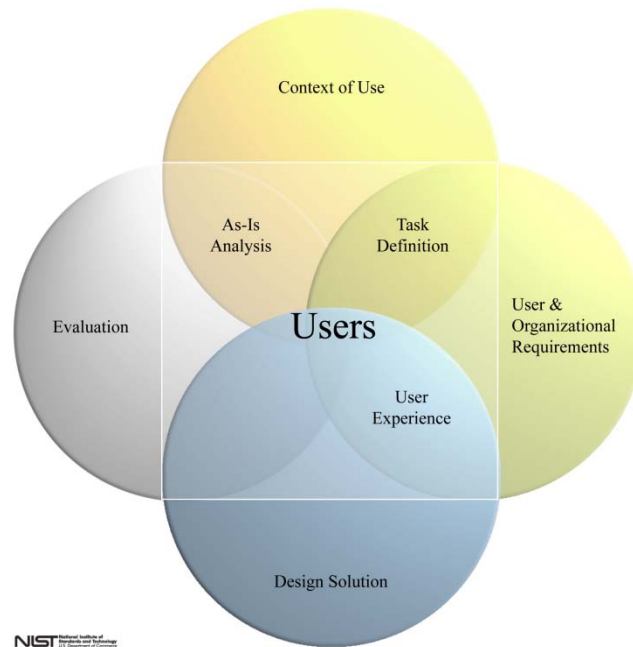
Figure 11Components of the Design Solution Phase

Additionally, we've found that users are also much more willing to give critical feedback about a rough prototype that is still in design and are less likely to be critical about a fully functioning system. This is yet another reason to solicit feedback during the early stages of the design process.

The design process should, in fact, be seen as an iterative process, whereby prototypes are evaluated with users and revised until a system is measurably easier to use.

This process ensures that the system is being developed with users in mind and helps to prevent any show-stopping issues from being discovered too late in the process.

Chapter 7
Evaluation

CONDUCT THE EVALUATION

Evaluation is an essential part of any project development lifecycle. It ensures that the design is on the right track and helps to identify issues that still need to be resolved.

A well-conducted and well-planned project will have several rounds of evaluation, at varying levels of fidelity. By incorporating user feedback throughout the design of a system, it is easier to identify major problems or flaws in a system at a much earlier stage. In the diagram below, it is important to note that the evaluation and design stages overlap.
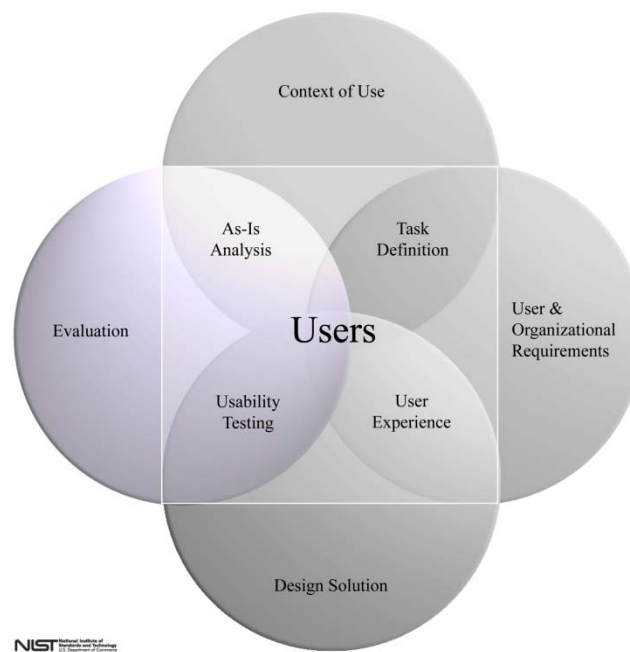
Figure 12: Evaluation in the User-Centered Design Process

Too often, design teams consider evaluation to be the final stage and wait to conduct any type of system evaluation until the entire system is nearing completion. This presents several risks. One major risk is that the evaluation may reveal major issues with the system that are too costly or too difficult to make in the latter stages of development. Therefore, we strongly suggest an iterative design process, wherein biometric project teams share design concepts with users in the early stages of development, when it is easier to make design changes.

ITERATIVE DESIGN & EVALUATION

In an iterative design process, users are asked to review concepts throughout the design process and based on the results of the evaluation, the design is revised in order to improve user performance and satisfaction.

