Human Factors Criteria for the Design and Acquisition of Non-keyboard Interaction Devices: A Revision to Chapter 9 of the Human Factors Design Standard

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June 2004

Draft
Final Report and Standard
DOT/FAA/CTxx/xx

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US Department
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The Human Factors Group
Federal Aviation Administration
Washington, DC 20591

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CTxx/xx		

4. Title and Subtitle	5. Report Date
Human Factors Criteria for the Design and Acquisition of Non-keyboard Interaction Devices: A Revision to Chapter 9 of the Human Factors Design Standard	June 2004
	6. Performing Organization Code AJP-6110
7. Author(s) Vicki Ahlstrom & Bonnie Kudrick	**8. Performing Organization Report No.** DOT/FAA/CTXX/XX
9. Performing Organization Name and Address Human Factors Team-Atlantic City Federal Aviation Administration William J. Hughes Technical Center Atlantic City International Airport, NJ 08405	**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.**
12. Sponsoring Agency Name and Address Federal Aviation Administration Human Factors Research and Engineering Group 800 Independence Ave., S.W. Washington, DC 20591	**13. Type of Report and Period Covered** Final Report **14. Sponsoring Agency Code** ATO-P

15. Supplementary Notes

16. Abstract

This document contains updates and expands the design criteria and scope of non-keyboard interaction devices from the Human Factors Design Standard. A research team of human factors experts evaluated the existing guidelines for relevance, clarity, and usability. They drafted new guidelines as necessary based on relevant sources and they reorganized the document to increase usability. This resulted in extensive changes to the original document, including the addition of new guidelines, sources, and topic areas. This report contains a brief introduction along with the modified guidelines.

17. Key Words	18. Distribution Statement
Guidelines Human factors Joystick Mouse Non-keyboard Interaction Devices Pointing devices Standard	This document is available to the public through the National Technical Information Service, Springfield, Virginia, 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	80	

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

Acknowledgements

The authors would like to thank the following people for giving their time and lending their expertise by reviewing this document: Chris Baber, PhD at the University of Birmingham, Birmingham, England, Alex Chaparro, PhD at Wichita State University, Wichita, Kansas and I. Scott Mackenzie, PhD at York University, Toronto, Canada.

We would also like to thank Dave Hess and Carol Hewitt, who created clear and accurate graphics for the document.

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1.0 INTRODUCTION

The Federal Aviation Administration (FAA) relies on countless devices to interact with the systems that make up the National Airspace System (NAS). In recent years, the number and type of interaction devices available to computer users has increased. As the FAA modernizes the NAS, decision-makers will be faced with a vast array of options for possible interaction devices. It is important for these decision-makers to have current information on non-keyboard interaction devices for the safety and performance of those using the devices as well as minimizing costs to FAA programs. This report and the associated set of updated standards and guidelines were developed to meet this need.

This document summarizes the process followed by the research team in the development of an updated and revised set of non-keyboard interaction device design criteria. The research and revision process used for creating this set of design criteria is explained in this document, followed by an appendix containing the design criteria itself. The material in the appendix is intended to replace the current material on non-keyboard interaction devices in the Human Factors Design Standard (HFDS).

Although the material on interaction devices was originally combined with the material on keyboards in a single chapter, the research team decided to present the interaction devices and keyboards information in two separate chapters based on an analysis of how people use the HFDS. An informal review of human factors studies conducted for acquisition programs indicated that these two topics are often addressed separately in acquisition and design activities. Thus, having two individual chapters, each focusing on a specific topic, allows the users to be more specific in the requirements definition process. This decision was validated by discussions with human factors practitioners currently working with FAA programs.

In this chapter "interaction devices" replaces the term input devices, to imply a less limited functionality of entering data into a computer system (Baber, 1997). In general, the keyboard is the most common data input device, while non-keyboard interaction devices such as mice, trackballs, and joysticks are used more frequently for cursor control and interaction with the system than they are for input. This chapter provides design criteria for pointing devices, touch screens and some alternative interaction devices. Despite overlap in the research on keyboards and touch screens, distinctions between criteria for keyboards and touch screens are sufficient to be addressed separately.

1.1 Purpose

The purpose of this document is to provide an updated set of non-keyboard interaction device guidelines and standards that meet the need of the FAA missions and systems.

1.2 Scope

This document is limited in scope to human factors guidance related to non-keyboard interaction devices.

Generally, the statements in this chapter refer to devices used to interact with data in computer systems. There are devices that could fit both under the category of control and interaction devices (such as knobs, dials, and switches), however, this chapter focuses on devices primarily used for computer interaction. Some of the most common interaction devices include: touch screens, speech recognition, mice, trackballs, joysticks, and light pens.

The majority of the devices referred to in this chapter can be considered pointing devices. A pointing device is a non-keyboard device that allows a user to navigate rapidly around the computer screen and to specify and select objects for manipulation and action. Examples include a mouse, trackball, stylus and grid, and light pen. Pointing devices are typically used for cursor control and direct manipulation of graphical objects such as icons.

1.3 Shall and Should

Each standard specified is identified as a “shall” or “should” statement. A solid, black square (■) adjacent to the standard identifies the “shall” statements. These originate from or are comparable to statements from authoritative sources such as those associated with FAA orders, standards, military specifications and peer-reviewed valid research.

Each “should” statement is identified by an open, white square (□). These represent best practices guidance that is applicable in most cases but may involve trade-offs or be influenced by domain or system-specific factors.

2.0 METHOD

Researchers organized the revision process in phases, which included the review and verification of information of the previous Human Factors Design Standard (HFDS) chapter on input devices, identification of new source material, systematic evaluation of literature, reorganization, addition and revision of certain topic areas, addition of information to justify the design criteria, and define tradeoffs associated with the design criteria. This document and the attached appendix with the design criteria were distributed to subject matter experts for review.

2.1 Review of HFDS chapter

In the first phase of this effort, a research team from the National Airspace System Human Factors Group sought out guidelines and standards that pertained to non-keyboard interaction device procurement and design. These guidelines and standards were compared against the current information from the HFDS. The information from the HFDS was then updated as needed. The researchers used the references from the guidelines to identify the primary sources cited by the reference documents. The primary sources were obtained and the information within the guidelines and standards was verified where possible. During the review of the current guidelines and standards it became evident that the research team needed to obtain additional source materials that were more current.

The researchers then expanded their search to identify current research related to existing and emerging interaction devices published in the literature. This literature search identified over 500 potentially relevant sources. The researchers obtained relevant sources and reviewed them for information pertinent to the design or procurement of interaction devices. Upon review of each source, researchers weighed the relevancy, adequacy and validity of the material before including it in the document. When information in the new source document warranted new or updated standards, a guideline was created or updated. When new source material proved statements in the current document were outdated or invalid, these statements were revised or deleted as necessary. Relevant information from the literature was rewritten into should or shall statements that could be used in requirements documents.

2.2 Reorganization

With the addition, deletion and revision of many of the guidelines and creation of specific standards, the entire chapter needed to be reorganized. Researchers performed card sorts with the guidelines and arranged the guidelines based on the results of the card sorts to facilitate easy access by users. The chapter is divided into sections including General Information, Pointing devices, Mouse, Puck, Trackball, Joystick, Touchpad, Stylus/light pen, Graphics/digitizing tablet, Touch screen, Speech/Voice Interaction, Alternative Interaction devices and Accommodating people with disabilities. Some of these sections have additional sub-sections.

2.3 Additional information

Users are often only able to implement some of the design criteria, but not all of them, due to budget constraints, time constraints, or other concerns. These users need to know what the consequences might be of violating design criteria or under which conditions violation of design criteria might be acceptable. Unfortunately, guidelines documents and standards (based on feedback from FAA users) do not always supply justification for the guideline or standard. Throughout the document, the researchers added paragraphs of information that provide the users with the basis they need to make informed decisions when faced with design choices.

2.4 Expert review

A draft of the newly created non-keyboard interaction device guidelines was circulated among a group of human factors professionals for review and comment. Reviewers included those individuals both inside and outside the FAA. The reviewers were asked to provide feedback on the chapter organization, content, clarity and relevance. Comments from the reviewers were used to make improvements on the final chapter.

3.0 SUMMARY OF CHANGES

The revision of Chapter 9 of the HFDS created notable changes. The primary change in the chapter is the update of information to include newer technologies and the lessons learned from research. The earlier chapter was published when computer interaction was in its infancy. At that time, the use of interaction devices was not as pervasive as now. Changes in the chapter address newer technologies not previously addressed and also incorporate research which was not available when the earlier chapter was created.

The search for current, updated information pertaining to interaction devices caused the realization that the chapter needed to be separated into two chapters. The chapter “Keyboards” remains Chapter 9, which is addressed in another report. However, the researchers found that “input devices” was a somewhat outdated term, due to the advent of new technology. The chapter that emerged from the initial “Input Devices” chapter is now referred to as “Non-Keyboard Interaction Devices”. The separation of these two areas was necessary to fully and completely address guidelines and standards that are continuing to evolve. The two separate chapters, Keyboards and Non-Keyboard Interaction Devices replace the current Chapter 9 of the HFDS.

The reorganization of the information in this document involved regrouping, separating and removing certain redundant, obsolete or unverifiable guidelines. New guidelines replaced outdated material where warranted.

These standards are created to aid in uniformity and cohesion of the design, use and procurement of non-keyboard interaction devices. However, with any set of standards, common sense and advice from human factors professionals should be sought for use in specific applications.

The revised Human Factors Criteria for the Design and Acquisition of Non-Keyboard Interaction Devices is considered a living document. It will be updated as necessary to keep abreast of emerging technology, additional research, technological advances, and user feedback.

The researchers attempted to create a useful, organized, and comprehensive document. This is evidenced throughout the document where the user will find that each standard has at least one valid source, if not more. The effort to supply the user with an organized, easy-to-use reference, document is also evidenced in the arrangement of the report, the glossary, and extensive list of references.

The researchers understand that there is always room for improvement and encourage comments and feedback. Comments and feedback should be sent to the first author (Vicki Ahlstrom) at the NAS Human Factors Lab, William J. Hughes Technical Center, Atlantic City International Airport, NJ 08405.

The full set of Non-Keyboard Interaction Device design criteria are presented in Appendix A. A table of contents precedes the document. The standards are followed by a glossary containing key terms and a list of references.

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Appendix A
Human Factors Standard for Non-Keyboard Interaction Devices (NKIDs)

Chapter 16: Non-Keyboard Interaction Devices
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16 Non-keyboard Interaction Devices (NKIDs)

Considerations when designing or choosing a non-keyboard interaction device include the specific user task, ergonomics, performance, preference, user comfort, and user abilities. Ergonomic risk factors associated with the use of interaction devices include:

- Prolonged static grip/static posture
- Frequency of actions
- Awkward postures
- Excessive force.

Although improving design may help to reduce risks for cumulative trauma disorders, workplace factors such as duration of use also contribute to the development of cumulative trauma disorders.

16.1 General Principles

- **16.1.1 Comfortable to hold and operate.** Interaction devices should be comfortable to hold and operate from the location where the user is most likely to interact with the system. [Source: NUREG-0700, 2002; Woods, Hastings, Buckle & Haslam, 2002]

- **16.1.2 User choice of device.** When more than one type of interaction device is present, the ability to choose which interaction device to use for a task should be decided by the user and not a requirement by the system. [Source: DON UISNCCS, 1992]

- **16.1.3 Accidental actuation.** Devices should be located and designed to prevent accidental activation. [Source: NUREG-0700, 2002]

- **16.1.4 Feedback.** Devices should provide visual or auditory feedback to the user that the input has been registered. [Source: NUREG-0700, 2002]

- **16.1.5 Speed.** Devices should provide rapid positioning of cursors or selection of choices commensurate with the functions to be served. [Source: NUREG-0700, 2002]

- **16.1.6 Accuracy.** Device accuracy should be commensurate with the functions to be served. [Source: NUREG-0700, 2002]

- **16.1.7 Efficiency.** Each device used should be necessary, should use minimal space, and should be the simplest and most effective device for the task. [Source: MIL-STD-1472F, 1999; NUREG-0700, 2002]

Exhibit 16.1.7 Advantages and disadvantages of different interaction devices

	Advantages	Disadvantages
Mouse	• Easy to learn and familiar to many users. • Has fast pointing speed and low error rate. • Useful for pointing, cursor selection, coarse drawing, and "dragging".	• Needs large footprint. • Can cause wrist to be held at non-neutral positions. • May need two devices to accommodate handedness. • Can fall off or be knocked off the work surface.
Trackball	• Small footprint required. • Easy for user to locate without looking. • Can be spun quickly to move the cursor over a long distance, such as a large display.	• Difficulty with concurrent button pressing while using. • Not good for drawing tasks. • Not as fast or accurate as other devices. • Can cause the wrist to be held in non-neutral position.
Joystick	• Can provide automatic return to origin. • Small footprint required. • Finger operated displacement joysticks can be fast for scrolling long distances.	• Less accurate than other interaction devices. • Cannot control speed independent of direction • Difficult to use for free-hand graphic input.
Touchpad	• Small footprint. • Can be used by both left and right hand.	• Slower and less accurate than mouse. • Friction between finger and pad may become uncomfortable to user.
Light pen/stylus	• Intuitive and easy to learn. • Direct eye hand coordination • One of the fastest devices for target acquisition and cursor positioning. • No extra desk space needed. • Allows handwriting input.	• User must be close to the screen. • Button depression may cause slippage and inaccuracy. • May cause arm fatigue. • Hand may obstruct a portion of screen when in use. • Stylus can be lost. • Requires pinch grip.
Touch screen	• No separate input device needed. • Fast. • Direct mapping of input. • Intuitive and easy to learn.	• Low resolution can cause difficulty when viewing. • Arm may obstruct view. • Fingerprints on screen. • May cause arm fatigue. • Not good for precise drawing tasks. • User must be close to screen. • Parallax can be a problem (e.g. user touching above or to the side of the target)
Voice input	• Does not require hands. • Does not require user to shift gaze. • Useable in dark or low light conditions. • Natural form of interaction.	• Entry can be slow. • Difficult to correct errors. • Background noise may interfere with recognition. • May require headset. • Voice changes (e.g. becomes stressed) can hamper recognition. • Speaker dependent systems require training. • Not appropriate for environments where voice is used extensively for other tasks.

