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## List of exhibits

# 9 Input devices

This section provides rules for keyboards, function keys, pointing devices, and some alternative input devices. The advantages and disadvantages of non-keyboard input devices are shown in Exhibit 9.0. The characteristics of these devices need to be considered in the selection of the appropriate controls for a given task.

At times, the line between what is considered a control and what is considered an input device can be blurred, such as the use of pushbuttons in conjunction with trackballs in some systems and the use of knobs to adjust parameters (such as range) in other systems. Information on pushbuttons, knobs, dials, and switches is contained in Chapter 6, Controls and Visual Indicators.

**Exhibit 9.0** Advantages and disadvantages of non-keyboard input devices

| Type of device | Advantages | Disadvantages |
|---|---|---|
| Mouse | Relatively fast | Requires additional flat work surface |
| | Has low error rates for large targets | Difficult to use for free-hand graphic input |
| | Allows user to concentrate attention on VDT screen | High error rates with small targets |
| | | Lost time when mouse held backwards or sideways |
| | | Some training needed |
| | | Wheel (ball) slipping sometimes a problem |
| Directional controllers (joystick and trackball) | Can be used comfortably with minimum fatigue | Slower than the light pen and other "point-to-devices" for simple input and option selections |
| | Does not cover parts of the screen in use | Must be attached, but not to the display |
| | Expansion or concentration | Unless there is a large joystick, an inadequate control to display ratio will result for positional control |
| | Ball control is an efficient use of space | The displacement of the stick controls both the direction and the speed of cursor movement |
| | | Trackball and joystick controllers are difficult to use for accurate free-hand graphic input |
| | | Difficult to integrate the activate switch with the trackball |

**Exhibit 9.0 (cont.)** Advantages and disadvantages of non-keyboard input devices

| | | |
|---|---|---|
| Light pen | Fast for simple input | May not feel natural to user, like a real pen or pencil does |
| | Good for tracking moving objects | Requires some fine motor control |
| | Minimal perceptual motor skills needed | May lack precision because of the aperture distance from the CRT screen surface, and parallax |
| | Efficient for successful multiple selection | Contact with the computer may be lost unintentionally |
| | User does not have to scan to find a cursor somewhere on the screen | Frequently requires simultaneous button depression may cause slippage and inaccuracy |
| | May be adaptable to bar coding | Must be attached to terminal, which may be inconvenient |
| | | Glare problem if pen tilted to reduce arm fatigue |
| | | Fatiguing if pen is held perpendicular to work surface |
| | | If pointing to dark area, may require user to flash the screen to find pen |
| | | One-to-one input only (zero order control) |
| | | May be cumbersome to use with alternate, incompatible entry methods, like the keyboard |
| | | Tends to be used for purposes other than originally intended, such as for key depression |
| | | Tends to be fragile |
| | | Hand may obstruct a portion of screen when in use |
| | | Care must be taken to provide adequate “activate” area around choice point |
| | | Cannot be used on gas plasma panel |

**Exhibit 9.0 (cont.)** Advantages and disadvantages of non-keyboard input devices

| | | |
|---|---|---|
| Stylus and grid | Good for graphic entry | Extra space required on work surface |
| | Can be designed to be used on horizontal surface | Displacement of visual feedback from motor activity may cause coordination problems |
| | Multipurpose input device | Entering hand printed characters to be recognized by the system is very slow (fewer than 40 characters/min) compared with typewriter entry (averaging 200 recognition characters/min) |
| | Minimal difficulty going from graphic input if character is built into the system, and the tablet is used for the input<br>Spatial correspondence between displays and control movement | Entering hand printed characters to be recognized by the system is very slow (fewer than 40 characters/min) compared with typewriter entry (averaging 200 recognition characters/min) |
| Touch screen | No separate input device | Low resolution |
| | Fast | Finger can block view |
| | | Fingerprints on screen |
| | | Tires arm |
| Voice activation | Does not require hands | Entry can be slow |
| | Does not require user to shift gaze | Must use specified vocabulary |
| | Useful for low light conditions | Some systems must be individualized to specific user |
| | Allows simultaneous activation of more than one control mode | If individual's voice changes (for example, become stressed) system may not respond |
| | Could be used in lieu of a translator, allowing natural, conversational version of different languages to control complicated systems | May require headset |
| | | Speaker-dependent systems require template loading time |

# 9.1 Keyboards

Keyboards vary greatly in the number and arrangement of keys. Most keyboards include the following:

a. **Alphanumeric keys -** The letters of the alphabet, numerals, and punctuation symbols (numeric keypads may be separate on portable computers).

b. **Dedicated formatting keys** - Keys for text formatting operations such as a **Space** bar, a **Tab** key, and a **Return** or **Enter** key.

c. **Modifier keys** - Keys that modify or qualify the effects of other keys for as long as they are held down, for example, **Shift, Ctrl,** and **Alt.**

d. **Navigation keys** - Keys that move a cursor, for example, **Arrow** keys, **Home, End, Page Up,** and **Page Down.**

e. **Fixed-function key** - Keys provided for extra or general functions, typically labeled **F1, F2,** and so on.

f. **Special purpose keys** - Keys that have a special function, such as **Help, Delete,** and **Backspace.**

- **9.1.1 When to use.** If applicable, keyboards shall be provided for the entry of alphabetic, numeric, and other special characters into the system. [Source: Department of Defense, (MIL-STD-1472D), 1989]

- **9.1.2 Include a numeric keypad for entering numeric data.** If an application requires substantial and repetitive input of numeric data, the keyboard shall include a numeric keypad. [Source: MIL-STD-1472D, 1989; Department of Defense (MIL-STD-1801), 1987]