In order to involve users as early as possible, users may be asked to evaluate low-fidelity designs or even a series of paper prototypes. As the design process evolves, the fidelity of the prototypes is also likely to progress and eventually result in a high fidelity test of a functioning system.

It is also important to note, that the number of users involved in these evaluation processes it typically much lower than that required to test for performance measurements. Whereas it may require hundreds of thousands of users to test a system's performance for captures, a usability evaluation may include as few as eight users. The small sample size required to conduct usability evaluations makes it much more realistic to conduct several iterative tests throughout the design and development of a biometric system or device.

TYPES OF EVALUATION

During the design and evaluation phases, the types and frequency of the evaluation may vary. At the earlier stages of the design, the evaluation may be more qualitative, where users are asked their impressions or reactions to initial designs. In the latter stages of development, biometric systems may be tested with users in a more quantitative usability test, where users' performance using the system is measured.

It is important to note that the best approach to evaluation combines both qualitative and quantitative evaluations.

Qualitative Feedback

Qualitative feedback is important in the design of any system. This type of feedback may come in a variety of forms, including:

- Asking users about their expectations of what the system will do and how it will function
- Observing users interacting with a system while 'thinking aloud' and noting areas that cause user confusion or frustration
- Probing for suggestions from users and asking users about their level of satisfaction with the system

Users' comments and concerns can be an extremely important way to learn whether or not the design of the system matches users' expectations of how the system should act. Although users' comments can be extremely informative, it is also essential to understand how well users can perform using the system in order to quantitatively measure the effectiveness of a design.

Quantitative Feedback

In order to evaluate the success of a design it is important to measure how well users are able to accomplish tasks using the system. Examples of quantitative measures that may be measured include:

- **Task Completion Rates:** Percent of users who successfully complete each task
- **Time on Task:** Time it takes for users to perform a task from beginning to end
- **Error Rates:** Number of errors made during the course of a task
- **Satisfaction Rating:** Satisfaction scores for the system

Many biometric design teams will begin the design process with a quantitative usability test, known as a baseline or benchmark usability test. The results of this test are used to measure the effectiveness of future design improvements. Many teams use the Common Industry Format (CIF) (ISO/IEC 25062:2006) to document the performance of the system. The CIF provides a standard way for organizations to present and report quantitative data gathered in a formal test. This report can be used as a benchmark for future comparisons.

Following the benchmark test, design teams typically revise the system to improve the system's effectiveness and efficiency. Once the changes have been made, the design team may repeat the same test methodology as the baseline test in order to determine if the changes have made a measureable impact. Typically, design teams hope that the changes improved users' success rates, decreased the time it takes to perform a task, decreased the number of errors made by users, and increased users' satisfaction with the system.

It is these types of metrics that can help a design team stay focused on making data-driven, performance-based improvements. In this environment, project teams try to make recommendations for improvement that they believe will improve the performance of the system and have a measureable impact on the effectiveness and efficiency of the system's design.

To learn more about usability testing, please see the chapter on usability methods.

CONCLUSION

Evaluation is a critical component of any design process and product improvement lifecycle. Without continual feedback from users, design teams suffer and end up operating blindly, not knowing whether design recommendations will actually improve the usability or a biometric system or worse case, make the system more difficult/confusing to use.

Armed with the results of an evaluation, design teams can operate much more efficiently and can focus their energy on design changes that will have the greatest impact on user performance and satisfaction, placing less emphasis on cosmetic changes that may only have a minor impact on the performance of their system. Teams that are able to effectively and accurately prioritize resources are much more cost-effective and productive in the long run.

Chapter 8
Usability Methods

The following sections will provide information on various usability techniques and research methods including:

- ☑ As-Is Analysis

- ☑ Cognitive Walkthroughs

- ☑ Competitive Analysis

- ☑ Contextual Inquiries / Naturalistic Observation

- ☑ Expert Reviews

- ☑ Focus Groups

- ☑ Parallel Design

- ☑ Usability Testing

- ☑ User Interviews

- ☑ User Surveys

AS-IS ANALYSIS

What is this method?

An As-Is Analysis is a complete evaluation of the existing system in its current state.

When should it be used?

It is important to conduct an As-Is Analysis at the beginning of any project in order to better understand the current system, its strengths and its weaknesses. By conducting a thorough analysis of the existing system, design teams can effectively develop system requirements and design solutions that better meet the needs of users. These 'targeted' design decisions will be much more effective in designing a usable, user-friendly product.