- **16.1.8 Smooth movement.** Interaction devices should allow smooth device movement. [Source: Woods, et al.,2002]

- **16.1.9 Suitable for users.** Devices should be suitable for the anthropometric and ergonomic characteristics of the intended user population. [Source: NUREG-0700, 2002]

- **16.1.10 Easy to use**. An interaction device shall be intuitive and easy to use. [Source: Woods et al., 2002]

- **16.1.11 Suitable for environment.** Devices should be compatible with the intended tasks and operational environment. [Source: NUREG-0700, 2002]

  Additional Information. Devices which are used in extreme environments should be resistant to heat, cold, humidity and moisture.

- **16.1.12 Right- and left-hand versions.** If an interaction device is designed for use by a specific hand, then both right- and left-hand versions should be available.[Source: Woods, et al.,2002]

- **16.1.13 Non-dominant hand use.** Interaction devices should not require operation by the user's non-dominant hand unless the task does not require precise action. [Source: Kabbash, MacKenzie & Buxton, 1993]

- **16.1.14 Operation with either hand.** If an interaction device will be shared between users who may be left or right-handed, it should be operable with either hand. [Source: Brown, 1988; Woods et al., 2002]

- **16.1.15 Information about use.** Users shall be instructed on how to use and care for the interaction device prior to using new interaction devices for tasks. [Source: Woods et al., 2002]

- **16.1.16 Cleaning.** Users should be provided with and encouraged to use cleaning materials appropriate to the interaction device. [Source: Woods et al., 2002]

  Additional information. Touch screens are prone to fingerprints and smears, which can interfere with operation. Mechanical mice and trackballs need regular cleaning to ensure proper functioning.

- **16.1.17 Maintenance.** Interaction devices shall be easy to clean and maintain. [Source: Woods et al., 2002]

16.2 Pointing devices

- **16.2.1 Functionality.** A pointing device shall be capable of:
  a. Moving a pointer on the screen,
  b. Selecting objects on which the pointer is placed, and
  c. Drop and drag operations. [Source: DON UISNCCS, 1992]

- **16.2.2 Single pointer.** A pointing device shall be associated with a single pointer on the screen. [Source: DON UISNCCS, 1992]

- **16.2.3 Moving the pointer.** A user shall be able to move the pointer on the screen by moving all or part of the pointing device. [Source: DON UISNCCS, 1992]

- **16.2.4 Direction of motion.** The pointer shall move in the same direction as the pointing device. [Source: DON UISNCCS, 1992]

- **16.2.5 Pointer movements**. A user shall be able to produce any combination of x and y movements using a pointing device to move the pointer anywhere on the screen. [Source: DON UISNCCS, 1992; NUREG-0700, 2002]

- **16.2.6 Non-disappearance of pointer.** A pointer shall not move beyond the outer boundaries of the screen nor shall it disappear from sight. [Source: DON UISNCCS, 1992]

  Exception. When there is another screen adjacent to the first, the pointer may move from one screen to the other. [Source: DON UISNCCS, 1992]

- **16.2.7 Control of the pointer.** A pointer shall not move on the screen unless a user moves the pointing device. That is, an application must not move a pointer arbitrarily. [Source: DON UISNCCS, 1992]

  Exceptions. One exception to this rule is if an application automatically moves the pointer in conjunction with the scroll bar. For example, when the user clicks on the down arrow to scroll through a document, the application may automatically move the pointer so that the pointer will remain on the scroll arrow.

  Another case may be when the pointer "jumps" or "snaps-to" a default button because the user has selected that default option. [Source: DON UISNCCS, 1992]

- **16.2.8 Pointer stability.** The stability of the pointer shall be within 1.3 mm (0.05 in) in any direction; the preferred stability is within 0.25 mm (0.01 in). [Source: DON UISNCCS, 1992]

- ❑ **16.2.9 Control/display ratio.** The control/display ratio (the relationship between movements of an interaction device and the movements on the display screen) should be compatible with user expectations for speed, direction, and location of movement. [Source: NUREG-0700, 2002]

- ❑ **16.2.10 Adjustable control/display ratio.** The control/display ratio (the relationship between movements of an interaction device and the movements on the display screen) should be adjustable when necessary to accommodate user proficiency and task demands. [Source: NUREG-0700, 2002]

- **16.2.11 Delay.** Delay between control movement and the confirming visual indicator response shall not exceed 0.1 second. [Source: MIL-STD-1472F, 1999]

- **16.2.12 Prolonged dragging.** Tasks using pointing devices should not require prolonged dragging, where the user keeps the button depressed while moving the device. [Source: Woods et al., 2002]

- **16.2.13 Redundant pointing functions.** A system that uses a pointing device, should also provide a means for carrying out critical pointing functions from the keyboard. [Source: DON UISNCCS, 1992; Scadden & Vanderheiden, 1988]

- **16.2.14 Sufficient force**. Force required to move and position the interaction device should be sufficient to prevent unintended movement but not so high as to be uncomfortable to the user. [Source: Woods, et al.,2002]

- **16.2.15 Stability of interaction device.** Interaction devices should be stable during normal usage, i.e., they should not slip or rock, unless such actions are a part of the device operation. [Source: NUREG-0700, 2002]

- **16.2.16 Grip surface.** The grip surface of the interaction device should be rough enough not to be slippery but smooth enough not to be abrasive or uncomfortable. [Source: Pheasant, 1996]

- **16.2.17 Matte surface.** The surface of an interaction device should have a specular reflectance (gloss) of 45% or less. [Source: NUREG-0700, 2002]

- **16.2.18 Sharp edges.** The pointing device shall have no sharp edges or surface features that can cause pressure spots. [Source: Pheasant, 1996]

16.3 Device position

- **16.3.1 Locate within easy reach.** Interaction devices shall be located within easy reach of the users without requiring the user to adopt uncomfortable positions to use them. [Source: Woods, et al., 2002]

- **16.3.2 Location of device.** If an interaction device will be used frequently, it should be located no further to the left or right than the user's shoulders. [Source: Baber, 1997; Cook & Kothiyal, 1998]

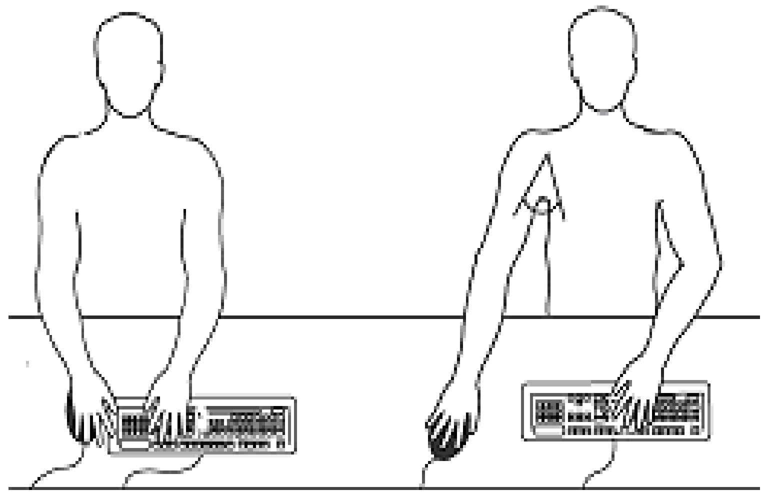


Exhibit 16.3.2 The arm on the rightmost figure is abducted from the body. It is desirable to reduce the angle of abduction between the body and the upper arm as shown in the leftmost figure.

Additional information. There are both postural and preference benefits of locating the interaction device centrally If an interaction device is located further to the left (for left-handed use) or right (for right-handed use) than the user's shoulders, it causes the user to abduct the shoulder during use, potentially leading to neck and shoulder strain.. An interaction device located to the right of an extended keyboard can cause increased muscle tension even after only 60 seconds of use. [Source: Cook & Kothiyal, 1998; Harvey & Peper, 1997; Karlqvist, Bernmark, Ekenvall, Hagberg, Isaksson & Rosto, 1999]

❑ 16.3.3 **Allow user to adopt and maintain neutral position.** Interaction devices should be located such that users are able to adopt and maintain neutral body positions as described in the list below.

a. Elbows at an angle of greater than 90 degrees.
b. Shoulders relaxed and upper arms next to the body
c. Wrist flexion/extension- less than 15 degrees
d. Forearm ulnar/radial deviation-less than 15 degrees
e. Wrist pronation/supination – 0-60 degrees pronation, with closer to 45 degrees pronation preferred

[Source: Armstrong & Chaffin, 1979; Bach, Honan, & Rempel, 1997; Cook & Kothiyal, 1998; Erdelyi, Sihoven, Helin & Hanninen, 1988; Grandjean, 1988; Grandjean, Hunting & Piderman, 1983; Hunting, Laubli & Grandjean, 1981; Keir, Bach

& Rempel, 1999; Marcus, Gerr, Monteilh, Ortiz, Gentry, Cohen, Edwards, Ensor & Kleinbaum, 2002; OSHA, 1997; Rempel, 1995; Rempel, Bach, Gordon & So, 1998; Sauter, Schleifer & Knutson, 1991; Simoneau & Marklin, 2001; Weiss, Gordon, Bloom, So & Rempel, 1995;Werner, Armstrong, Bir & Aylard, 1997; Zipp, Haider, Halpern, & Rohmert, 1983]

- ❑ 16.3.4 **Height of support.** The workstation or interaction device support surface should be less than 30 mm (1.18 in) above elbow height to allow adequate arm and shoulder support without causing excessive shoulder elevation. [Source: Karlqvist et al., 1999]

- ❑ 16.3.5 **Limb support.** If the pointing device is used to make precise or continuous adjustments, hand, wrist, or arm supports should be provided. [Source: Karlqvist et al., 1999; NUREG-0700, 2002]

- ❑ 16.3.6 **Frequency and duration of breaks**. At minimum, a 5-minute break should be taken for every hour of interaction device use. [Source: Woods et al., 2002]

- ❑ 16.3.7 **Frequent switching between devices.** Tasks should not require frequent switching between interaction devices. [Source: Brown, 1988; NUREG-0700, 2002]

Additional information. Switching between interaction devices can interrupt the flow of a task Each time a user switches from one device to another, it takes time for the user to reposition the hand or hands on the device (homing time), increasing the time for task completion.