- **9.1.3 Numeric keyboards.** Keyboards intended solely for the entry of numbers shall have the numerals "1" through "9" arranged in a three by three array, with "0" centered below the bottom row. [Source: Department of Energy (DOE-HFAC1), 1992]

- **9.1.4 Numeric keyboards for communication.** If the keyboard will be used primarily for communications, it shall use the "telephone" arrangement, that is, with the numerals 1, 2, and 3 in the top row. [Source: DOE-HFAC1, 1992]

- **9.1.5 Numeric keyboards for number manipulation.** If the keyboard will be used primarily for manipulating numbers, it shall use the "calculator" arrangement, that is, with the numerals 1, 2, and 3 in the bottom row. [Source: DOE-HFAC1, 1992]

- **9.1.6 Alphanumeric keyboards.** Keyboards intended for the entry of both alphabetic and numeric information shall conform to the standard "QWERTY" arrangement. [Source: DOE-HFAC1, 1992]

▫ **9.1.7 Key size.** The minimum horizontal surface width for a key on a typing keyboard should be 12 mm. [Source: American National Standard Institute (ANSI), 1988]

▫ **9.1.8 Horizontal spacing of keys.** Horizontal centerline distances should be between 18-19 mm. [Source: ANSI, 1988]

▫ **9.1.9 Vertical spacing of keys.** Vertical centerline distances should be between 18-21 mm. [Source: ANSI, 1988]

▪ **9.1.10 Force to depress keys.** The maximum force needed to depress keys shall measure between 0.25N and 1.5N with a preferred range between 0.5N and 0.6N. [Source: ANSI, 1988]

▫ **9.1.11 Keyboard slope.** The slope of the keyboard for typing should be between 0 and 25 degrees, preferably less than 15 degrees. [Source: ANSI, 1988]

▫ **9.1.12 Standard keyboards.** If feasible, standard keyboards should be used. Nonstandard keyboards should contain only those keys that are used by the keyboard user. [Source: Nuclear Regulatory Commission (NUREG-0700), 1996; DOE-HFAC1, 1992]

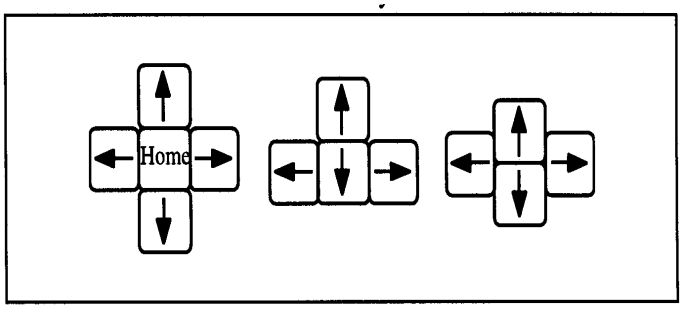
**Discussion.** The presence of non-relevant keys, such as those that might be used by programmers, adds to keyboard complexity and may induce errors. [Source: NUREG-0700, 1996; DOE-HFAC1, 1992]

▪ **9.1.13 Two-dimensional cursor control.** If a keyboard will be used for text processing, it shall provide for movement of the cursor in two dimensions, for example by including a set of cursor control keys. [Source: DOE-HFAC1, 1992]

▫ **9.1.14 Cursor control key layout.** If cursor control keys are included, they should be arranged in a two-dimensional array. [Source: DOE-HFAC1, 1992]

▪ **9.1.15 Cursor movement keys.** Cursor movement keys shall be arranged in a spatial configuration reflecting the direction of actual cursor movement. Exhibit 9.1.15 shows the arrangement of cursor movement keys. [Source: National Aeronautics and Space Administration (NASA-STD-3000A), 1989; DOE-HFAC1, 1992]

**Exhibit 9.1.15** Cursor movement keys



- **9.1.16 Positive feedback.** Where applicable, feedback shall be provided to inform the operator that the intended key was pressed and that the next operation may be initiated. [Source: MIL-STD-1472F, 1999]

- **9.1.17 Changing data.** Users shall be provided a means to change previous entries by delete, backspace, and insert actions. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

- **9.1.18 Keyboard equivalents to function keys.** If an application assigns operations to function keys, the operations that can be performed with a function key should also be performable with alphanumeric keys. [Source: Keane (DISA HCISG V1.0), 1992]

- **9.1.19 Keyboard equivalents to pointing device operations.** If an application provides both a keyboard and a pointing device, the operations that can be performed with the pointing device should also be performable with the keyboard. [Source: DISA HCISG V1.0, 1992]

- **9.1.20 Consistent keyboards.** If a system contains more than one keyboard, the configuration of alphanumeric, numeric, and special function keys shall be consistent throughout the system. [Source: MIL-STD-1472F, 1999]

## 9.2 Fixed-function keys

- **9.2.1 Standardization.** Fixed-function keys should be standardized throughout the system. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

- **9.2.2 Availability.** Fixed-function keys should be selected to control functions that are continuously available; that is, the lock out of fixed-function keys should be minimized. Mechanical overlays should not be used to lock out function keys. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

- **9.2.3 Non-active keys.** When a keyboard is dedicated for use with only a specific application, blank keys on the keyboard should replace non-active fixed-function keys. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

- **9.2.4 Grouping.** Fixed-function keys shall be grouped logically and shall be placed in distinctive locations. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

# 9.3 Pointing devices

This section contains rules for pointing devices in general, the shape of the pointer itself, and buttons on pointing devices.

**Definitions.** A **pointing device** is 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. A **pointer** is 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.