While it is critical to conduct an As-Is Analysis at the beginning of any large design project, it is also essential to continually evaluate the design of your system throughout the entire project lifecycle. By continually monitoring the quality of your product, you are in a much better position to implement improvements that will have a measurable impact.

How do you conduct an As-Is Analysis?

An As-Is Analysis should collectively evaluate and measure as many facets of a product as possible. This may mean that you need to gather data from multiple sources, including:

Performance data	▪ Throughput
	▪ Ratio of submissions to successful captures
Observational data	▪ How do users currently use the system?
	▪ When do they struggle?
	▪ Which aspects of the system cause confusion or frustration?
User Feedback	▪ Do users request assistance?
	▪ What is the most common concern or frequently asked question?
	▪ Do users use the help documents or instructional guides provided? If so, how?
	▪ Do users require training? If so, where do they struggle the most?

User Interviews and Surveys	▪What do users think of the system?
	▪Which aspects do they believe are the most difficult to use?
	▪What suggestions for improvement can your users offer?
Usability Testing	▪Which aspects of the system are the most difficult to use?
	▪Which are the easiest to use?
	▪What causes users to struggle?
	▪What improvements can be made to address these issues?
Expert Reviews	▪Which areas of the system do usability experts believe are vulnerable to usability issues?
Competitive Analysis	▪How does your product compare to your competitors?
	▪Are there aspects of your competitors' products that perform better than yours?
	▪How can you create a product that will outperform that of your competition?

What are the benefits/limitations?

An As-Is Analysis takes into consideration all of the types of feedback and evaluation conducted on your system to give design teams an overarching view of the system. This process is an extremely useful process and one that can be used to benchmark the performance of your existing system, so that the success of future design changes can be measured and quantified.

With a broad knowledge of the various facets of your system and your users, development teams can effectively target design decisions and changes. When requirements and design decisions are not based upon this deep foundation of knowledge, design teams are operating blindly, making choices that may or may not impact the actual system performance. Many teams have labored over system requirements and the various ways to implement a particular feature or function, only to have expended a lot of time, energy and resources on a feature that will not truly have an impact on the ultimate performance of a system and the users of that system.

It is critical to conduct a thorough As-Is Analysis, in order to make targeted, effective design decisions that will enhance the ease of use, reduce system complexity, improve user performance and satisfaction, and reduce support and training costs.

COGNITIVE WALKTHROUGHS

What is this method?

Cognitive walkthroughs are an 'inspection' method (which means that actual users are not involved in the process). It is a method in which a usability expert or a group of experts inspect the system by walking through a set of tasks as a user would, noting any problems or difficulties a user may encounter. Although typically conducted by a usability expert, cognitive walkthroughs can be conducted by anyone with a thorough understanding of the system including software engineers, system designers/developers, documentation specialists, subject matter experts, etc.

When should it be used?

Cognitive walkthroughs can be performed at any stage of design but typically occur during the early design stages and may be conducted on paper prototypes, low-fidelity prototypes or fully functioning biometric systems.

How do you conduct a Cognitive Walkthrough?

The first step to conducting a Cognitive Walkthrough is to review the data gathered and analyzed during the Context of Use and User / Organizational Requirements phases. To conduct a Cognitive Walkthrough, begin by answering the following questions:

Users
- Who are the users of your biometric system?

- Who are the primary users? Secondary users?

  Consider all aspects of use, including the end user, the system operator and the system analyst.

  Now select one user type for your cognitive review.

Tasks
- What tasks will users perform using the system?

- Is this a repeat task for users?

- What type of knowledge will users have going into this

task? What is their experience with the system?

Once you have selected a set of tasks to evaluate, you must break each task down into its sub-parts. By breaking the task down into smaller sequential steps, it is easier to tell when the system does not meet users' expectations.

Once you have selected a user profile and a task, the individuals conducting the Cognitive Walkthrough use the system to perform the task as though they were seeing the system through the eyes of the user. By stepping into the role of the user, the experts evaluate the system looking for issues or problems that users may encounter.

What are the benefits/limitations?

Cognitive Walkthroughs can be very good at helping to identify potential usability issues early in the design phases. In order for the walkthroughs to be effective, it is essential that the individual or team conducting the walkthrough has a thorough understanding of the users in order to simulate their experiences with the system.