16.4 Buttons on pointing devices

- ▪ 16.4.1 **Buttons.** One or more buttons shall be provided on pointing devices to allow the manipulation of objects on the screen. [Source: MIL-STD-1472F, 1999]

- ❑ 16.4.2 **Button operations.** A user should be able to perform the following actions with any button on a pointing device:

  a. Press. Depress a button and hold it down.
  b. Release. Release a button that has been depressed.
  c. Click. Press and release a button without moving the pointing device.
  d. Double click. Press and release a button twice in rapid succession without moving the pointing device.
  e. Drag. Depress a button and move the device while

holding the button down.

f. Move. Move the pointing device without pressing any buttons. [Source: DON UISNCCS, 1992]

▪ 16.4.3 **Button functions.** Each button on a pointing device shall have a specific function (within the context of the application) that is executed whenever a user presses the button. [Source: DON UISNCCS, 1992]

▪ 16.4.4 **One-button devices.** If the device has only one button, that button shall provide the "select" function. [Source: DON UISNCCS, 1992; Price & Cordova, 1983]

Additional information. Two or three button devices are preferred to single button devices. Single button devices often require the user to double or triple click to get to the functions that are assigned to other buttons on the two or three button devices. Clicking on a single button per function is faster than double clicking. Double clicking can be fatiguing and difficult for some users. More than three buttons can make it difficult for the user to remember what each button does. [Source: Price & Cordova, 1983]

▪ 16.4.5 **Two-button devices.** If a device has two buttons, the left one shall provide the "select" function and the right button shall provide a "menu" function. [Source: DON UISNCCS, 1992]

Additional information. The select function selects or activates objects on the screen or sets the location of the cursor. The menu function causes the appearance of a menu appropriate to the location of the pointer. [Source: DON UISNCCS, 1992]

▪ 16.4.6 **Middle button mapping.** Mapping of a unique (application-specific) function to the middle button shall not contradict or interfere with the function assigned to this button by the system or by another application. [Source: DON UISNCCS, 1992]

❑ 16.4.7 **No inadvertent movement.** Activation of integrated buttons or keys should not cause inadvertent movement of the interaction device. [Source: Woods, et al., 2002]

▪ 16.4.8 **Location of buttons.** Buttons shall be located so that the users can easily operate them without stretching or repositioning the hand. [Source: Woods et al., 2002]

❑ 16.4.9 **Maintaining control.** Buttons should be operable without diminishing the user's control of the device. [Source: MIL-STD-

1472F, 1999]

- **16.4.10 Left-right reversal.** A system shall provide users the ability to reverse the left-right operation of the buttons. [Source: DON UISNCCS, 1992]

- **16.4.11 Activation by finger flexion.** Buttons should be activated through flexion, not extension of the finger. [Source: Woods, et al., 2002]

- **16.4.12 Button contact surface.** Button contact surface should be perpendicular to the direction of displacement and finger motion. [Source: MIL-STD-1472F, 1999]

- **16.4.13 Activation force.** Buttons that will be used frequently should have a maximum activation force of between .25 and 1.5 N (.90 and 5.40 ounce-force). [Source: NUREG-0700, 2002]

- **16.4.14 Displacement.** Buttons that will be used frequently should have a displacement of between 1.5 and 6.0 mm (.06 and .24 in). [Source: NUREG-0700, 2002]

- **16.4.15 Feedback.** Interaction device buttons should provide feedback to the users upon activation. [Source: Verplank & Oliver, 1989]

- **16.4.16 Type of feedback.** Interaction device buttons should provide tactile feedback, auditory feedback or a combination of tactile and auditory feedback. [Source: Verplank & Oliver, 1989]

Additional information. Auditory feedback is often provided in the form of a click that is heard when a button is pressed.

- **16.4.17 Toggle button.** A locking (or toggle) feature should be provided for buttons on interaction devices that are used for tasks involving continuous or prolonged button depression. [Source: Casali, 1992]

Additional information. People with disabilities may have difficulty simultaneously holding a select button down and moving the device, for example, in "dragging" an object in a graphical display. [Source: Casali, 1992]

- **16.4.18 Tactile distinction between buttons.** Buttons should be distinguishable from one another tactilely, such as through a distinguishable ridge or space between the buttons. [Source: Verplank & Oliver, 1989]

16.5 Mouse

Description. A mouse is a hand-held interaction device whose movement on a flat surface registers the relative displacement of the cursor. The mouse is the most satisfactory general purpose pointing device. It allows frequent and precise cursor positioning across long distances. It is useful for pointing, cursor selection, coarse drawing, and “dragging” of virtual objects across the screen.

There are two general types of mice:

a. Mechanical- a small ball rolls along a surface and the ball determines orientation. Mechanical mice must be cleaned regularly to maintain optimal performance.

b. Optical –uses visible light or infrared to detect changes in its position.

Advantages to the mouse are that it is easy to learn, has fast pointing speed, and low error rate.

Disadvantages to the mouse include the desktop space (“footprint”) it requires to operate properly and the increasing evidence linking musculoskeletal problems with prolonged mouse use. [Source: Brown; 1988; Card, English, & Burr, 1978; Douglas & Mithal, 1997; Lu, 1984; Reinhart & Marklin, 1985]

Exhibit 16.5 Mouse

16.5.1 General

❑ **16.5.1.1 Use**. A mouse should be used for one to one control only (for example, the generation of x and y outputs by the user results in proportional displacement of the pointer). [Source: MIL-STD-1472F, 1999]

Additional information. This type of pointing device may be used on any flat surface to generate x and y coordinate values that control the position of the pointer on the associated display. It may be used for data pick off or for entry of coordinate values. [Source: MIL-STD-1472F, 1999]

❑ 16.5.1.2 **Free-drawn graphics.** A mouse should not be used to generate free-drawn graphics. [Source: MIL-STD-1472F, 1999]

▪ 16.5.1.3 **Dynamic characteristics.** The design of the mouse and the placement of the maneuvering surface shall allow the user to consistently orient the mouse within 10° of the correct orientation without visual reference to the mouse. [Source: MIL-STD-1472F, 1999]

Additional information. If the user grasps the mouse in what seems to be the correct orientation and moves it rectilinearly along what is assumed to be straight up the y-axis, then the direction of movement of the cursor on the display is to be between 350° and 10°. [Source: MIL-STD-1472F, 1999]

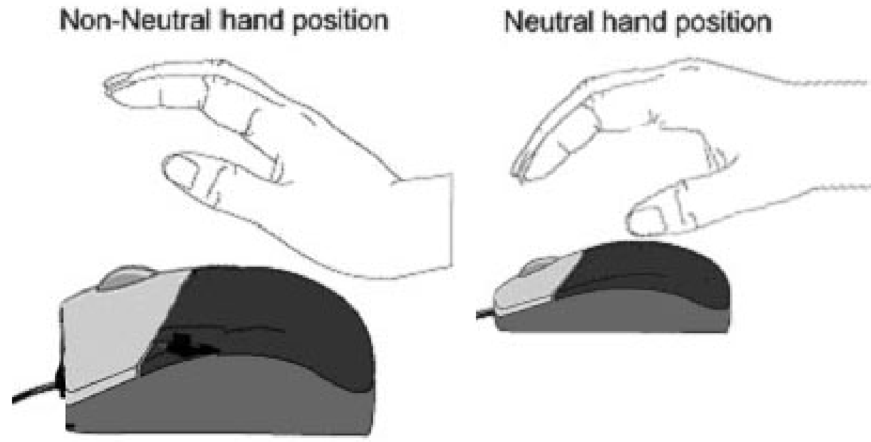
❑ 16.5.1.4 **Motion sensor location.** The motion sensor should be located toward the front of the interaction device, under the fingertips, not the palm. [Source: Verplank & Oliver, 1989]

▪ 16.5.1.5 **Easily moved.** The mouse shall be easy to move in any direction without a change of hand grasp. [Source: MIL-STD-1472F, 1999]

▪ 16.5.1.6 **Lateral range.** A complete lateral movement of the mouse from side to side within the maneuvering area (such as a mouse pad) shall move the pointer from side to side on the display regardless of the scale setting or offset unless expanded movement is selected for an automatic sequencing mode of operation. [Source: MIL-STD-1472F, 1999]

▪ 16.5.1.7 **Hand position.** A mouse shall be shaped to allow the user to maintain a comfortable neutral hand and finger position during use. [Source: Woods et al., 2002]

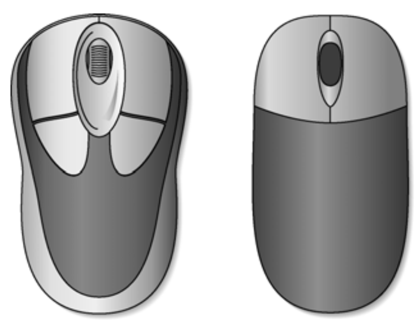
Exhibit 16.5.1.7 Neutral and non-neutral hand position**.**



- **16.5.1.8 Shape mouse sides.** The sides of a mouse should be sculpted (wider at the top and narrower at the base) to make it easier to grasp. [Source: Pekelney & Chu, 1995]

Additional information. If the users have an easier time of gripping the mouse, they do not need to apply as much force to hold the device, reducing potential of force related musculoskeletal disorders.

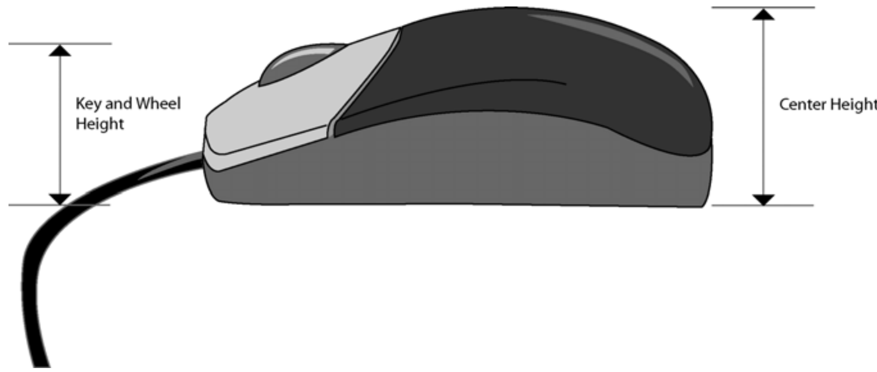
Exhibit 16.5.1.8 Mouse with contoured sides (left) and without contour (right).



- **16.5.1.9 Texture of mouse sides.** The sides of a mouse should be of a firm material with sufficient friction to allow the user to grip and move the mouse without the grip slipping. [Source: Pekelney & Chu, 1995]

- **16.5.1.10 Front of mouse.** The front of a mouse should be slightly lower than the middle of the mouse to allow the user to maintain a slightly curled finger posture. [Source: Pekelney & Chu, 1995]

Exhibit 16.5.1.10 Mouse with a slightly lower front**.**



- **16.5.1.11 Angled to reduce pronation.** The side of the mouse farthest from the user's thumb should be slightly lower than the rest of the mouse to allow the user to maintain a more neutral wrist posture. [Source: Kier, et al.,1999]

Additional information. A mouse that is shaped to reduce wrist pronation will be specific to either the left or right hand and may not be suitable for operational environments where users have to share interaction devices.

16.5.2 Mouse pad

Description. A mouse pad is a surface designed specifically to be used in conjunction with a mouse.

Exhibit 16.5.2 Mouse on mouse pad.

- **16.5.2.1 Smooth surface.** A mouse pad shall have a flat horizontal surface free from warping with sufficient friction for the mouse to operate smoothly, but not so much friction as to impede the mouse from gliding smoothly over the surface. [Source: Def-Stan-00-25, 1992]

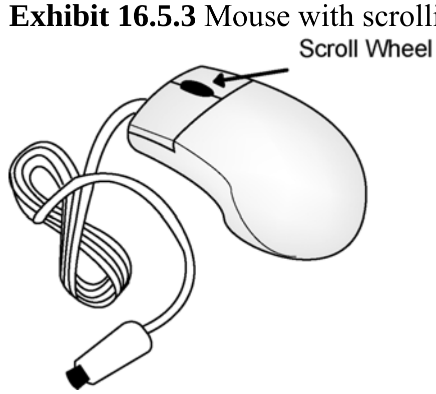
- 16.5.2.2 **Mouse pad.** Mouse pads shall be provided for mouse use. [Source: Woods et al., 2002]

- 16.5.2.3 **Mouse pad size.** Mouse pads shall be of sufficient size to allow the cursor to be moved around the screen without requiring the mouse to be picked up and repositioned frequently. [Source: Woods et al., 2002]

16.5.3 Scroll wheel

Description. A scroll wheel is a control designed similar to a continuous operation thumbwheel. It is usually located between the two mouse buttons and is used to control scrolling. For some mice, the scroll wheel can also act as a third button if it is depressed. It is generally made of rubber or plastic.