## 9.3.1 General

- **9.3.1.1 Functionality.** When present, a pointing device shall be capable of (1) moving a pointer on the screen, (2) selecting objects on which the pointer is placed, and (3) drop and drag operations. [Source: Department of the Navy (DON UISNCCS), 1992]

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

- **9.3.1.3 Moving the pointer.** A user shall be able to move the pointer on the screen by moving all or part of the pointing device. The pointer shall move in the same direction that the pointing device moves. A user shall be able to move the pointer anywhere on the screen. [Source: DON UISNCCS, 1992]

- **9.3.1.4 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. This rule does not apply when a cursor is moved quickly and the screen refresh rate is too slow to show the full path of the cursor. [Source: DON UISNCCS, 1992]

- **9.3.1.5 Control of the pointer.** A pointer should not move on the screen unless a user moves the pointing device. That is, an application should 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]

- **9.3.1.6 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]

- **9.3.1.7 Movement ratio.** The ratio of movement of the pointing device to the movement of the pointer should default to approximately 1:1 and be adjustable by the user. [Source: DON UISNCCS, 1992]

- **9.3.1.8 Type of device.** The pointing device selected for an application should be the one thatmost appropriately meets the application requirements and is most cost-effective. The appropriateness of some specific types of pointing devices for tasks is as follows:

  a. A **mouse** is a general purpose-pointing device suitable for a wide range of applications.

  b. A **joystick** is appropriate for tasks requiring precise adjustments and continuous control.

  c. A **trackball** is appropriate for generating precise X and Y output values and cumulative travel in any direction.

  d. A **light pen** is appropriate for non-critical, imprecise functions, especially if the primary task is item selection.

  e. A **stylus and grid** is appropriate for graphic entry. [Source: MIL-STD-1472D, 1989; MIL-STD-1801, 1987]

  **Discussion.** Another factor that may contribute to the appropriateness of a given input device is the expectations, experiences, or preferences of the intended user population. If a given user population has a wealth of experience, familiarity, or acquired skill with a particular type of device, careful consideration needs to be given to replicate the features, functionality, performance, and "feel" to which they are accustomed. [Source: MIL-STD-1472D, 1989; MIL-STD-1801, 1987]

## 9.3.2 Mouse

- **9.3.2.1 Use.** A mouse should be used for zero order control only (for example, the generation of X and Y outputs by the controller results in proportional displacement of the pointer). [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

  **Discussion.** 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-1472D, 1989; DOE-HFAC1, 1992]

- **9.3.2.2 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-1472D, 1989; DOE-HFAC1, 1992]

  **Discussion.** 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 CRT is to be between 350° and 10°. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

- **9.3.2.3 Easily moved.** The mouse shall be easy to move in any direction without a change of hand grasp. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

- **9.3.2.4 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. Users shall be able to specify or modify the lateral movement ratio. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

- **9.3.2.5 Dimensions and shape.** The mouse shall have no sharp edges but shall be shaped roughly as a rectangular solid, with limiting dimensions as shown in Exhibit 9.3.2.5. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

**Exhibit 9.3.2.5** Dimensions of a mouse

| Dimension | Minimum mm (in) | Maximum mm (in) |
|---|---|---|
| Width (spanned by thumb to finger grasp) | 40 (1.6) | 70 (2.8) |
| Length | 70 (2.8) | 120 (4.7) |
| Thickness | 25 (1.0) | 40 (1.6) |

## 9.3.3 Joystick and trackball

Joysticks and trackballs are appropriate to use if precise input functions are required. They are most useful when used to control direct pointing, rather than discrete controls such as cursor control keys.

### 9.3.3.1 General

- **9.3.3.1.1 Activation and deactivation.** A discrete mechanism shall be provided to allow the user to activate and deactivate the joystick or trackball. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

  **Definitions.** 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. An **isometric joystick** responds to the amount and direction of pressure applied to it, but it does not move. Displacement joysticks usually require less force than isometric joysticks and are thus less fatiguing over long operating periods.

### 9.3.3.2 Hand-operated displacement joysticks

- **9.3.3.2.1 Specifications.** The handgrip length of a hand-operated displacement joystick shall be in the range 110 to 180 mm (4.3 to 7.1 in); the grip diameter shall not exceed 50 mm (2 in); clearance shall be at least 100 mm (4 in) to the side and 50 mm (2 in) to the rear. 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]

- **9.3.3.2.2 Movement characteristics.** Movement shall not exceed 45° from the center position. Movement shall be smooth in all directions, and positioning of a follower shall be attainable without noticeable backlash, cross-coupling, or need for multiple corrective movements. If the joystick is to be used for generating free-drawn graphics, the CRT shall have a refresh rate sufficiently high to give the appearance of a continuous track when the follower is moved. Delay between control movement and the confirming visual indicator response shall be minimized and shall not exceed 0.1 sec. [Source: MIL-STD-1472F, 1999]

- **9.3.3.2.3 When to use.** If accuracy is more important than speed, a displacement joystick should be used rather than an isometric joystick. If a displacement joystick is used for rate control, the joystick should be spring-loaded so that it returns to center. If a joystick will have a secondary control, a displacement joystick should be used rather than an isometric joystick. [Source: MIL-STD-1472F, 1999]

  **Discussion.** Uses of displacement joysticks include (1) picking data from a CRT, (2) generating free-drawn graphics, (3) controlling a vehicle, (4) aiming sensors, and (5) serving as a mounting platform for a secondary control such as thumb- or finger-operated switches. [Source: MIL-STD-1472F, 1999]