It should be noted that since Cognitive Walkthroughs are an inspection technique and do not involve real-world users, experts may not always pick up on subtleties in a design that could impact a user. While this technique does help to focus the design on the needs of users, it should not be the only user-centered methodology employed, as expert evaluations cannot replace the value of real-world input from users.

COMPETITIVE ANALYSIS

What is this method?

A Competitive Analysis is a technique that is used to evaluate the systems of your competition so that you may learn from others' design decisions and understand how another organization is attempting to fill a similar need. In the simplest of terms, you compare and contrast your system with that of your competition.

When should it be used?

Competitive Analysis can be conducted at any stage of the product lifecycle. It is typically important to conduct a Competitive Analysis if you are planning to make some improvements to your system or when your competitors release updates to their systems.

How do you conduct a Competitive Analysis?

There are several ways to perform a Competitive Analysis, ranging from very informal to very formal. In conducting a Competitive Analysis, begin by identifying your 'competition.' It's important to think outside of the box for this part of the process, as there may be others who are providing similar, but not identical services. By looking for examples from others, it is wise to gather a broad sample from several different products and systems.

A Competitive Analysis can be as formal or as informal as you would like it to be. It can be as informal as simply reviewing competitors' systems to identify the differences between the products. Or, it can be more formal, in that you actually conduct a Cognitive Walkthrough, contextual inquiry, expert review, focus group, usability test, user interview or user survey on the competing system. Depending on the detail needed, it is possible to conduct a blind A/B comparison, wherein users are asked about two (or more) products and asked to compare the systems. In this type of evaluation, it is essential that users do not know the affiliation of the person or group of people conducting the evaluation, as this knowledge may bias users' comments and performance. This type of A/B comparison can be extremely helpful in identifying which design options elicit improved user performance and decreased user frustration.

What are the benefits/limitations?

This technique is an extremely valuable way to learn about various design solutions before investing time and resources on system improvements. Not only does this method help project teams to improve upon good designs and to avoid design solutions that are not effective, it also helps teams to build a better understanding of the existing marketplace and the types of products and systems that users will be interacting with.

Since users will inevitably learn from their interactions with other systems and will make assumptions about the way your system should work based upon these previous experiences, it is important to have a thorough understanding of your competitors' products.

Armed with this information, project teams will have the necessary resources to make informed design decisions.

CONTEXTUAL INQUIRY/NATURALISTIC OBSERVATION

What is this method?

Contextual Inquiry is a method that allows you to observe users in a real-world environment, performing tasks as they would if they were not being observed. In contrast to other techniques such as usability testing, user interviews, user surveys, and focus groups, the evaluator travels to the user to observe them in a naturalistic setting and allows the user to 'drive' the session.

Contextual Inquiries take into consideration the entire process including the initial approach, instructional guides, physical and environmental conditions, situational factors, hardware design, software design, etc. It evaluates the entire process in order to provide a complete view of how users interact with a system in a real-world context.

When should it be used?

Contextual Inquiries can be conducted at any stage of the process, but typically tend to be performed on a fully functioning system.

How do you conduct a Contextual Inquiry?

During a Contextual Inquiry, a usability expert or team of experts typically travel to observe users in a real-world environment, such as an airport or border crossing. Although typically conducted by a usability professional, the inquiry can be conducted by anyone with a thorough knowledge of the system and the system's users.

The individual performing the inquiry is typically very passive, allowing users to act naturally as though they were not being observed. During the inquiry, the usability expert may ask questions to better understand a user's actions, but typically questions are held until the end to avoid interrupting a user's normal workflow. The person performing the inquiry may also ask for permission to tape the sessions so that they may capture the entire process and conduct an in-depth review following the inquiry.

This process should be repeated with several users under varying conditions in order to identify trends in users, in the environment, and with the technology.

Following the observations, the individual conducting the evaluation will summarize their observations, noting workarounds or shortcuts that users have created, itemizing instances where users deviated from the expected workflow, listing features that performed well, as well as features that were difficult for users to understand.

What are the benefits/limitations?

The benefit of a Contextual Inquiry is that you have an opportunity to observe users in the environment in which they will use the system. It helps to identify design issues that may arise because of environmental factors (i.e. the noise level in an airport may be too loud for users to hear audible cues that tested just fine in a usability lab) physical conditions (i.e. instructional guides that are positioned too far in advance of a system that users forget what to do by the time they reach the device) or occurrences (unexpected interruptions of the biometric process).