Exhibit 16.5.3 Mouse with scrolling wheel



- 16.5.3.1 **High friction surface.** The rim of the scroll wheel shall have a high friction surface to make it easy to turn. [Source: MIL-STD-1472F, 1999]

- 16.5.3.2 **Direction of motion.** The scroll wheel shall cause the cursor to move up when the wheel is moved up and down when the wheel is moved down. [Source: MIL-STD-1472F, 1999]

- ❑ 16.5.3.3 **Long distance scrolling.** A fingertip-operated isometric joystick should be used instead of a scroll wheel on a mouse for scrolling if the task requires frequent scrolling over long distances (more than 200 lines). [Source: Hinckley, Cutrell, Bathiche & Muss, 2002; Zhai & Smith, 1999; Zhai, Smith & Selker, 1997]

Additional information. Scrolling performance is better with a fingertip-operated isometric joystick than a scroll wheel (adjusted to one line per notch) over long distances [Source: Hinckley et al., 2002; Zhai & Smith, 1999; Zhai et al., 1997]

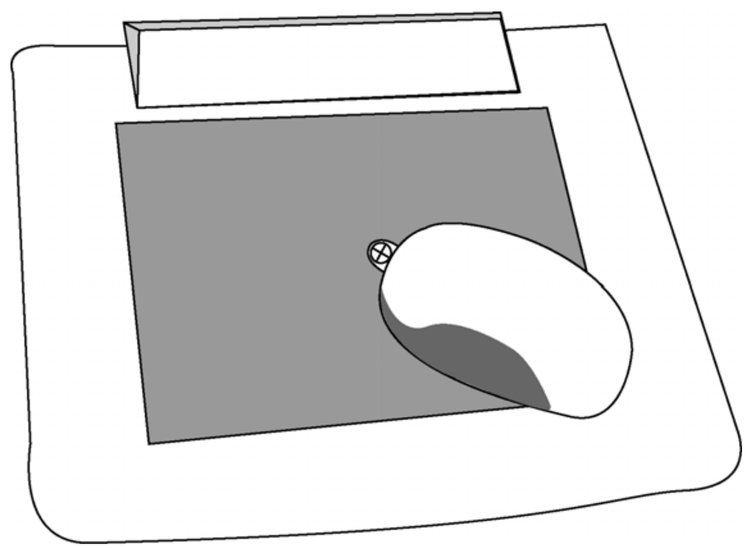
- **16.5.3.4 Minimize sustained pressure.** A scroll wheel should not require continuous sustained downward finger pressure. [Source: Kier, et al., 1999]

Additional information. Sustained downward pressure on the scroll wheel involves forces similar to those required for sustained dragging operations. Sustained dragging operations with a mouse are associated with increased carpal tunnel pressure.

16.6 Puck

Description. A puck is similar to a mouse, except that it has a window with crosshairs for pinpoint placement on a digitizing tablet and it can have as many as 16 buttons.

Exhibit 16.6 Puck and graphics tablet.



- **16.6.1 Puck.** Pucks shall conform to the same provisions as those for the mouse given in Section 16.5.

16.7 Trackball

Description. A trackball is an interaction device that is stationary with a ball that can be manipulated by the thumb, fingers, or palm of the hand. There are usually one to four buttons surrounding the ball, which are used like mouse buttons.

Exhibit 16.7a Hand-operated trackball

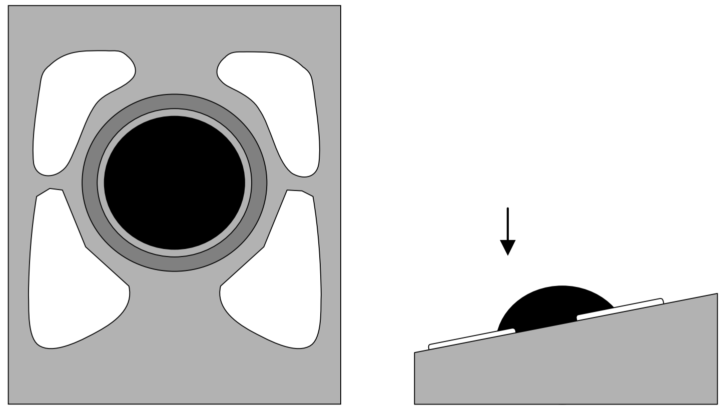
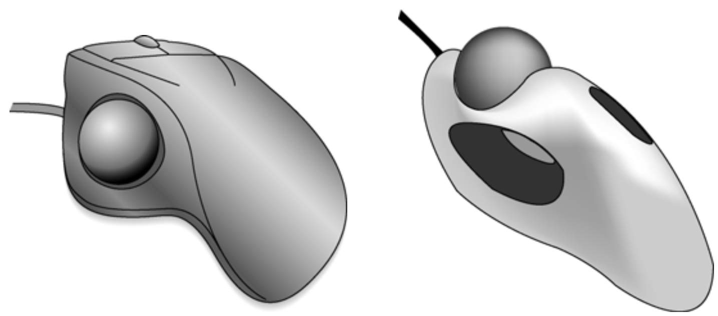


Exhibit 16.7b Thumb-operated trackball (left) and finger-operated trackball (right)

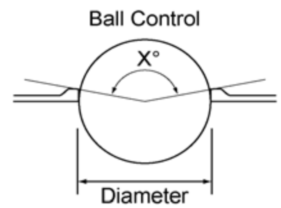


- ❑ 16.7.1 **Diameter.** The diameter of a hand-operated, desktop mounted trackball should be between 50 and 150 mm (1.97 and 5.91 in), with 100 mm (3.93 in) preferred. [Source: MIL-STD-1472F, 1999]

  Additional information. Although smaller trackballs are available, the smaller the trackball surface is, the more frequent, repetitive motions are necessary to move the cursor from one location to another. Smaller trackball sizes may be acceptable when there is limited space (such as with a laptop computer).

- ❑ 16.7.2 **Surface.** The exposed surface of a trackball should be between 100 and 140 degrees, with 120 degrees preferred. [Source: MIL-STD-1472F, 1999]

Exhibit 16.7.2 Surface exposure



	Minimum	Maximum	Preferred
Diameter	50mm	150mm	100mm
Surface Exposure "X°"	100°	140°	120°

- ❑ 16.7.3 **Resistance.** The resistance for a trackball should be between .3 and 1.0 N (1.08 and 3.60 ounce-force) for normal operating environments. [Source: Def-Stan-00-25, 1992; MIL-STD-1472F, 1999]

- ❑ 16.7.4 **Resistance for high vibration environments.** Trackballs intended for use in high vibration environments should have a resistance of at least 1.7 N (6.11 ounce-force). [Source: Def-Stan-00-25, 1992]

- ▪ 16.7.5 **Limb support.** If a trackball will be used to make precise or continuous adjustments, a wrist or arm support or both shall be provided. [Source: MIL-STD-1472F, 1999]

- ▪ 16.7.6 **Movement characteristics**. A trackball shall be capable of rotation in any direction so as to generate any combination of x and y output values. [Source: MIL-STD-1472F, 1999]

- ❑ 16.7.7 **Free area around ball.** There should be at least 50 mm (1.97 in) free space around the trackball. [Source: Def-Stan-00-25, 1992]

- ▪ 16.7.8 **Cross-coupling**. When moved in the x or y direction alone, the control shall exhibit no apparent cross-coupling (that is, movement of the follower in the orthogonal direction). [Source: MIL-STD-1472F, 1999]

- ▪ 16.7.9 **Backlash.** There shall be no backlash apparent to the user. [Source: MIL-STD-1472F, 1999]

  Additional information: Backlash is a sudden backward jarring or reflex motion caused by irregularities in velocity or a movement back from an impact.

- ▪ 16.7.10 **Gross and fine positioning.** Control ratios and dynamic features shall meet the dual requirements of rapid gross positioning and smooth, precise fine positioning. [Source: MIL-STD-

1472F, 1999]

- ❑ **16.7.11 When to use.** Ball controls should be used only as position controls, that is, applications in which a movement of the ball produces a proportional movement of a follower on a visual indicator. [Source: MIL-STD-1472F, 1999]

Additional information. Ball controls rotate freely in all directions; therefore, they are suitable for applications such as data pickoff and accumulative travel; however, they do not provide for automatic return to a point of origin.

- ❑ **16.7.12 Distance from front of workstation.** A trackball should be located 120 mm- 250 mm (4.72-9.84 in) from the front of the workstation. [Source Def-Stan-00-25, 1992]

- ❑ **16.7.13 Location relative to display.** A trackball should be located not more than 320 mm (12.60 in) to the left or right of the center of the display. [Source: Def-Stan-00-25, 1992]

- ❑ **16.7.14 Smooth movement.** A trackball should have smooth movement. [Source: Def-Stan-00-25, 1992]

- ❑ **16.7.15 Smooth cursor movement.** A trackball should cause smooth movement of the cursor. [Source: Def-Stan-00-25, 1992]

16.8 Joystick

Exhibit 16.8 Different types of joysticks**.**

Description. Joysticks can come in a variety of different shapes and sizes. Some joysticks are operated using the whole hand, others are smaller and are operated using the finger and thumb. Even smaller joysticks are operated by either the tip of a finger or the tip of the thumb.

Within the different shapes and sizes of joysticks, there are two common functional classifications:

a. A displacement joystick is a joystick that moves in the direction it is pushed. Displacement joysticks are usually spring-loaded so that they return to their center position when the force is removed.

b. An isometric joystick responds to the amount and direction of pressure applied to it, but it does not move.

16.8.1 General

- **16.8.1.1 Joystick within a module.** If the joystick is contained in a separate module, the module shall be mounted to allow operation of the joystick without the base slipping, moving, or tilting. [Source: MIL-STD-1472F, 1999]

- **16.8.1.2 Smooth movement.** Movement shall be smooth in all directions, and positioning of a follower (e.g. cursor, crosshairs or tracking symbol) shall be attainable without noticeable backlash, cross-coupling, or need for multiple corrective movements. [Source: MIL-STD-1472F, 1999; NUREG-0700, 2002]

- **16.8.1.3 Sufficient refresh rate.** If the joystick is to be used for generating free-drawn graphics, the display monitor shall have a refresh rate sufficiently high to give the appearance of a continuous track when the follower is moved. [Source: MIL-STD-1472F, 1999]

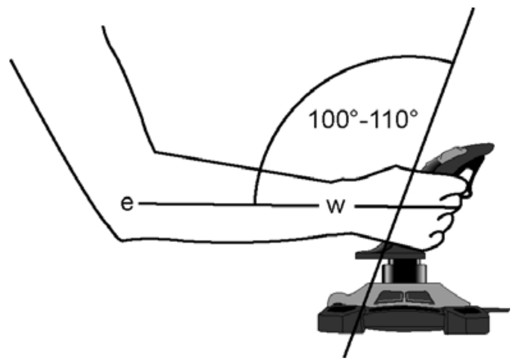
- **16.8.1.4 Handgrip length.** The handgrip length of a hand-operated joystick shall be in the range 110 to 180 mm (4.3 to 7.1 in). [Source: NUREG-0700, 2002]

- **16.8.1.5 Handgrip diameter.** The handgrip diameter of a hand-operated joystick shall not exceed 50 mm (1.97 in), with a diameter of 30-50 mm (1.18-1.97 in) preferred. [Source: NUREG-0700, 2002; Pheasant, 1996]

- **16.8.1.6 Handgrip clearance.** The clearance for a hand-operated joystick shall be at least 100 mm (3.93 in) to the side and 50 mm (1.97 in) to the rear. [Source: NUREG-0700, 2002]

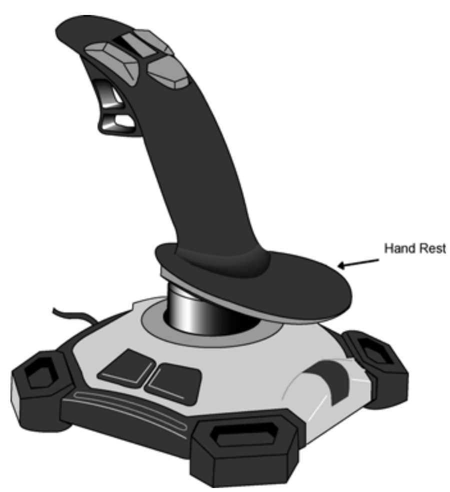
- ❑ **16.8.1.7 Handgrip shape.** The handgrip should be shaped to allow a wrist position of 100-110 degrees. [Source: Pheasant, 1996]

Exhibit 16.8.1.7 Angled joystick allowing more neutral wrist position.