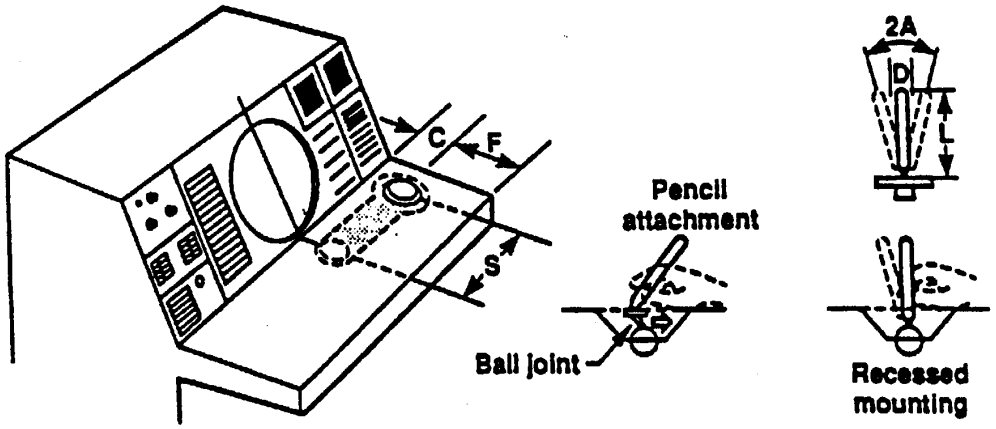
- **9.3.3.2.4 When not to use.** Displacement joysticks shall not be used with automatic sequencing of a CRT cursor or tracking symbol if they have a dead band near the center or hysteresis. An exception may be made if they are instrumented for null return or zero-set to the instantaneous position of the joystick at the time of sequencing. Upon termination of the automatic sequencing routine, the joystick center shall again be registered to the scope center. [Source: MIL-STD-1472F, 1999]

### 9.3.3.3 Finger-operated displacement joysticks

Finger-operated displacement joysticks are useful for free-drawn graphics. In this application, they are not usually spring-loaded to return to center. It is desirable that they have sufficient friction to remain in their last position when the hand is removed.

- **9.3.3.3.1 Finger-operated displacement joystick specifications.** The dimensions, resistance, and clearance of finger-operated displacement joysticks shall not exceed the maximum or minimum values given in Exhibit 9.3.3.3.1. [Source: MIL-STD-1472F, 1999]

**Exhibit 9.3.3.3.1** Finger-operated displacement joystick specifications




| | D diameter | L length | Resist-ance | A Displace-ment | S display clearance to stick clearance | C around stick | F stick clearance to shelf front |
|---|---|---|---|---|---|---|---|
| Minimum | 6.5 mm (0.25 in) | 75 mm (3.0 in) | 3.3 N (12.0 oz) | -- | 0 | † | 120 mm (4.75 in) |
| Maximum | 16 mm (0.6 in) | 150 mm (6.0 in) | 8.9 N (32 oz) | 45° | 400 mm (15.75 in) | -- | 250 mm (9.9 in) |

† Maximum stick excursion plus 100 mm (4.0 in).

- **9.3.3.3.2 Mounting.** The joystick shall be mounted in a way that provides forearm or wrist support. If the joystick is a separate modular device, the module shall be mounted so that the joystick can be manipulated without slippage, movement, or tilting of its base. [Source: MIL-STD-1472F, 1999]

- **9.3.3.3.3 Movement characteristics.** Movement shall not exceed 45° from the center position. Movement shall be smooth in all directions, and positioning of a follower shall be attainable without noticeable backlash, cross-coupling, or need for multiple corrective movements. Control ratios, friction, and inertia shall meet the dual requirements of rapid gross positioning and precise fine positioning. Recessed mounting or pencil attachments may be used as indicated in Exhibit 9.3.3.3.1 to provide greater precision of control. If the joystick is to be used for generating free-drawn graphics, the CRT shall have a refresh rate sufficiently high to give the appearance of a continuous track when the follower is moved. Delay between control movement and the confirming visual indicator response shall be minimized and shall not exceed 0.1 sec. [Source: MIL-STD-1472F, 1999]

### 9.3.3.4 Thumb tip and fingertip-operated displacement joysticks

- **9.3.3.4.1 Usage.** Thumb tip and fingertip-operated displacement joysticks may be mounted on a handgrip, which can serve as a steady rest to damp vibration or increase precision. If they are so mounted, the handgrip shall not itself also function as a joystick. [Source: MIL-STD-1472F, 1999]

- **9.3.3.4.2 Mounting.** Thumb tip and fingertip-operated displacement joysticks shall be mounted in a way that provides wrist or hand support. Console-mounted joysticks shall be mounted as shown in Exhibit 9.3.3.3.1. [Source: MIL-STD-1472F, 1999]

- **9.3.3.4.3 Movement characteristics.** Movement shall not exceed 45° from the center position. If the joystick is a separate modular device, the module shall be mounted so that the joystick can be manipulated without slippage, movement, or tilting of its base. [Source: MIL-STD-1472F, 1999]

### 9.3.3.5 Hand-operated isometric joysticks

Isometric joysticks are also known as "stiff" sticks, "force" sticks, and "pressure" sticks. These 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 (1) there is a need for return to a precise center after each use, (2) feedback to the user is primarily visual rather than tactual from the control itself, and (3) 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]

- **9.3.3.5.1 Specifications.** The handgrip length of a hand-operated isometric joystick shall be in the range of 110 to 180 mm (4.3 to 7.1 in). The grip diameter shall not exceed 50 mm (2 in). Clearances of 100 mm (4 in) to the side and 50 mm (2 in) to the rear shall be provided to allow for hand movement. The maximum force for full output shall not exceed 118 N (26.7 lb). [Source: MIL-STD-1472F, 1999]

- **9.3.3.5.2 Mounting.** Hand-operated isometric joysticks shall be mounted in a way that provides forearm support. If the joystick is a separate modular device, the module shall be mounted so that the joystick can be manipulated without slippage, movement, or tilting of its base. [Source: MIL-STD-1472F, 1999]