It is this type of subtle, but extremely important information that Contextual Inquires help to uncover.

One of the drawbacks to this technique is that there is sometimes so much data to analyze that it becomes a very time-consuming and labor-intensive effort.

EXPERT REVIEW

What is this method?

An Expert Review is similar to a Cognitive Walkthrough in that it is conducted by an expert or team of experts. The main difference between a Cognitive Walkthrough and an Expert Review is that an Expert Review evaluates a system against a set of best practices, design guidelines, and standards.

Expert Reviews are sometimes referred to as Heuristic Reviews as evaluators may choose to evaluate a system according to a set of heuristics (or design principles) such as Jakob Nielsen's 10 heuristic guidelines. (Nielsen)

When should it be used?

Expert Reviews can be conducted at any stage of the process and may be conducted on a paper prototype, low-fidelity prototype or fully functioning system.

How do you conduct an Expert Review?

During an Expert Review, a usability professional or team of usability professionals reviews the system for adherence to design guidelines and heuristics, noting where the system fails to meet certain standards. Based on the review, the usability professional will provide a set of recommendations and suggestions for improvement.

What are the benefits/limitations?

An Expert Review is a method that can be performed fairly quickly and inexpensively. However, just like the Cognitive Review, it is important to note that the review is being done by an expert or team of experts. Since experts do not have the same experiences and perspectives as users, they sometimes miss usability issues or identify issues that are 'false alarms' (issues that are not really usability issues).

In an effort to offset potential misses and false alarms, it is generally recommended that more than one individual be involved in an Expert Review. One approach is to have a team of usability experts conduct the review independently of each other and then share the issues they identified. The list of issues can then be reviewed to find issues that were identified by multiple usability professionals. While not a perfect solution, this principle can help to ensure that the most commonly identified issues are fixed first.

Like all 'inspection' methods, it is recommended that project teams also involve users in the design and development of any biometric system.

FOCUS GROUP

What is this method?

A Focus Group is a large group interview or discussion that allows project teams to explore opinions and gather feedback from users.

When should it be used?

Focus Groups tend to be very useful at the beginning of a design project to gather information about users' needs and to ask for feedback on initial design concepts. However, Focus Groups do not tend to be a good evaluation technique, in that it is very difficult to gather meaningful data from a group evaluation. Since users will be using a system as individuals, it is much more helpful to gather this type of information in one-on-one interviews or usability testing.

How do you conduct a Focus Group?

To conduct a Focus Group, first begin by recruiting a group of users (8 – 12) who represent your user population. Next, select a moderator or facilitator. The moderator should be someone who can objectively ask questions of the group and is not tied to one particular design concept. It is also critical that the moderator be a skilled leader in order to drive the conversation of the group and ensure that each focus group participant has an opportunity to voice his/her opinions.

During the Focus Group, the moderator may ask users about previous experiences with biometric devices, may try to probe into any issues or concerns users have had in the past, and finally may try to present some design ideas/concepts to gather the group's feedback.

The Focus Groups may be recorded or observed by other team members through a one-way mirror. Following the Focus Groups, the team will summarize the findings and recommendations resulting from the sessions.

What are the benefits/limitations?

Focus Groups are a good way to quickly gather data from several users within a user segment. They can be a helpful way to gauge users' opinions and gather early feedback on design concepts, however, they tend not to be as useful in the latter stages of the design, when other techniques such as usability testing are more effective.

PARALLEL DESIGN

What is this method?

Parallel Design is a method that enables large teams to generate many design concepts quickly in an attempt to bring the best design concepts forward by saturating the design space.

In short, it is a method that asks designers to each independently create a design. The group then shares their ideas and designers are asked to iterate their design concepts by improving upon the ideas shared. This technique helps designers to quickly build off concepts presented by their colleagues, and with each iteration, improve upon the ideas presented.

When should it be used?

Parallel Design should be used at the beginning of any design phase that will result in major changes to a system. It is a technique that works best in the early stages of a project.

How do you conduct a Parallel Design session?