- ❑ **16.8.1.8 Hand rest.** The hand-operated joystick should be designed to support the user's hand. [Source: Sherr, 1988]

Exhibit 16.8.1.8 Joystick with hand support**.**



- ▪ **16.8.1.9 Handle grip.** Joysticks that have handle grips shall allow enough room for both the palm of the hand and the web of the thumb, measuring at least 115 mm x 50 mm (4.53 x 1.97 in). [Source: Pheasant, 1996]

Exhibit 16.8.1.9 Joystick with handle grip**.**

- **16.8.1.10 Free of pinch points.** Joysticks shall be free of pinch points between moving parts. [Source: Pheasant, 1996]

16.8.2 Hand-operated displacement joysticks

Description. The displacement joystick can be moved in any direction and the displayed cursor moves proportionally. The joystick responds to any pressure in any direction. [Source: Salvendy, 1987]

Displacement joysticks usually require less force than isometric joysticks and are thus less fatiguing over long operating periods, but are also prone to greater tracking error than isometric joysticks. [Source: Boff & Lincoln, 1988]

- ❑ **16.8.2.1 Cursor control.** For cursor control and designation of points, the displacement joystick should be used instead of the isometric joystick. [Source: Def-Stan-00-25, 1992]
- ❑ **16.8.2.2 Positioning accuracy.** Displacement joysticks should be used instead of isometric joysticks if positioning accuracy is more critical than positioning speed. [Source: MIL-STD-1472F, 1999; NUREG-0700, 2002]
- ❑ **16.8.2.3 Return to center.** Displacement joysticks should be spring-loaded to return to center when the force is removed. [Source: MIL-STD-1472F, 1999; NUREG-0700, 2002]
- ❑ **16.8.2.4 Joystick with secondary control.** If a joystick will have a secondary control, a displacement joystick should be used rather than an isometric joystick. [Source: MIL-STD-1472F, 1999]
- ▪ **16.8.2.5 Movement characteristics.** Movement shall not exceed 45° from the center position. [Source: MIL-STD-1472F, 1999; NUREG-0700, 2002]
- ❑ **16.8.2.6 Output.** The output of the displacement joystick should be proportional to and in the same direction as the displacement of the joystick from the center. [Source: NUREG-0700, 2002]
- ▪ **16.8.2.7 When not to use.** Displacement joysticks shall not be used with automatic sequencing of a cursor or tracking symbol if they have a dead band near the center or hysteresis. [Source: MIL-STD-1472F, 1999]

Exception. An exception may be made if they are instrumented for null return or zero-set to the instantaneous position of the joystick at the time of sequencing.

- **16.8.2.8 Return to center.** Upon termination of an automatic sequencing routine, the joystick center shall again be registered to the scope center. [Source: MIL-STD-1472F, 1999]

16.8.3 Hand-operated isometric joysticks

Description. Isometric joysticks have no perceptible movement, but they can respond to the amount and direction of pressure applied. They are appropriate for tasks requiring precise or continuous control movement in two or more related dimensions. They are particularly appropriate for applications in which:

a. There is a need for return to a precise center after each use,
b. Feedback to the user is primarily visual rather than tactual from the control itself,
c. There is minimal delay and tight coupling between the control and system reaction

They may also be used as mounting platforms for secondary controls, such as thumb- and finger-operated switches, although operation of secondary controls is more likely to induce error on an isometric handgrip than on a displacement handgrip. [Source: MIL-STD-1472F, 1999]

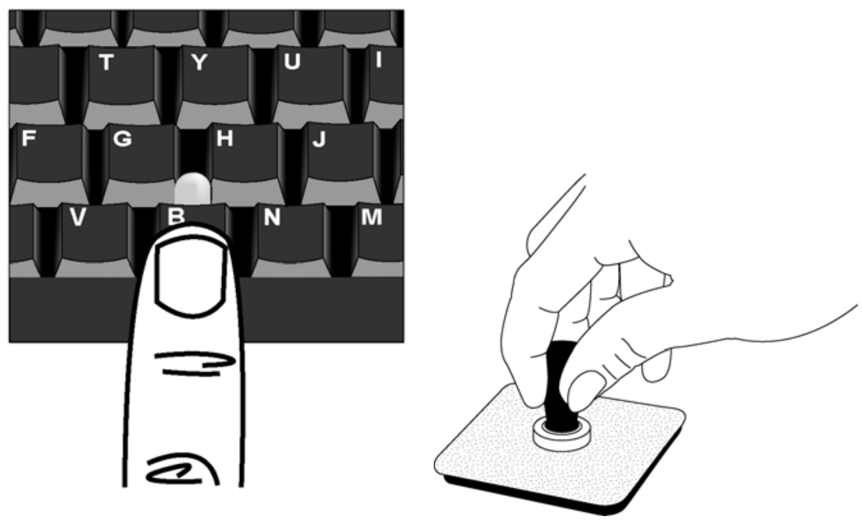
- **16.8.3.1 Isometric joysticks.** The output of an isometric joystick shall be proportional to and in the same direction as the user's applied force. [Source: NUREG-0700, 2002]

- ❑ **16.8.3.2 Maximum force.** Maximum force for full output should not exceed 118 N (27 pound-force). [Source: NUREG-0700, 2002]

16.8.4 Miniaturized joysticks

Miniaturized joysticks exist that are intended to be controlled by a finger grip, or by a fingertip or thumb. They allow control when there is insufficient space for a full sized control. Finger grip may have an advantage over a handgrip control for delicate control movements. The pinching grip produces a two-fold increase in carpal tunnel pressure compared to pressing a key with the same amount of force. High levels of carpal tunnel pressure have been associated with repetitive stress injuries. [Source: Grandjean, 1988, Keir, et al., 1998]

Exhibit 16.8.4 Fingertip-operated joystick (left) and finger-operated joystick (right).



❑ **16.8.4.1 Use.** Miniaturized joysticks should only be used where space limitations do not allow standard size devices. [Source: MIL-STD-1472F, 1999]

❑ **16.8.4.2 Outdoor use.** Miniaturized joysticks should not be used if the operators are likely to be wearing gloves or mittens. [Source: MIL-STD-1472F, 1999]

▪ **16.8.4.3 Mounting.** Thumb tip- and fingertip-operated displacement joysticks shall be mounted in a way that provides wrist or hand support. [Source: MIL-STD-1472F, 1999]

❑ **16.8.4.4 Finger-operated displacement joystick diameter**. A finger-operated joystick should be between 6.5 and 16.0 mm (.26 - .63 in) diameter. [Source: MIL-STD-1472F, 1999]

❑ **16.8.4.5 Finger-operated displacement joystick length**. A finger-operated joystick should be between 75 and 150 mm (2.95 and 5.91 in) long. [Source: MIL-STD-1472F, 1999]

- 16.8.4.6 **Force for fingertip joystick.** The force for operating a fingertip joystick should be between 3.3 and 4.5 N (.74 and 1.01 pound-force) [Source: Def-Stan-00-25, 1992]

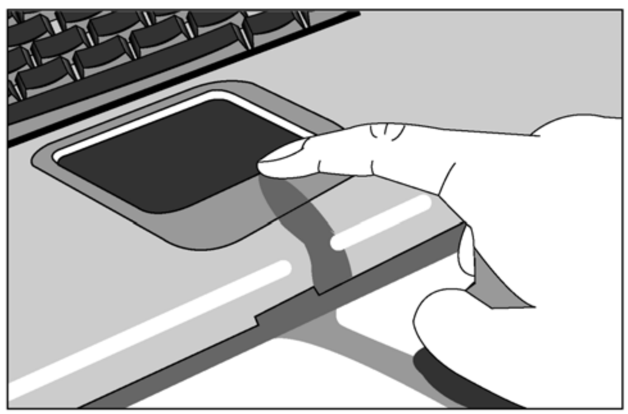
- 16.8.4.7 **Force for thumb-operated joystick.** The force for a thumb tip-operated joystick should be between 9 and 22 N (2.02 and 4.95 pound-force). [Source: Def-Stan-00-25, 1992]

Exhibit 16.8.4.7 Thumb-operated joystick.

16.9 Touchpad

Description. A touchpad, also known as a track pad is a small, touch- sensitive pointing device. Touchpads are commonly found in conjunction with notebook (laptop) computers. Touchpads provide a small flat surface on which the user controls the cursor by moving a finger across the surface, mimicking mouse actions. Although some research has found that touchpad use causes less ulnar deviation than mouse use, it has been associated with longer movement time and more errors than mouse use. [Source: Akamatsu & MacKenzie, 2002; Cakir, Cakir, Muller & Unema, 1995]

Exhibit 16.9 Touchpad



- **16.9.1 Touchpad location.** Where possible, touchpads should not be integrated with the keyboard to allow users to position the touchpad where it is most comfortable. [Source: Kelaher, Nay, Lawrence, Lamar & Sommerich, 2001]

- 16.9.2 **Location for left- or right- hand use.** If the touchpad is integrated with the system it should be located at the bottom center if it will be used by both left- and right-handed users, bottom right of the keyboard if it will only be used by right-handed users, or bottom left of the keyboard if it will only be used by left-handed users. [Source: Kelaher et al., 2001]

- 16.9.3 **Continuous pressure.** Tasks using touchpads should not require the user to maintain pressure on the pad for extended periods of time. [Source: Buxton, Hill & Rowley, 1985]

Additional information. With long periods of use, the friction between the finger and the touchpad can become uncomfortable for the user. The limit for comfortable use is likely to vary from user to user, with no single acceptable duration limit across all users.

- 16.9.4 **Touchpad location for mobile (wearable computer) interaction.** A touchpad used for mobile interaction should be located on the front of the thigh unless the work will be done in a prone position. [Source: Thomas, Grimmer, Zucco & Milanese, 2002]

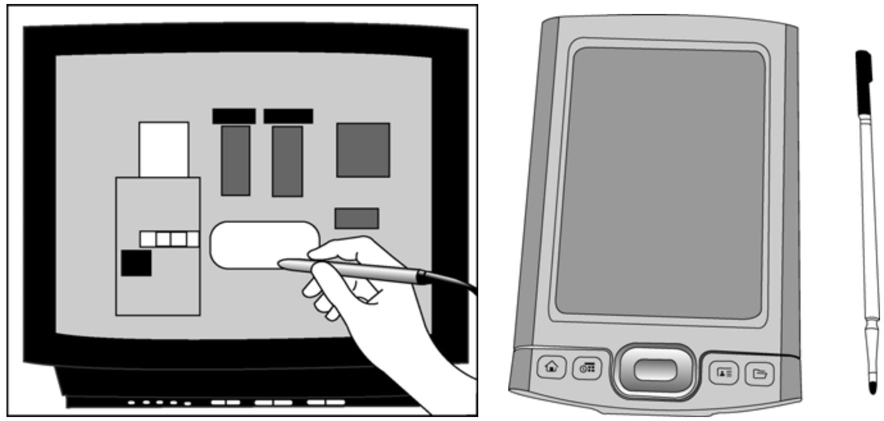
- 16.9.5 **Touchpad location for prone mobile (wearable computer) interaction.** A touchpad used for mobile interaction should be located on the forearm when the work will be done in a prone position. [Source: Thomas et al., 2002]

16.10 Stylus and light pen

Description. A stylus is an interaction device that is shaped like a pen and is used on digitizing tablets or touch screens.

A light pen is a pen-shaped device that utilizes a light-sensitive detector to select objects on a display screen. The user is able to move the pointer and select objects on the display screen by directly pointing to the objects with the pen.

Exhibit 16.10 Light pen and computer screen (left) and stylus with Personal Data Assistant (right).



A light pen is appropriate to use if item selection is the primary type of data entry. A stylus and grid is appropriate to use as a multipurpose interaction device when combined with a program for character recognition. The stylus and grid are also good for graphic entry although they are much slower than keyboard entry for alphanumeric data.

Grid and stylus devices may be transparent media placed directly on a visual indicator, or they may be located elsewhere, in a location that makes stylus manipulation convenient.

Light pens are useful for selecting from menus by pointing to the desired options, drawing and computer aided design (CAD). [Source: MIL-STD-1472F, 1999]

Advantages of a light pen or stylus are direct eye-hand coordination, and no extra desk space needed;

Disadvantages of a light pen or stylus are arm fatigue, arm and light pen obscure display, and the user must be close to the display. [Source: Arnaut & Greenstein, 1988]

16.10.1 General

- ❑ **16.10.1.1 Light pen use.** Light pens should be used to select, move the cursor, or draw. [Source: Brown, 1988]

- ❑ **16.10.1.2 Grid and stylus use**. Grid and stylus devices should be used only for one to one control functions, that is, applications in which displacement of the stylus from a reference position causes a proportional displacement of the follower. [Source: MIL-STD-1472F, 1999]

  Additional information. Grid and stylus devices may be used for data pickoff from a display monitor, the entry of points onto a visual indicator, the generation of free-drawn graphics, and similar control applications.