### 9.3.3.6 Thumb tip and fingertip-operated isometric joysticks

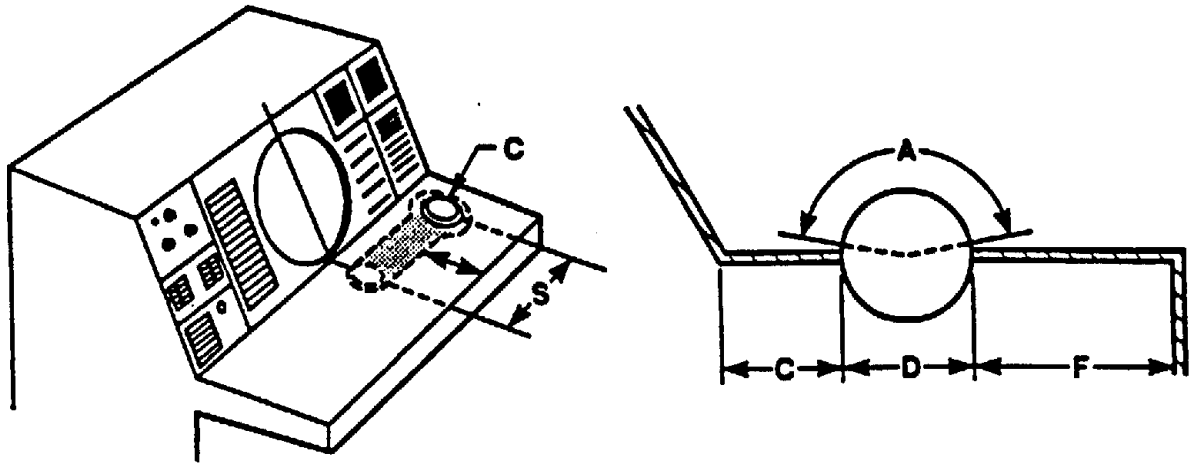
- **9.3.3.6.1 Mounting.** Thumb tip- and fingertip-operated isometric joysticks shall be mounted in a way that provides wrist or hand support. They may be mounted on a handgrip that serves as a steady rest to damp vibrations or to increase precision. If they are so mounted, the handgrip itself shall not function simultaneously as a joystick controller. Console-mounted joysticks shall be mounted as shown in Exhibit 9.3.3.3.1. If the joystick is a separate modular device, the module shall be mounted so that the joystick can be manipulated without slippage, movement, or tilting of its base. [Source: MIL-STD-1472F, 1999]

### 9.3.3.7 Ball controls

Other names for ball controls are "track ball," "ball tracker," "joy ball," and "rolling ball."

- **9.3.3.7.1 Specifications.** The dimensions, exposure, resistance, and clearance of ball controls shall not exceed the maximum and minimum values given in Exhibit 9.3.3.7.1. [Source: MIL-STD-1472F, 1999]

**Exhibit 9.3.3.7.1** Ball control specifications
[Source: MIL-STD-1472F, 1999]




| | Dimensions | | Resistance | | Clearance | | |
|---|---|---|---|---|---|---|---|
| | D Diameter | A Surface exposure | Precision required | Vibration or acceleration conditions | S Display clearance to ball clearance | C Around ball | F Ball to shelf front |
| Minimum | 50 mm (2.0 in) | 100 | -- | -- | 0 | 50 mm (2.0 in) | 120 mm (4.75 in) |
| Maximum | 150 mm (6.0 in) | 140 | 1.0 N (3.6 oz) | 1.7 N (6.0 oz) | 320 mm (12.6 in) | -- | 250 mm (9.75 in) |
| Preferred | 100 mm (4.0 in) | 120 | 0.3 N (1.1 oz) | -- | -- | -- | -- |

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

- **9.3.3.7.3 Movement characteristics.** A ball control shall be capable of rotation in any direction so as to generate any combination of X and Y output values. When moved in either the X or Y direction alone, the control shall exhibit no apparent cross-coupling (that is, movement of the follower in the orthogonal direction). There shall be no backlash apparent to the user. Control ratios and dynamic features shall meet the dual requirements of rapid gross positioning and smooth, precise fine positioning. [Source: MIL-STD-1472F, 1999]

- **9.3.3.7.4 When to use.** 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. 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]

- **9.3.3.7.5 Movement of a follower off a visual indicator.** If the application allows a ball control to move its follower off the edge of a visual indicator, the application shall advise the user how to bring the follower back onto the visual indicator. [Source: MIL-STD-1472F, 1999]

## 9.3.4 Light pen

A light pen is appropriate to use if item selection is the primary type of data entry. For example, a light pen may be used when non-critical, imprecise input functions are required. It may also be used as a track-oriented readout device. It can be positioned on the display screen to detect the presence of a computer-generated track by sensing its refresh pattern. The display system will then present a cursor on the designated track. With suitable additional circuitry, a cursor can be made to track the movement of the light pen across the surface, thus allowing it to function as a two-axis controller capable of serving the same purposes as stylus and grid devices.

- **9.3.4.1 Dimensions and mounting.** A light pen shall be between 120 and 180 mm (4.7 and 7.1 in) long with a diameter between 7 and 20 mm (0.3 and 0.8 in). A clip shall be provided to hold the light pen when it is not in use. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

- **9.3.4.2 Activation.** A light pen shall be equipped with a discrete activating and deactivating mechanism. A push-tip switch, requiring between 0.5 to 1.4 N (2 to 4 oz) of force to activate, is preferred. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

- **9.3.4.3 Feedback.** Two forms of feedback 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, that informs the user that the system is recognizing the presence of the light pen. The feedback shall be large enough to be seen under the point 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. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

## 9.3.5 Stylus and grid

A stylus and grid is appropriate to use as a multipurpose input device when combined with a program for character recognition. The stylus and grid are also very 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.