Parallel Design sessions are a great way to generate a lot of design ideas very quickly. During a Parallel Design session, various members of the project team identify a particular feature that needs improvement and then focus their attention on creating a useful, usable solution. The session should include various members from the project team and can be conducted with graphic designers, hardware/software engineers, usability professionals, marketing specialists, documentation writers, etc. The sessions can be conducted with as few as three participants and with as many as a team feels comfortable including. A group of around 10-20 members tends to be just about right.

During the design session, the team will begin by discussing the feature to be designed (or redesigned). It is essential that the team discuss the users of the system, as well as the tasks to be completed. Lastly, the team should review any data gathered from other usability methods, including user interviews, usability tests, competitive analysis, expert reviews, etc.

Once the team has agreed upon the users and tasks, as well as some of the key requirements for the feature, each member of the group is asked to independently create a design. Once the designs are created, they are shared with the group. One easy way to share the designs is to have each person create their design on a large piece of paper and then post the paper prototypes around the perimeter of the room so that everyone can walk around the room and review the concepts.

After everyone has had a chance to review the concepts, the individual members are again asked to independently create a new design. In the new design, the parallel design participants are asked to integrate the best concepts from the other designs and attempt to

improve each concept. After the designs are completed, they are once again posted for the group to review. This process can be repeated several times throughout a one or two-day session.

At the conclusion of the session, the group should select the best concepts from the designs presented and build one to two optimal design solutions.

What are the benefits/limitations?

Not only is this technique an effective way to quickly generate as many design ideas as possible, but it is also a very effective way to continually improve on the ideas of others in collaborative and cooperative fashion. By including team members from various parts of your project team, design ideas that are not normally thought of by a single system designer can have a very positive impact on the overall design of a system.

Additionally, this technique is a very useful way to gather buy-in from stakeholders throughout your organization, as team members feel as though they have had a part in creating the design of the system.

USABILITY TESTING

What is this method?

Usability Testing is an evaluation method that asks real-world users to 'try out' or test a design of a system, while a usability professional notes areas where users struggle or make mistakes. Sessions may be recorded or observed by members of the design team in order to identify usability issues with the system.

When should it be used?

Usability Testing is a technique that should be used throughout the entire design lifecycle. It can be conducted on paper prototypes, low-fidelity prototypes and fully functioning systems.

How do you conduct a Usability Test?

To conduct a usability test, it is important to identify the users you want to test as well as the tasks you'd like to evaluate. Once you've selected the user group you'd like to test, you'll need to recruit a representative mix of users who closely match your actual user population. Many organizations will test with eight users from each user group, while other organizations will recruit larger numbers of users. When conducting performance testing where the goal is to analyze quantitative data, you may want to recruit 30 or more users. But, if this is your first usability test, you may want to start out with eight users and then determine if you need a larger sample.

After you've defined your users, you'll want to select the tasks that you would like users to perform. Once you have a set of tasks, you'll need to translate these tasks into 'scenarios' or stories that ask a user to perform a task without actually telling a user how to do the task. The scenario should also try to avoid 'give-away' wording by not using the exact same terminology that the system does.

During the usability test, the participant works one-on-one with the facilitator. The facilitator gives the participant the scenarios one at a time and then asks the user to perform the task. During this time, the facilitator notes areas of concern or confusion and may also ask the participant to 'think aloud' in order to better understand why a user is behaving in a certain manner.

Following the test, the design team will report the findings of the usability test. For quantitative testing, many teams use the Common Industry Format (CIF) (ISO/IEC 25062:2006) to document the performance of the system. The CIF provides a standard way for organizations to present and report quantitative data gathered in a usability test, so that it can later be compared to the results gathered in subsequent tests.

What are the benefits/limitations?

Usability test sessions are an extremely valuable way to observe users interacting with your system and to note areas of concern.

Not only does usability testing provide an opportunity to observe users interacting with a system, it enables design teams to better understand why a user behaves in a certain way or why an individual is confused. By asking users to explain what they are doing as they are using the system and to probe or follow-up on interesting actions, design teams have an opportunity to see the system through the eyes of a user.

Usability testing not only provides insights into users' behavior, it also allows project teams to quantifiably measure the success of a system, including capturing metrics such as error rates, successful performance on tasks, time to complete a task, etc. This valuable data can be used to benchmark the performance of a system and subsequently measure the impact of future design improvements. In addition to the more quantitative measures, usability testing offers insights into more qualitative issues, such as the level of users' frustration, confusion, intimidation, and overall satisfaction with the system. The combination of quantitative and qualitative data can be very informative when developing recommendations to improve the system design.