- ■ **16.10.1.3 Dynamic characteristics.** Movement of the stylus or light pen in any direction on a grid surface shall result in smooth movement of the cursor in the same direction. [Source: MIL-STD-1472F, 1999]

- ■ **16.10.1.4 Discrete stylus placement.** Discrete placement of the stylus or light pen at any point on a grid shall cause the cursor to appear at the corresponding coordinates and to remain steady in position as long as the stylus or light pen is not moved. [Source: MIL-STD-1472F, 1999]

- ■ **16.10.1.5 Refresh rate of cursor.** The refresh rate of the cursor shall be sufficiently high to ensure the appearance of a continuous track whenever the stylus or light pen is used for the generation of free-drawn graphics. [Source: DOE-HFAC1, 1992; MIL-STD-1472F, 1999; NASA-STD-3000B, 1995]

- ❑ **16.10.1.6 Long periods of unsupported use.** A light pen or stylus should not be used if the task requires holding the pen or stylus up to the screen for long periods of time. [Source: Brown, 1988; NUREG-0700, 2002]

  Additional information. Light pens seldom provide support to the user's arm. Forcing the user to hold the arm up for long periods of time can lead to fatigue. There is no single time limit for what constitutes an acceptable length of time for unsupported use. [Source: Brown, 1988]

- ❑ **16.10.1.7 Rest breaks.** A light pen or stylus should not be used for long periods of time without breaks. [Source: Keir et al., 1998]

Additional information. The pinching grip used to operate a stylus produces a two-fold increase in carpal tunnel pressure compared to pressing a key with the same amount of force. High levels of carpal tunnel pressure have been associated with repetitive stress injuries. [Source: Keir, et al., 1998]

❑ 16.10.1.8 **Frequent switching between devices.** Tasks involving light pens or a stylus should not require frequent switching between interaction devices. [Source: NUREG-0700, 2002]

▪ 16.10.1.9 **Length.** A light pen shall be between 120 and 180 mm (4.7 and 7.1 in) long. [Source: NUREG-0700, 2002]

▪ 16.10.1.10 **Diameter.** The diameter of a light pen shall be between 7 and 20 mm (0.3 and 0.8 in). [Source: NUREG-0700, 2002]

▪ 16.10.1.11 **Holder for pen.** A conveniently located means shall be provided to hold the light pen or stylus when it is not in use. [Source: NUREG-0700, 2002]

▪ 16.10.1.12 **Activation.** A light pen shall be equipped with a discrete activating and deactivating mechanism. A push-tip switch, requiring between 0.3 and 0.8 N (1.1 and 2.9 ounce-force) of force to activate, is preferred. [Source: MIL-STD-1472F, 1999]

▪ 16.10.1.13 **Feedback.** Feedback on the position of the light pen and the activation of the light pen shall be provided to the user when using a light pen.

a. Feedback concerning the position of the light pen, preferably in the form of a displayed cursor or highlighting, informs the user that the system is recognizing the presence of the light pen.

b. Feedback that the light pen has been activated (for example, the push-tip switch has been triggered) and the input have been received by the system lets the user know that the action has been acknowledged by the system. [Source: DOE-HFAC1, 1992; MIL-STD-1472F, 1999]

▪ 16.10.1.14 **Size of feedback.** Feedback on the position of the light pen shall be large enough to be seen under the point of the light pen. [Source: DOE-HFAC1, 1992; MIL-STD-1472F, 1999]

❑ 16.10.1.15 **Light pen field size**. Light pen selectable fields should be at least 1.8 mm (.07 in). [Source: Ren & Moriya, 2000]

- ❑ **16.10.1.16 Cold environments.** A stylus should be used instead of the finger as an interaction device in extremely cold environments. [Source: Blomkvist & Gard, 2000]

16.10.2 Handwriting interaction

Description. Although keyboards are recognized as the fastest means of data entry, there are situations in which a keyboard or mouse are difficult or inconvenient to use. A touch screen used together with a stylus allows handwriting recognition to be an option. Handwriting recognition systems usually require some amount of training. The accuracy of handwriting recognition varies. Some ways to improve the accuracy of handwriting recognition are to require discrete input, to restrict input to digits and uppercase letters, or to use specialized gesture-based or shorthand systems. Handwriting interaction generally requires both of the user's hands (one to hold the stylus and one to hold the device) and visual resources (it cannot usually be accomplished eyes-free).

- ❑ **16.10.2.1 Handwriting or drawing interaction.** Computer systems used together with a light pen or stylus for handwriting interaction or drawing should be able to track the position of the pen or stylus, display the electronic ink, recognize the handwriting, provide endless "paper", and store the drawn or written pages. [Source: Meyer, 1995]

- ▪ **16.10.2.2 Flat writing surface.** Systems that are meant for handwriting interaction shall have a flat writing surface. [Source: Meyer, 1995]

- ❑ **16.10.2.3 Frequent handwritten interaction.** Systems that require frequent handwritten interaction should either be horizontal or able to be placed horizontally. [Source: Meyer, 1995]

- ❑ **16.10.2.4 Resolution.** The resolution for systems used for handwriting interaction should be at least 240 dots/cm. [Source: Meyer, 1995]

- ❑ **16.10.2.5 Adaptable.** Systems that use handwriting recognition as interaction should adapt to the user's handwriting style. [Source: Meyer, 1995]

- **16.10.2.6 Trainable recognition.** Systems that use handwriting recognition as interaction should continue to learn from the user's interaction based on corrections made. [Source: Meyer, 1995]

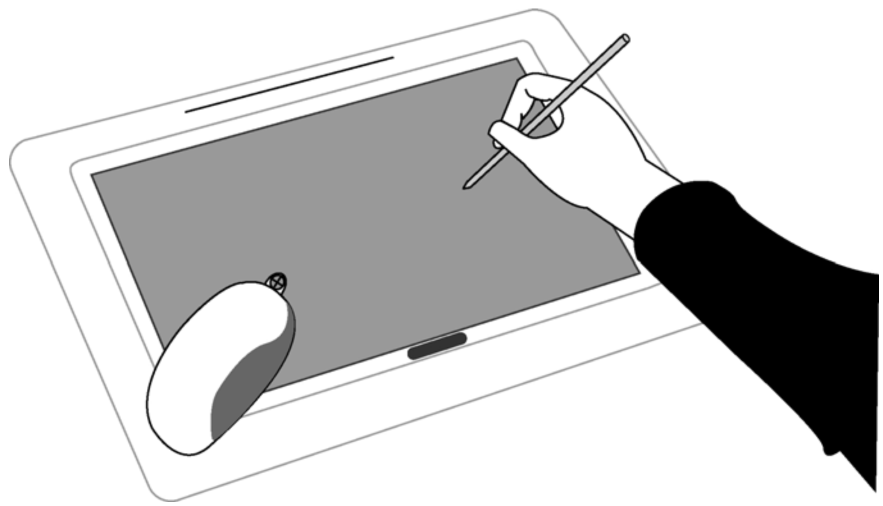
- **16.10.2.7 Large amounts of data input.** If a task requires large amounts of data input, a keyboard should be used instead of a stylus. [Source: Frankish, Hull & Morgan, 1995; Lewis, LaLomia & Kennedy, 1999; Meyer, 1995]

Additional information. Handwriting recognition as an input is significantly slower and more error-prone than keyboard or virtual keyboard interaction. [Source: Levin, Clough & Sanderson, 2003; MacKenzie & Soukeroff, 2002; MacKenzie, Zhang & Soukeroff, 1999; Mahach, 1989]

16.11 Graphics tablets (digitizing tablet)

Description. Graphics tablets are flat panels used to interact with a display. The surface of the tablet represents the surface of the display but is separate from the display. There are two types of graphics tablets: digitizing tablets and touch tablets. Digitizing tablets have a special stylus or puck attached to them by a cable. A touch tablet responds to the touch by a finger or pen. These graphics tablets are becoming less common, being largely replaced by touch screens. [Source: Sherr, 1988]

Exhibit 16.11 Graphics tablet with puck and stylus.



Advantages to a graphics tablet are that:

a. It allows a natural relationship between interaction and screen.

b. The hand does not obscure display.

c. There are no parallax or arm fatigue problems as with a touch screen.

d. Control-display gain can be modified.

e. It can be used in absolute or relative mode.

Disadvantages of a graphics tablet are that:

a. It may have low positioning accuracy.

b. Character data entry is slow.

c. Requires indirect eye-hand coordination.

d. Requires space.

e. The user may lose or break digitizer stylus.

[Source: Arnaut & Greenstein, 1986]

❑ **16.11.1 Feedback.** Touch tablets should include a feedback or confirmation mechanism to signal that an entry has been recognized. [Source: Arnaut & Greenstein, 1988]

- ❑ **16.11.2 Size of grid.** Transparent grids that are used with graphics tablets should approximate the size of the display and should be mounted below the display in an orientation to preserve directional relationships to the maximum possible extent. [Source: NASA-STD-3000B, 1995; NUREG-0700, 2002]

- ■ **16.11.3 Remote grid placement.** A remote grid shall have an orientation that is consistent with the directional relationships of the display. [Source: DOE-HFAC1, 1992; NASA-STD-3000B, 1995]

- ❑ **16.11.4 Smooth surface.** The active area of a tablet should be flat, smooth, and free from warping or imperfections. [Source: Buxton, Hill & Rowley, 1985]

16.12 Touch screen

Description. A touch screen is an interaction device that permits users to interact with the system by pointing to objects on the display. Touch screens may degrade image quality through reduced display luminance or through reduced display resolution. These degradations can result from the overlaid device itself and from dirt on the surface resulting from touching. Touch screens can also introduce parallax because of the separation between the touch surface and the image, and they can introduce glare problems. [Source: Avery & Bowser (DOE HFDG ATCCS V2.0), 1992]

A touch screen is generally one of the fastest interaction devices, but may be fatiguing for the user, depending on the orientation of the screen (a screen tilted 30 degrees is considered less fatiguing than one orthogonal). In some studies touch screens were found to be less accurate than other devices, but this may depend on the size of the target, the activation method used, and the type of touch screen technology used. [Source: Albert, 1982; Kabbash et al., 1993; Sears, Revis, Swatski, Crittenden & Shneiderman,1993]

Exhibit 16.12 Touch screen.

There are five basic types of touch screens:

a. *Capacitive*- consists of a transparent conductive film on a glass overlay. Touching the surface changes a small electrical signal passing through the film, and this signal is converted into a corresponding x-y coordinate. This technology is associated with minimal parallax, 85% transmissivity, and a medium amount of glare. It has high durability, high touch resolution, high clarity and is not affected by dirt, grease or moisture. Disadvantages are that it must be touched with a bare finger or electronic stylus. For example, it will not work with a gloved hand or other non-capacitive interaction devices.

b. *Resistive* - devices in which pressure results in the contact of two conductive layers. This technology is associated with minimal parallax, 50 to 75% transmissivity, and a high amount of glare. Advantages are high durability and resistance to dirt and dust. Disadvantages are that clarity tends to be less than other types of screens and sharp objects can damage it.

c. *Infrared* - uses infrared transmitters along two perpendicular sides of the display frame and photocell receptors along the opposite sides of the frame. A user's touch breaks the matrix of light beams, generating appropriate x-y coordinates. This technology is associated with noticeable parallax between the plane of the light beams and the screen surface (particularly for curved surfaces), low resolution, and no glare. Research has found infrared touch screens to be faster and more accurate than resistive touch screens. (Source: Beringer, 1989)

d. *Surface acoustic wave*- is similar to infrared touch screens except that they use ultrasonic beams rather than light beams. x-y coordinates are determined by differential timings in reception of the acoustic waves. This technology is associated with minimal parallax, 92% transmissivity (high clarity), and a medium amount of glare. It has high durability and does not require frequent recalibration. Disadvantages are that it can be affected by dirt or moisture.

e. *Pressure-sensitive devices*- uses strain gauges mounted between the display screen and an overlay. Output voltages of these strain gauges are encoded into the appropriate x-y coordinates. This technology is associated with minimal parallax and no glare. Transmissivity is not affected because the overlay is built into the display screen.

16.12.1 General

- ❑ 16.12.1.1 **Limits of use.** Touch screens should not be used if the task requires holding the arm up to the screen for long periods of time. [Source: NUREG-0700, 2002; Pfauth & Priest, 1981]

- ❑ 16.12.1.2 **When to use.** A touch panel or screen should be used to provide an overlaying control function to a display device (e.g., a CRT, an electroluminescent display, or a programmable indicator) if direct visual reference access and optimum direct control access are desired. [Source: DOE-HFAC1, 1992; MIL-STD-1472F, 1999]

- ❑ 16.12.1.3 **Functions not to use with touch screen.** Touch screens should not use scrolling, click and drag, or double click. [Source: Woods et al., 2002]

Additional information. Functions that mimic mouse functions such as scrolling, click and drag, or double click are awkward to use on a touch screen.

- ❑ 16.12.1.4 **Location.** Touch screens should be located within easy reach of the 5th percentile user. [Source: Def-Stan-00-25, 1992]

- ❑ 16.12.1.5 **Touch screen angle.** Touch screens used for frequent input should be mounted at 30 -45 degrees from the horizontal. [Source: Plaisant & Sears, 1992]

Additional information. Most users prefer using touch screens that are 30 -45 degrees from the horizontal over screens that are 75 degrees from the horizontal. Touch screens that are 30 degrees from horizontal have also been reported to cause fewer errors and less fatigue. Users tend to touch slightly below targets when the touch screens are angled due to parallax, thus touch screens that are angled require slightly larger interaction buttons.