- **9.3.5.1 Specifications.** A transparent grid used as an overlay on a visual indicator shall conform to the size of the visual indicator. A grid that is displaced from the visual indicator shall conform as closely as possible to the size and orientation of its related visual indicator. The visual indicator shall contain a follower that appears at the position on the visual indicator that corresponds (that is, has the same coordinate values) to the location of the stylus on the grid. [Source: MIL-STD-1472F, 1999]

- **9.3.5.2 Dynamic characteristics.** Movement of the stylus in any direction on the grid surface shall result in smooth movement of the follower in the same direction. Discrete placement of the stylus at any point on the grid shall cause the follower to appear at the corresponding coordinates and to remain steady in position as long as the stylus is not moved. The refresh rate of the follower shall be sufficiently high to ensure the appearance of a continuous track whenever the stylus is used for the generation of free-drawn graphics. [Source: MIL-STD-1472F, 1999]

- **9.3.5.3 When to use.** Grid and stylus devices may be used for data pickoff from a CRT, the entry of points onto a visual indicator, the generation of free-drawn graphics, and similar control applications. These devices should be used only for zero order 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]

- **9.3.5.4 Refresh rate.** The refresh rate for the cursor shall be sufficiently high to ensure the appearance of a continuous track whenever the stylus is used to generate free-drawn graphics. [Source: NASA-STD-3000A, 1989; DOE-HFAC1, 1992]

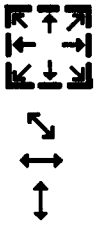
- **9.3.5.5 Remote grid size.** A remote grid shall approximate the size of the display. [Source: NASA-STD-3000A, 1989; DOE-HFAC1, 1992]

- **9.3.5.6 Remote grid placement.** A remote grid shall have an orientation that is consistent with the directional relationships between them and the display without violating any anthropometrics rules. [Source: NASA-STD-3000A, 1989; DOE-HFAC1, 1992]

## 9.3.6 Pointer shapes

- **9.3.6.1 General-purpose pointer shape.** An arrow pointing up and to the left shall be the general-purpose pointer (↖). This and other examples of pointer shapes associated with specific functions are illustrated in Exhibit 9.3.6.1. If an application provides any of these functions, it shall change the pointer to the associated shape whenever that function is invoked. An application shall redefine the shape of a pointer only when the pointer is inside an application window (including the border). [Source: DON UISNCCS, 1992]

**Exhibit 9.3.6.1** Pointer shapes associated with functions

| Shape | Name | Function | Hotspot |
|---|---|---|---|
|  | Arrow | **Pointing.** Used in most window areas for object selection. | The point of the arrow. |
|  | I-beam | **Pointing.** Used in text areas to position the text cursor and perform actions on text. The I-beam pointer is hidden during the time between any keyboard action and pointer movement (that is, when text entry is occurring at the location of the text cursor). | On the vertical bar of the I-beam about one-third from the top. |
|  | Watch (or hourglass) | **Working.** Indicates that an operation is being performed in a window area. When the working pointer is displayed, all pointing device and keyboard actions are ignored in the area. | Not applicable |
|  | Caution sign | **Caution.** Indicates that action is expected in another window area before input can be made in the current area and that the pointer has no effect in the area. When the caution pointer is displayed, all pointing device and keyboard actions are ignored in the area. | Not applicable |
|  | Resize pointer | **Resize.** Indicates positions for area resize, with the direction of the arrow in the pointer indicating the direction of increasing size. The horizontal and vertical resize pointers indicate resize in either the horizontal or vertical direction. The diagonal resize pointers indicate resize in both the horizontal and vertical directions simultaneously. The resize pointer appears when the pointer is on the frame border. | On the corner or line at the position pointed to by the arrow. |
|  | Move arrows | **Moving.** Indicates a move operation in progress or a resize operation before the resize direction has been determined. During a resize operation, the four-directional arrow pointer indicates a direction for resizing and changes to the appropriate resize arrow when the pointer is on the frame border. | The intersection of the arrows. |
|  | Sight or cross | **Sighting.** Used to make fine position selections (for example, to select a location on a map display). | The intersection of the lines. |

- **9.3.6.2 "Hotspot."** A pointer shall have a "hotspot," that is an active point (although this active point may not be readily apparent to the user). The hotspot shall indicate the precise location where an operation will occur. These points are specified for a variety of pointer shapes in Exhibit 9.3.6.1. [Source: DON UISNCCS, 1992]

  **Definition.** A **hotspot** is the precise part of a screen pointer that marks the screen position where an operation on a pointing device will have an effect. [Source: DON UISNCCS, 1992]

- **9.3.6.3 Hotspot and pointer shape.** The screen location of a hotspot shall not change if the pointer changes from one shape to another. [Source: DON UISNCCS, 1992]

- **9.3.6.4 Additional pointer shapes.** If an application provides a function for which a pointer shape does not exist in Exhibit 9.3.6.1, the application may provide a new pointer shape. If this is done, the new shape should (1) be easy to see, (2) obscure as little information as possible on the screen, (3) have a hotspot that is obvious and easy to locate, (4) provide a hint of its purpose, and (5) not be easily confused with other objects on the screen. [Source: DON UISNCCS, 1992]

## 9.3.7 Pointing device buttons

One or more buttons are provided on pointing devices to allow the manipulation of objects on the screen.