While usability testing can be expensive and time-consuming it is also extremely useful in that the results are reliable and detailed.

USER INTERVIEWS

What is this method?

User interviews are a valuable way to learn what users think of your system in a one-on-one discussion.

When should it be used?

User interviews should be conducted throughout the entire design lifecycle.

How do you conduct a User Interview?

User Interviews are one of the simpler user-centered design techniques. A User Interview is basically a one-on-one discussion with a user. During the interview, an interviewer may ask questions about a user's past experience with a product, a user's needs in using a specific type of biometric device, any concerns a user may have, etc. The interview may also ask users who've used the system to recall issues that they've encountered and propose ideas for improvement. Additionally, an interview may include presenting design ideas and concepts to a user and gathering feedback. This semi-structured method may explore the issues that are most important to the team at any given moment.

During an interview, the interviewer should have a basic list of questions that will be asked, but should also be able to follow-up and probe on interesting comments that a user makes. Some of the most valuable aspects of an interview can be gained from a probing question that was never part of the original interview script. Therefore, it's important that an interviewer be able to probe into interesting areas, as well as know when to bring the discussion back to the pre-defined list of questions.

What are the benefits/limitations?

Interviews are a wonderful way to learn about users' opinions, feelings and reactions to a system. Users tend to be very good at telling us what isn't working on a system or identifying where they have problems, however, they tend to not be able to recommend a solution. It's important to note that users are typically not good designers, which means that interviews should be used to help better understand an issue so that a skilled team of designers can architect an effective solution. Additionally, while users may be able to explain problems that they've encountered in the past, they are typically not able to remember all of the details of the situation or the issues that it caused. Therefore, interviews can never replace the value of user observation, whether in a Contextual Inquiry or Usability Test.

While extremely valuable, interviews can be time-consuming to conduct and analyze.

USER SURVEY

What is this method?

In a User Survey, users are asked a series of questions that are typically aimed at learning more about a user group or about users' views of a system. Surveys enable design teams to gather a lot of information very quickly which can be statistically analyzed.

When should it be used?

Surveys can be conducted throughout the product lifecycle and can be targeted to the issues that the team is dealing with at any given moment.

How do you conduct a User Survey?

In today's wired world, User Surveys tend to be conducted online which is less costly than mail or phone surveys. The online surveys may try to help a product team learn about its users, including demographic information, past experience with biometric devices, knowledge level with these types of systems, etc. Or, a survey may be more focused on identifying the top issues users have encountered with a system and soliciting ideas for improvement. Whatever the topic of the survey, it is important to design the survey with best practices in survey design in mind. For instance, it is important to ensure the survey does not ask leading questions and to ensure that the length of the survey isn't too long (which may detract some users from completing it).

When designing a survey, it is also important to balance the number of open-ended questions and close-ended questions. Open-ended questions are a wonderful way to gather deeper insights into users' opinions, however these types of questions are difficult and time-consuming to analyze. Additionally, since open-ended questions require more work on the part of the respondent, it is important to note that a survey with too many open-ended questions may prevent users from completing the survey.

Close-ended questions may not offer the same individual insights that open-ended questions do, but they also provide the ability to statistically analyze the data and to perform cross-tabulations with other close-ended questions.

What are the benefits/limitations?

Surveys provide an easy way to gather a lot of data very quickly, yet they suffer from many of the same issues as interviews. Since surveys are asking users to provide opinions and recall experiences, they cannot replace the value of user observation. Additionally, poorly-written surveys can bias design decisions. The data gathered from a survey is only as good as the questions asked. Therefore, it is critical to pilot the survey instrument prior to launching a full-blown survey.

Another issue that can negatively impact the quality of a survey is the sampling methodology. It is important to note, that a survey may not include a representative sample of the user population. Since users have the ability to opt-in or to quit at any time, it is important to review the data to identify segments of the population who are underrepresented. The self-selection nature of surveys makes it extremely difficult to find a truly random sample.

While this technique is certainly more complex than some of the others, the insights that can be learned and the amount of data that can be gathered in a short period of time make this technique a very important part of any design process.

Chapter 9
Conclusion

In today's global society, the use of biometrics to confirm personal identity is a key component to our nation's security. And, as such, there is an escalating need to design *usable and intuitive* biometric systems which accurately identify individuals.