- ▪ 16.12.1.6 **Minimize accidental activation.** Touch screens shall be designed to minimize accidental activation (protect against potential harmful interaction). [Source: Brown, 1988]

Additional information. Touch screens that are too sensitive can be activated by dropped objects or objects lightly brushing against them (such as a sleeve), causing unwanted effects.

- ❑ **16.12.1.7 Arm support**. If frequent or continuous operation is needed, a support for the user's arm (such as an elbow rest) should be provided. [Source: Brown, 1988; Plaisant & Sears, 1992]

Additional information. Touch screens are more suited to intermittent use.

- ❑ **16.12.1.8 Location height**. Touch screens should be located low enough so that the user is not frequently holding an arm high in the air. [Source: Shneiderman, 1991]

- ❑ **16.12.1.9 Switching between devices.** Tasks involving touch screens should not require frequent alternating use of the touch screen and keyboard or other interaction devices. [Source: NUREG-0700, 2002]

- ■ **16.12.1.10 Luminance transmission.** Touch screens shall have sufficient luminance transmission to allow the display to be clearly readable in the intended environment. [Source: MIL-STD-1472F, 1999; NUREG-0700, 2002]

- ❑ **16.12.1.11 Color of overlay.** Touch screen overlays should have a neutral tint to avoid alteration of color codes. [Source: NUREG-0700, 2002]

- ❑ **16.12.1.12 Activation strategy.** A lift-off (take-off) strategy should be used for touch screens that require the selection of small targets. [Source: Potter, Weldon & Shneiderman, 1988]

Additional information- Lift-off is a target selection strategy that allows the user to touch the screen, drag their finger to adjust the selection, and lift it once it is in the correct location to make the selection.

- ❑ **16.12.1.13 Land-on strategy.** If a land-on strategy is used, targets should be no smaller than 20 mm (.79 in) square. [Source: Beringer, 1989; Plaisant & Sears, 1992]

- ❑ **16.12.1.14 Positive indication.** Touch screens should provide a positive indication of activation to the user. [Source: MIL-STD-1472F, 1999]

- **16.12.1.15 Response time.** Touch screen response time should be less than 100 ms. [Source: MIL-STD-1472F, 1999]

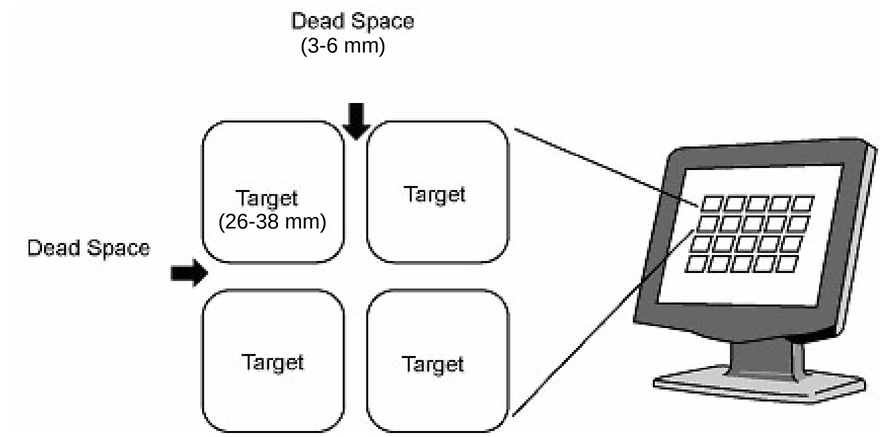
- **16.12.1.16 Image quality.** A touch screen interface should not degrade overall image quality in such a way that it impairs user performance. [Source: MIL-STD-1472F, 1999]

16.12.2 Touch screen buttons

- **16.12.2.1 Size for touch screen virtual keyboard keys**. Keys displayed on a touch screen for typing with a finger should be no smaller than 26 mm (1.02 in) square (or 22 mm (.87 in.) square if optimized for bias). [Source: Geartner & Holzhausen, 1980; Gould, Greene, Boies, Meluson, & Rasamny, 1990; Sears, 1991; Sears et al., 1993]

Additional information. The optimum touch sensitive area depends on the speed and accuracy requirements of the task and the size of the user's fingers. Keys of 26 mm square should be sufficient to capture 99% of user touches for non-optimized touch screens. Smaller touch screen buttons are associated with higher error rates and slower interaction. Users with larger fingers may have difficulty with buttons that are the minimum size. Smaller sizes are possible for limited data entry when larger sized keys are not practical or possible. If space is at a premium (such as on handheld devices), users with larger fingers can be accommodated by providing a stylus as the means of interaction instead of the finger if the touch screen technology permits. [Source: Geartner & Holzhausen, 1980; Gould, 1990; Sears, 1991; Sears et al., 1993]

Exhibit 16.12.2.2 Touch screen target and dead space.



- **16.12.2.2 Minimum dead space.** The dead space surrounding each touch area (button/key) should be at least 3 mm (.1 in). [Source: Martin, 1988; NUREG-0700, 2002; Usher & Ilett, 1986]

Additional information. Dead space minimizes accidental activation of keys.

- **16.12.2.3 Maximum dead space.** The maximum separation between touch screen buttons should be 6 mm (.25 in). [Source: NUREG-0700, 2002]

- **16.12.2.4 Test with representative users.** Touch screen button size should be tested with representative users conducting realistic tasks. [Source: Beringer & Bowman, 1989; Beringer & Peterson, 1985; Geartner & Holzhausen, 1980; MacKenzie & Zhang, 2001; Sears & Shneiderman, 1991]

Additional information. Different tasks have different requirements for size, speed, and accuracy. Optimum size may be affected by the task, the screen angle, the activation strategy and the touch screen technology. Testing with representative users allows the designer to determine the optimal size and performance trade-off for that system.

- **16.12.2.5 Touch screen button maximum dimensions.** Touch screen button/keys should be no bigger than 38 mm (1.5 in). [Source: MIL STD 1472 F, 1999]

- **16.12.2.6 Dimensions if screen and image are separate.** If the touch screen and the image plane of the screen are separated, the dimensions of the touch areas should be increased to avoid user performance degradation attributable to parallax problems. [Source: Beringer & Bowman, 1989; Beringer & Peterson, 1985, Weisner, 1988]

- **16.12.2.7 Touch screen size for angled displays.** Touch screen targets should be 2.8- 3.8 mm (.11-.15 in) larger for displays tilted 15-30 degrees than for displays perpendicular to the viewer's line-of-sight. [Source: Beringer & Bowman, 1989; Beringer & Peterson, 1985]

- **16.12.2.8 Type of feedback.** The system should provide feedback to indicate activation either visually such as the change of button through reverse video, or auditory such as a click, or both. [Source: Beringer & Peterson, 1985]

- **16.12.2.9 Touch screen force.** Force required to activate touch screens should be a maximum of 1.5 N (5.3 ounce-force) and a minimum of .25 N (.9 ounce-force). [Source: NUREG-0700, 2002]

- **16.12.2.10 Touch screen keyboard layout**. The virtual keyboard for a touch screen should use a QWERTY key arrangement. [Source: Bohan, Phipps, Chaparro & Halcomb, 1999; Sears, Jacko, Chu, & Moro, 2001]

- **16.12.2.11 Touch screen numeric pad layout**. Numeric keypads displayed on a touch screen should be in a 3 by 4 matrix with the numbers 1, 2, and 3 across the top and the zero centered at the bottom, also known as the telephone layout. [Source: Long, Whitefield & Dennett, 1984]

Exhibit 16.12.2.11 Telephone numeric pad layout.

- **16.12.2.12 Label location.** Labels for touch screen buttons or keys should be displayed on the button or key, not adjacent to the button or key. [Source: Calhoun & Herron, 1982]

- **16.12.2.13 Label information.** Each button label should provide sufficient information for the proper identification of that button. [Source: Calhoun & Herron, 1982]

- **16.12.2.14 Avoid similar labels.** Similar names for different functions should be avoided as labels for buttons on a touch screen. [Source: Calhoun & Herron, 1982]

16.13 Voice Interaction

Description. Voice interaction can be used when hands or eyes are not free. It is suited for discrete simple commands in situations where there is low interaction volume and speed is not a concern. Typing is a faster means of data entry, particularly for high volume of data input. Voice interaction with a computer competes for resources in situations that require the use of voice for other tasks. [Source: Brown, 1988]

- **16.13.1 Phonetically distinct vocabulary.** Spoken entries used for transactions should be phonetically distinct from one another to eliminate misinterpretation. [Source: MIL-STD-1472F, 1999]

Additional information. Spoken command entries are not to be chosen arbitrarily. Trade-offs between phonetic distinctiveness and familiarity of terminology need to be evaluated.

- **16.13.2 Easy error correction**. Feedback and simple error correction procedures shall be provided for speech interaction so that if the computer has not correctly recognized a spoken entry, the user can easily cancel the entry and try again. [Source: MIL-STD-1472F, 1999]

- **16.13.3 Alternative devices.** Alternative interaction devices shall be available so that if the system cannot recognize a voice entry after repeated attempts, or the device fails, another type of input entry can be substituted. [Source: MIL-STD-1472F, 1999]

- ❑ **16.13.4 Users with accents.** Voice interaction should not be used if the situation requires interaction with users that have different dialects and accents, particularly if high accuracy is a priority. [Source: Simpson, McCauley, Roland, Ruth & Williges, 1985]

  Additional information. Voice recognition software may have difficulty with dialects and accents, lowering recognition accuracy.

- ❑ **16.13.5 When not to use.** Voice entry should not be the primary interaction for stressful situations or for critical tasks performed during high workload. [Source: Def-Stan-00-25, 1992; Simpson et al., 1985]

  Additional information. Voice patterns can change with stress, decreasing the accuracy of the voice recognition software.

- ❑ **16.13.6 Training time.** Voice should not be used for unconstrained interaction if there is not sufficient time to train the system. [Source: Brown, 1988]

  Additional information. Most voice recognition systems require the user to “train” the system by providing a voice sample using a known text. Accuracy of voice recognition software decreases without training.

- ❑ **16.13.7 Avoid in noisy environments.** Voice interaction should be avoided in noisy environments. [Source: Simpson et al., 1985]

  Additional information. Noisy environments can have a significant impact on the accuracy of speech recognition. One way to overcome this restriction is through noise-canceling microphones. This intervention strategy (noise-canceling microphone) may not be effective if the primary background noise is other voices.

- ❑ **16.13.8 Number of syllables for voice commands.** Voice commands and voice menu items should be more than one syllable where possible. [Source: Harris & Biermann, 2002]

  Additional information. Errors decrease significantly for words with more than one syllable, especially when there are a large number of potential menu items or commands. [Source: Harris & Biermann, 2002]

- **16.13.9 Slang and abbreviations.** Voice recognition interaction systems should include occupation specific slang or common abbreviations in the voice recognition vocabulary. [Source: Revels, Kancler, Quill & Donahoo, 2001]

- **16.13.10 Structure voice menus to allow shortcuts.** Voice recognition systems used for menu navigation should structure the voice commands to allow users to take advantage of more direct input (for example, skip menu items when possible). [Source: Revels et al., 2001]

- **16.13.11 Limited vocabulary.** Vocabulary for voice command systems should be minimized consistent with the system needs. [Source: MIL-STD-1472F, 1999]

- **16.13.12 Low risk tasks.** Voice input should be used only if the consequence of recognition errors is low. [Source: MIL-STD-1472F, 1999]

- **16.13.13 Infrequent tasks.** Voice input systems should not be used for frequent interaction. [Source: MIL-STD-1472F, 1999]

- **16.13.14 Inhibited when not desired.** Users should be able to inhibit the voice input when speech recognition is not desired. [Source: MIL-STD-1472F, 1999]

- **16.13.15 Noise filter.** Voice input systems should be able to automatically reject unintended or involuntary sounds. [Source: MIL-STD-1472F, 1999]

- **16.13.16 Normal speech.** Voice input systems should allow the user to speak in a normal manner (not require interword delays or exaggerated speech). [Source: MIL-STD-1472F, 1999]

- **16.13.17 Describe position or manipulate objects.** Voice input systems should not be used for tasks that involve describing the position or manipulating objects. [Source: MIL-STD-1472F, 1999]

16.14 Alternative interaction devices

16.14.1 General

- ❑ **16.14.1.1 Consistent interaction.** If an alternate interaction device is used in an application, the manner in which users interact with the device (e.g., for navigation or selection) should be consistent with their interactions with other interaction devices. [Source: DON UISNCCS, 1992]

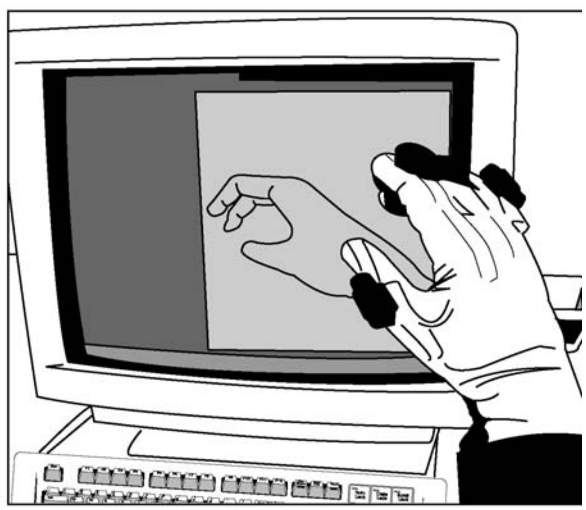
- ▪ **16.14.1.2 Type of device.** The alternate interaction device selected for an application shall be the one that most appropriately meets the application requirements. [Source: MIL-STD-1801, 1987]

16.14.2 Six degree of freedom interaction devices

Description. Six degree of freedom interaction devices are designed for use in three-dimensional environments such as stereoscopic virtual reality displays. There are many different devices for this purpose (such as bat, fingerball, and glove). Use of these devices can be fatiguing, as there is generally a lack of arm support.