- **9.3.7.1 Button operations.** A user shall 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]

- **9.3.7.2 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. If the device has only one button, that button shall provide the "select" function; if it has two buttons, the left one shall provide the "select" function and the right button shall provide a "menu" function. [Source: DON UISNCCS, 1992]

  **Definitions.** 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]

  **Discussion.** If applicable, a system may require that a middle button be used for a particular function (for example, as another means to execute a default action). An application can map a function to the middle button if the function does not contradict or interfere with the function assigned to this button by the system or by another application. [Source: DON UISNCCS, 1992]

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

## 9.4 Alternative input devices (non-keyboard, non-pointing devices)

Application developers are encouraged to use input devices in unique ways to support efficient user performance within an application. In addition, developers might determine that devices such as voice input or touch panels are appropriate alternatives for user input.

### 9.4.1 General

- **9.4.1.1 Consistent interaction.** If an alternate input 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 input devices. [Source: DON UISNCCS, 1992]

- **9.4.1.2 Type of device.** The alternate input device selected for an application shall be the one that most appropriately meets the application requirements and is most cost-effective. The appropriateness of some specific types of input devices for tasks is as follows:

  a. A **touch screen or touch panel** is appropriate for data entry and item selection if typing skills are not required.

  b. An **optical character recognition device** is appropriate for the entry of formatted, printed data.

  c. A **voice input** device is appropriate if the user's visual and manual performances are constrained. [Source: MIL-STD-1801, 1987]

## 9.4.2 Touch interactive devices/Touch panels

A touch-interactive device (TID) is an input device that permits users to interact with the system by pointing to objects on the display. TIDs 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. TIDs 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]

There are six basic types of TID.

a. **Fixed-wire** TIDs place wires, either in parallel or in a grid, in front of the display. Finger contact with the wire(s) generates the X-Y coordinates of the user's touch. This technology is associated with minimal parallax, 70 to 80% transmissivity, and a medium to high degree of TID glare.

b. **Capacitive** TIDs consist 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 TID glare.

c. **Resistive membrane** TIDs are "sandwich" devices in which a touch results in the contact of two conductive layers. Specific current and voltage levels are associated with individual X-Y coordinates. This technology is associated with minimal parallax, 50 to 60% transmissivity, and a high amount of TID glare.

d. **Infrared or light-emitting diode** TIDs use 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, 100% transmissivity, and no TID-related glare.

e. **Surface acoustic wave** TIDs are similar to infrared TIDs 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, and a medium amount of TID glare.

f. **Pressure-sensitive** devices use 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 TID glare. Transmissivity is not affected because the overlay is built into the display screen.

▫ **9.4.2.1 Use.** A touch panel or screen should be used to provide an overlaying control function to a display device (e.g., a CRT, an electro luminescent display, or a programmable indicator) if direct visual reference access and optimum direct control access are desired. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

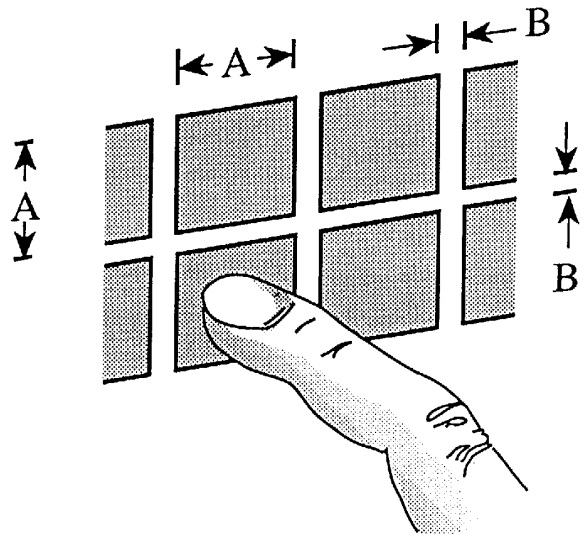
▪ **9.4.2.2 Luminance transmission.** Touch panels shall have sufficient luminance transmission to allow the display to be clearly readable in the intended environment. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

▪ **9.4.2.3 Positive indication.** A positive indication of touch-panel activation shall be provided to acknowledge the system response to the control action. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

▪ **9.4.2.4 Dimensions and separation.** The dimensions and separation of responsive areas of the touch panel shall not exceed the maximum and minimum values given in Exhibit 9.4.2.4. [Source: MIL-STD-1472D, 1989; DOE-HFAC1, 1992]

**Note.** The maximum values listed in the Exhibit apply to logically grouped touch panel responsive areas. An adverse environment may warrant larger sizes and separations.

**Exhibit 9.4.2.4** Touch panel responsive area dimensions




| | A<br>Size | B<br>Separation |
|---|---|---|
| Minimum | 19 mm<br>(0.75 in) | 3 mm<br>(0.13 in) |
| Maximum | 38 mm<br>(1.5 in) | 6 mm<br>(0.25 in) |

- **9.4.2.5 Display feedback.** Display of user command or action feedback for touch panels shall not exceed 0.25 seconds. [Source: MIL-STD-1472D, 1989]

- **9.4.2.6 Minimal parallax.** Touch-interactive devices should be selected and mounted to minimize parallax problems. [Source: Avery & Bowser (DOE HFDG ATCCS V2.0), 1992]

- **9.4.2.7 Minimal specular glare.** Touch-interactive devices should be selected and mounted to minimize specular glare. [Source: DOE HFDG ATCCS V2.0, 1992]

### 9.4.3 Voice control

- **9.4.3.1 Phonetically distinct vocabulary.** Spoken entries used for transactions should be phonetically distinct from one another to eliminate misinterpretation. Testing should be performed to determine which sounds and words or phrases could be distinguished reliably. [Source: MIL-STD-1472F, 1999]

  **Discussion.** Spoken command entries are not to be chosen arbitrarily. Tradeoffs between phonetic distinctiveness and familiarity of terminology need to be evaluated.