To date, the design of the biometric systems has focused primarily on the effectiveness of a device, including system performance, functionality, reliability and precision. As technology evolves and the performance of these devices improves, it is critical to turn our attention to designing truly usable, user-friendly biometric devices.

ENSURING SUCCESSFUL BIOMETRIC SYSTEMS

In order to ensure the continued success of biometric systems and devices, it is critical the traditional product development process evolve into a user-centric model that takes into consideration the essential role users play in the biometric process. By understanding the partnership between biometric systems and users, we can begin to have a substantial impact on the design of these systems, including:

- Improved ease-of-use
- Reduced product complexity
- Enhanced system performance
- Increased user satisfaction

By focusing on these attributes, biometric designers can improve the usability of their devices, and as a result, may also improve system performance and throughput, resulting in a significant return on investment, including:

- Increased accuracy and reduced errors
- Decreased time to capture an acceptable sample
- Improved productivity and fewer attempts required
- Reduced need for assistance from system operators
- Decreased support and training costs

Thus, usability improvements not only lead to better, easier-to-use products, they can also lead to substantial cost savings as a result of improved system performance.

USABILITY AND BIOMETRIC SYSTEMS

In order to improve the usability of biometric systems and reap the benefits of improved system performance, it is critical to take a holistic approach in which users are a key component in the design of a biometric system. By adopting a user-centered design process, wherein users become our design partners and have an integral role in the development of a biometric system, we can begin to have a measurable impact on a system's ease of use.

In this handbook, we've introduced some of the key concepts of this user-centered design lifecycle, including:

- Defining the **Context of Use**
  Including operational environment, user characteristics, tasks, and social environment

- Determining the **User & Organizational Requirements**
  Including business requirements, user requirements, and technical requirements

- Developing the **Design Solution**
  Including the system design, user interface, and training materials

- Conducting the **Evaluation**
  Including usability, accessibility, and conformance testing
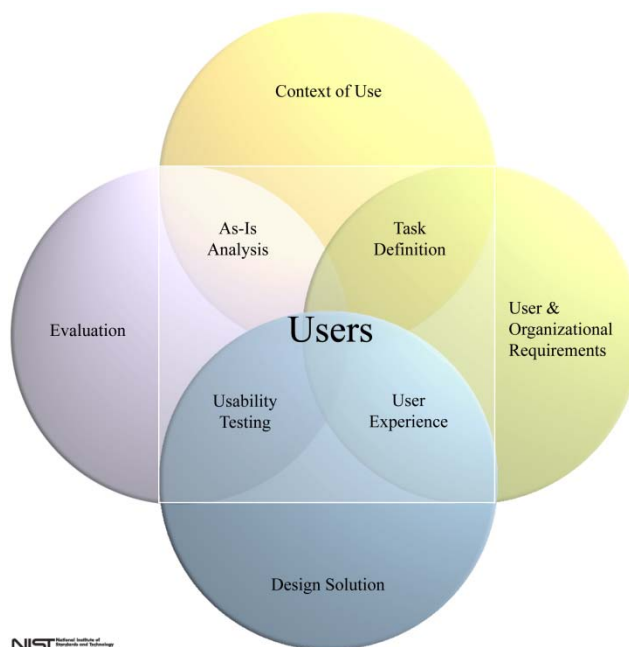

Figure 13: Biometric User-Centered Design Process

While this handbook introduced some of the key user-centered design and usability concepts, it is only meant to be an introduction to a topic that has the potential to significantly improve the future of biometric systems. We've provided a basic outline and some key methods which will help biometric system designers begin to incorporate usability throughout their product lifecycles. But, this is only a start: additional research in the field of usability and biometrics is greatly needed.

At the National Institute of Standards and Technology, we've created the Usability and Biometrics effort which is dedicated to providing resources, such as this handbook, in order to advance biometrics and usability research. In addition to promoting the benefits of usability, we are working to conduct research on how users' interactions and characteristics affect the success of biometric devices, so that we may better understand these issues and their implications for the design of a system.

In an effort to improve the design of biometric technologies, we encourage others to conduct and share their research in this emerging area so that we can continue to improve the usability and ease-of-use of these systems and advance the future of biometric technologies.

For more information on this and other NIST usability and biometric projects, please visit http://zing.ncsl.nist.gov/biousa/.

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