Glove devices can sense the movement of the fingers and joints and the location and motion of the hand. These devices can recognize predefined gestures as commands. Glove devices are most commonly used as a means of interacting with three-dimensional environments such as virtual reality.

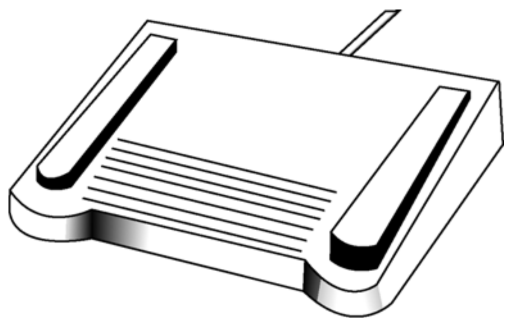
Exhibit 16.14.2 Data glove being used as an interaction device.



- **16.14.2.1 Use.** Six degree of freedom devices should be used for tasks that require interaction in multiple dimensions simultaneously. [Source: Zhai, 1998]

16.14.3 Foot controlled interaction device

Exhibit 16.14.3 Foot controlled interaction device.

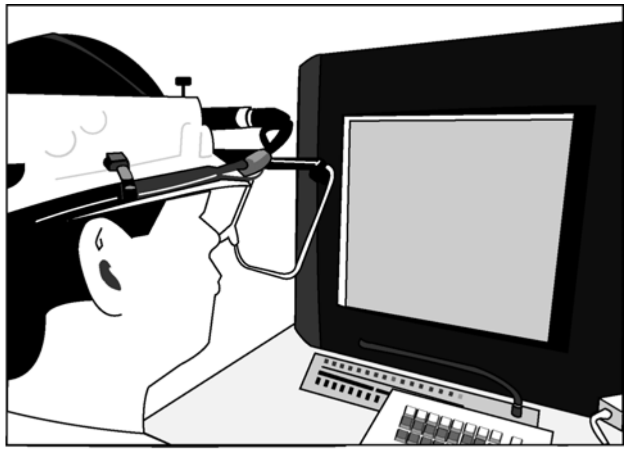


Although foot controls are used as controls for automobiles and some airplanes, attempts to create a foot control to replace the mouse as a pointing device have been largely unsuccessful. Problems cited with foot controls are the lack of fine control and leg cramps. [Source: Pearson & Weisner; 1986]

- **16.14.3.1 Foot controls.** Foot operated controls should comply with section 6.1.3 of the Human Factors Design Standard.

6.14.4 Eye/Gaze controlled interaction device

Exhibit 16.14.4 Eye controlled interaction device



There are two different lines of research into the eye movement as an interaction device. One, using the eye movements as a replacement for a pointing device, is primarily focused on assisting users with disabilities, the other, using the eye movements as a supplement, has broader implications.

Advantages:

a. Eye movements are among the fastest methods of target selection, faster even than the mouse.

Disadvantages:

a. Eye movements have inherent problems as a pointing device
b. Eye tracking equipment is currently too expensive for common use
c. Difficulty in differentiating what the user intends to select from random gazes.
d. Eye movements as an interaction method can also be fatiguing.

Additional information: A user does not want the system to select everything that the user looks at as the eyes are continually scanning the screen.

- **16.14.4.1 Target size.** Targets for eye movement interaction shall be no smaller than 1.2 degrees of visual angle. [Source: Bates & Istance, 2002]

  Additional information. Jitter associated with eye gaze causes error for small targets.

- **16.14.4.2 Visual workload.** Eye gaze should not be used as an interaction method when other task components place a high demand on visual attention. [Source: Calhoun, Arbak & Boff, 1984]

- **16.14.4.3 Dwell time.** Dwell time for selection should be between 150-250 msec. [Source: Jacob, 1991]

- **16.14.4.4 Hard select button.** When possible, gaze should be used for the pointing function, but a hard button should be used as a selection method. [Source: Ware & Mikaelian, 1987]

- **16.14.4.5 Vibration.** Head mounted and eye-gaze pointing devices should not be used in environments subject to vibration. [Source: MIL-STD-1472F, 1999]

- **16.14.4.6 Precise movements.** Head mounted and eye-gaze pointing devices should not be used if the task requires frequent, precise movements. [Source: MIL-STD-1472F, 1999]

16.15 Accommodating people with disabilities

- **16.15.1 Connection point for alternative interaction device.** A computer or computer system should provide a point at which an alternative interaction device can be connected if modifications cannot be made to make a standard interaction device accessible. [Source: Scadden & Vanderheiden, 1988]

  Additional Information. Adapters have been made available recently that enable people with hand tremors to eliminate excessive cursor movement. These adapters plug in between the mouse and the computer and can be switched on or off. The adaptive device can also be set to filter out unintentional multiple clicks due to hand tremors.

- ❑ **16.15.2 Interaction from alternative device.** The computer should treat input from an alternative device the same as input from standard interaction devices. [Source: Scadden & Vanderheiden, 1988]

- ❑ **16.15.3 Alternatives to interaction devices.** When an interaction device necessary for computer operation requires continuous visual feedback for operation, an alternate method should be provided for accomplishing as many of the functions as possible. [Source: Scadden & Vanderheiden, 1988]

Additional information. It may not be possible to provide a reasonable alternative for some functions. For example, inputs such as free hand sketching cannot be done easily without a device that requires eye-hand coordination. [Source: Scadden & Vanderheiden, 1988]

Glossary

Abduction - A movement of a body segment in a lateral plane away from the midline of the body, such as raising the arm sideways.

Backlash - a sudden backward movement or reaction; the jarring or reflex motion caused by irregularities in velocity or a reverse of motion. In a mechanical system, any lost motion between driving and driven elements due to clearance between parts; a movement back from an impact.

Capacitive touch screen - Consists of a transparent conductive film on a glass overlay. Touching the surface changes a small electrical signal passing through the film, and this signal is converted into a corresponding X-Y coordinate.

Clutching - The action of picking up and repositioning a mouse (or other like interaction device) due to wheel slippage or sticking.

Control/Display ratio (C/D ratio) - The relationship between movements of an interaction device and the movements on the display screen.

Dead space - Space between buttons on a touch screen.

Digitizing tablet (or graphics tablet) - A tablet that contains electronics that enable it to detect movement by a cursor which can be in the form of a pen or stylus or a "puck". A digitizing tablet enables the user to draw and sketch with precision into a computer. A digitizing tablet consists of an electronic tablet and a cursor or pen. A pen (also called a stylus) looks like a simple pen but uses an electronic head instead of ink.

Displacement joystick - A displacement joystick is a joystick that moves in the direction it is pushed. Displacement joysticks are usually spring-loaded so that they return to their center position when force is removed.

Drag and drop - A common method for manipulating files and/or text. The user moves the pointer over an icon representing a file and presses an interaction device button and holds the button down while moving the pointer (dragging the file) to another place and then releases the button (dropping the file).

Extension - A movement in the opposite direction of flexion which causes an increase in the angle at the joint, such as straightening the wrist or raising the hand at the wrist joint.

First contact - A selection strategy that the user chooses the selectable region the finger first comes in contact with. The user moves their finger to the area of choice, selects that region by touching and the process is initiated. (See Land-on).

Flexion - A movement of a segment of the body causing a decrease in the angle as the joint, such as bending at the wrist.

Footprint - The floor or desk area taken up by an interaction device or a piece of hardware.

Graphics tablet - (see digitizing tablet).

Hotspot - The precise part of a screen pointer that marks the screen position where an operation on a pointing device will have an effect.

Infrared or light-emitting touch screen - Uses infrared transmitters along two perpendicular sides of the display frame and photocell receptors along the opposite sides of the frame. A user's touch breaks the matrix of light beams, generating appropriate X-Y coordinates.

Isometric joystick - An isometric joystick responds to the amount and direction of pressure applied to it, but it does not move.

Land-on - A target selection strategy which allows the user to make selections where their fingers first touch the screen.

Lift-off - A target selection strategy that allows the user to touch the screen, drag their finger to adjust the selection, and lift it once it is in the correct location to make the selection.

Light pen - A pen shaped device that utilizes a light-sensitive detector to select objects on a display screen. The user is able to move the pointer and select objects on the display screen by directly pointing to the objects with the pen.

Mechanical mouse - A mouse with a small ball that rolls along a surface and the ball determines orientation.

Menu function - Causes the appearance of a menu appropriate to the location of the pointer.

Mouse - An indirect, hand -held pointing device, which is used to convey x-y movement to a computer. Initially a small square-like shape, many newer versions of the mouse exist with the same functionality but with more design considerations to prevent repetitive stress injuries.

Mouse pad - A flat, smooth horizontal surface free from warping or imperfections with sufficient friction for the mouse to operate smoothly, but not so much friction as to impede the mouse from gliding smoothly over the surface.

Optical mouse - Any kind of mouse that uses visible light or infrared to detect changes in its position.

Parallax - is a mismatch between the sensed finger position and the apparent finger position due to viewing angle and displacement between the sensing and display surfaces. Generally all touch surfaces will be slightly above the target due to the glass surface of the display being between the phosphor and the finger or stylus.

Pointer - A symbol displayed on the screen that is controlled by a pointing device. Its shape may change depending on the function that is invoked at a particular moment or its location on the screen.

Pointing device - A non-keyboard device that allows a user to navigate rapidly around the screen and to specify and select objects for manipulation and action. Examples include a mouse, trackball, stylus and grid, and light pen.

Pressure-sensitive devices touch screen - Uses strain gauges mounted between the display screen and an overlay. Output voltages of these strain gauges are encoded into the appropriate X-Y coordinates.

Pronation - Rotation of the hand and forearm so that the palm faces downward.

Puck - A puck is similar to a mouse, except that it has a window with crosshairs for pinpoint placement on a digitizing tablet and it can have as many as 16 buttons.

Radial deviation – A movement of the hand toward the radius so as to decrease the angle between the thumb and radial side of the upper arm.

Refresh rate - How frequently an electron beam passes a particular pixel per unit of time.

Resistive membrane touch screen – Touch screen device in which a touch results in the contact of two conductive layers. Specific current and voltage levels are associated with individual X-Y coordinates.

Reticule window - A network of fine lines, dots, crosshairs, or wires in the focal plane of the optical instrument or tablet.

Scroll wheel - A wheel in the middle of a mouse allowing the user to quickly move up and down the screen without dragging the scrollbar.

Select function - Selects or activates objects on the screen or sets the location of the cursor.

Stylus - An interaction device that is shaped like a pen and is used on digitizing tablets or touch screens.

Supination - Rotation of the forearm and hand so that the palm faces up.

Surface acoustic wave touch screen - A screen similar to infrared touch screens except that they use ultrasonic beams rather than light beams. X-Y coordinates are determined by differential timings in reception of the acoustic waves.

Take-off - (see lift-off).

Touchpad - A stationary pointing device used mainly on laptop computers. Touchpads provide a small, flat surface in which the user slides his or her finger over using the same movements as you would a mouse. Also referred to as “trackpad”.

Touch screen - A visual display terminal screen that responds to instructions as the user touches the screen with a finger or stylus.

Trackball - An interaction device that is stationary with a ball that can be manipulated by the thumb, fingers, or palm of the hand. There are usually one to four buttons surrounding the ball, which are used just like mouse buttons.

Trackpad - (see touchpad).

Ulnar deviation – A movement of the hand toward the ulna so as to decrease the distance between the little finger and the ulnar side of the forearm.

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