- **9.4.3.2 Easy error correction.** Feedback and simple error correction procedures shall be provided for speech input 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]

- **9.4.3.3 Alternative devices.** Alternative input 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]

## 9.5 Interchangeability among input devices

The interchangeability among input devices by the user can be useful during specific operations. Users may want to perform some actions using a keyboard and others actions using a pointing device. The ability to choose which input device must be optional to the user and not a requirement by the system.

- **9.5.1 Redundant control.** If more than one input device is present, a user should be able to control computer interaction with all of them. For example, a keyboard should be capable of executing navigation and selection operations when used in conjunction with a mouse, light pen, or other input devices. [Source: DON UISNCCS, 1992]

  **Discussion.** Full interchangeability is not required. It is assumed that a user will select the input device that is most appropriate for the task being performed. For example, a user may rely on direct manipulation, using a pointing device such as a mouse or trackball, as the primary means of interaction for object selection and manipulation. Similarly, a user may use a keyboard primarily for text entry and for object selection being performed in conjunction with or interspersed with text entry. [Source: DON UISNCCS, 1992]

## 9.6 Accommodating people with disabilities

Most of the difficulty experienced by people with physical disabilities in using computer systems stem from using input devices, such as a keyboard or a mouse, and from handling storage media, such as computer diskettes. [Source: Scadden & Vanderheiden, 1988]

- **9.6.1 Redundant pointing functions.** A system that uses a pointing device, such as a mouse, should provide a means for carrying out all of the pointing functions from the keyboard. [Source: Scadden & Vanderheiden, 1988]

- **9.6.2 Toggle select key.** A toggle type of select key should be available as a standard feature or as an option. [Source: Casali, 1992]

  **Discussion.** 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]

- **9.6.3 Avoiding inadvertent operation.** A computer or computer system intended to be operable by people with moderate motor disabilities should provide either a means for delaying the acceptance of a keystroke for a preset, adjustable amount of time or a keyguard or means for mounting a keyguard. [Source: Scadden & Vanderheiden, 1988]

  **Definition.** A **keyguard** is a keyboard cover with holes over keys. [Source: Scadden & Vanderheiden, 1988]

- **9.6.4 Keyguards.** Keyboards should be designed so that keyguards can be mounted easily. [Source: Scadden & Vanderheiden, 1988]

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

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

- **9.6.7 Readability of lettering on keys and controls.** The lettering on keys and controls required for the operation of a computer or computer system should be large enough to be read easily and have a distinct contrast with its background. [Source: Scadden & Vanderheiden, 1988]

  **Discussion.** This might be accomplished by providing keycaps that can be removed easily and replaced with special keycaps for the visually impaired. [Source: Scadden & Vanderheiden, 1988]

- **9.6.8 Alternatives to input devices.** When an input 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]

  **Discussion.** 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]

- **9.6.9 Non-visual indication of state of toggle keys.** A computer or computer system should provide blind users with a non-visual indication of the state of toggle keys that is available automatically or upon the user's request. [Source: Scadden & Vanderheiden, 1988]

- **9.6.10 Key demarcation.** All keys should have edges that can be discerned by touch. [Source: Scadden & Vanderheiden, 1988]

  **Discussion.** In particular, flat membrane keys without ridges outlining the keys are particularly difficult. [Source: Scadden & Vanderheiden, 1988]

- **9.6.11 Identification of "home" keys.** The "home" keys of keyboards and keypads should have a distinct marking that can be discerned by touch. [Source: Scadden & Vanderheiden, 1988]

- **9.6.12 Key labels.** Alternatives to visual key labeling should be made available for visually impaired users. [Source: Scadden & Vanderheiden, 1988]

- **9.6.13 Special display window.** A windowing environment should provide the capability of opening and maintaining a special window that can remain fully visible and available continuously for use by special input routines. [Source: Scadden & Vanderheiden, 1988]

- **9.6.14 Connection point for switches.** Computers and computing systems should provide a point at which at least two momentary contact input switches could be connected. [Source: Scadden & Vanderheiden, 1988]

- **9.6.15 Distinguishing macro input from typed input.** Computers and computing systems should be able to distinguish between typed, auto-repeat, and macro-generated "keystrokes". [Source: Scadden & Vanderheiden, 1988]

  **Discussion.** "Keystrokes" generated by assistive devices or assistive software may be sent faster than the application software can recognize them, in which case, they may be ignored, thus preventing use of the assistive device or software. [Source: Scadden & Vanderheiden, 1988]

## Glossary

**Alphanumeric keys** - The letters of the alphabet, numerals, and punctuation symbols (numeric keypads may be separate on portable computers).

**Dedicated formatting keys** - Keys for text formatting operations such as a **Space** bar, a **Tab** key, and a **Return** or **Enter** key.

**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.

**Fixed-function key** - Keys provided for extra or general functions, typically labeled **F1, F2,** and so on.

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

**Isometric joystick** - An isometric joystick responds to the amount and direction of pressure applied to it, but it does not move. Displacement joysticks usually require less force than isometric joysticks and are thus less fatiguing over long operating periods.

**Keyguard** - A keyboard cover with holes over keys.

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

**Modifier keys** - Keys that modify or qualify the effects of other keys for as long as they are held down, for example, **Shift, Ctrl,** and **Alt.**

**Navigation keys** - Keys that move a cursor, for example, **Arrow** keys, **Home, End, Page Up,** and **Page Down.**

**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.

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

**Special purpose keys** - Keys that have a special function, such as **Help, Delete,** and **Backspace.**

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