##### Trackball

* Description:
  + A spherical object (ball) that rotates freely in all directions in its socket.
  + Direction and speed is tracked and translated into cursor movement.
* Advantages:
  + Direct relationship between hand and pointer movement in terms of direction and speed.
  + Does not obscure vision of screen.
  + Does not require additional desk space (if mounted on keyboard).
* Disadvantages:
  + Movement is indirect, in a plane different from the screen.
  + No direct relationship exists between hand and pointer movement in terms of distance.
  + Requires a degree of eye-hand coordination.
  + Requires hand to be removed from keyboard keys.
  + Requires different hand movements.
  + Requires hand to be removed from keyboard (if not mounted on keyboard).
  + Requires additional desk space (if not mounted on keyboard).
  + May be difficult to control.
  + May be fatiguing to use over extended time.

**Description.** Commonly used with notebook PCs, the trackball is a ball that rotates freely in all directions in its socket. The ball is rotated with one’s fingertips, and its direction and speed are tracked and translated into equivalent screen cursor movement. Trackballs are well suited for navigational control, as in video games or exploration of 3-D environments. In these tasks, smooth movement is more im- portant than fine target acquisition.

**Advantages.** In terms of direction and speed, a trackball possesses a direct relation- ship between how it is rolled and how the cursor moves on the screen. The cursor moves in the same direction and speed ratio as the ball is rotated. Many trackballs are mounted on the keyboard itself, permitting the user’s hands to remain close to the keys. Trackballs on the keyboard do not require additional desk space, although the keyboard must often be expanded to allow for their inclusion.

**Disadvantages**. Trackballs share a common problem with several other controls: control movement is in a different plane from the screen, or indirect. The cursor, or pointer, is separated from the control itself—the pointer being on the screen, the control on the keyboard. To effectively use a trackball requires learning the proper psychomotor skills, fine finger movements for accurate pointing, and gross hand movements for moving longer distances. The fine finger movements necessary to use them can be difficult to perform. Over longer periods of use, they can be fatiguing. When paired with keyboard tasks, they require a shift in motor activity from keystrokes to finger/hand movement.

##### Joystick

* Description:
  + A stick or bat-shaped device anchored at the bottom.
  + Variable in size, smaller ones being operated by fingers, larger ones requiring the whole hand.
  + Variable in cursor direction movement method, force joysticks respond to pres- sure, movable ones respond to movement.
  + Variable in degree of movement allowed, from horizontal-vertical only to continuous.
* Advantages:
  + Direct relationship between hand and pointer movement in terms of direction.
  + Does not obscure vision of screen.
  + Does not require additional desk space (if mounted on keyboard).
* Disadvantages:
  + Movement indirect, in plane different from screen.
  + Indirect relationship between hand and pointer in terms of speed and distance.
  + Requires a degree of eye-hand coordination.
  + Requires hand to be removed from keyboard keys.
  + Requires different hand movements to use.
  + Requires hand to be removed from keyboard (if not mounted on keyboard).
  + Requires additional desk space (if not mounted on keyboard).
  + May be fatiguing to use over extended time.
  + May be slow and inaccurate.

**Description.** A joystick, like its aircraft namesake, is a stick or bat-shaped device usu- ally anchored at the bottom. They come in variable sizes, smaller ones being oper- ated by fingers, larger ones requiring the whole hand. The smaller joysticks require fine motor coordination, the larger ones more gross coordination. Some, called *force* joysticks, are immovable, responding to pressure exerted against them. The direction and amount of pressure is translated into pointer movement direction and speed. Others, called *movable* joysticks, can be moved within a dish-shaped area. The direction and distance of the movements create a similar pointer move- ment on the screen. Some kinds of joysticks permit continuous movements, others only horizontal and vertical movements. Joysticks may also be mounted on the keyboard. Joysticks are also well suited for navigational control where smooth movement is most important.

**Advantages.** Joysticks typically possess a direct relationship between hand and cur- sor movement in terms of direction. They do not obscure vision of the screen and, when mounted on the keyboard, do not require additional desk space.

**Disadvantages.** Joysticks are also indirect devices, the control and its result being located in different planes. They require developing a skill to use and can be slow and inaccurate. Use over extended time, they may also be fatiguing. When

paired with keyboard tasks, they require a shift in motor activity from keystrokes to finger/hand movement.

##### Graphic Tablet

* + - Description:
      * Pressure-, heat-, light-, or light-blockage-sensitive horizontal surfaces that lie on the desktop or keyboard.
      * May be operated with fingers, light pen, or objects like a stylus or pencil.
      * Pointer imitates movements on tablet.
    - Advantages:
      * Direct relationship between touch movements and pointer movements in terms of direction, distance, and speed.
      * More comfortable horizontal operating plane.
      * Does not obscure vision of screen.
    - Disadvantages:
      * Movement is indirect, in a plane different from screen.
      * Requires hand to be removed from keyboard.
      * Requires hand to be removed from keyboard keys.
      * Requires different hand movements to use.
      * Requires additional desk space.
      * Finger may be too large for accuracy with small objects

**Description.** A graphic tablet, also called a *touch* tablet, is a device with a horizontal surface sensitive to pressure, heat, light, or the blockage of light. It may lie on the desk or may be incorporated on a keyboard, and it is operated with fingers, light pen, or objects like a pencil or stylus. The screen pointer imitates movement on the tablet.

**Advantages.** With graphic tablets, a direct relationship exists between touch move- ments and pointer movements in terms of direction, distance, and speed. The screen mimics the tablet. When used with objects like styluses, light pens, or pencils, the operational angle, horizontal, is more comfortable than those vertically oriented.

**Disadvantages.** Tablets are also indirect controls, creating coordination problems. To use them requires moving one’s hand from the keyboard and, if using another device, picking it up. If the finger is the tablet-activation object, accuracy with small objects is difficult. Tablets also require desk space.

##### Touch Screen

* + - Description:
      * A special surface on the screen sensitive to finger or stylus touch.
* Advantages:
  + Direct relationship between hand and pointer location in terms of direction, dis- tance, and speed.
  + Movement is direct, in the same plane as screen.
  + Requires no additional desk space.
  + Stands up well in high-use environments.
* Disadvantages:
  + Finger may obscure part of screen.
  + Finger may be too large for accuracy with small objects.
  + Requires moving the hand far from the keyboard to use.
  + Very fatiguing to use for extended period of time.
  + May soil or damage the screen.
* Design Guidelines:
  + Screen objects should be at least 3/4 3/4 in size.
  + Object separation should be at least 1/8.
  + Provide visual feedback in response to activation. Auditory feedback may also be appropriate.
  + When the consequences are destructive, require confirmation after selection to eliminate inadvertent selection.
  + Provide an instructional invitation to begin using.

**Description.** A touch screen is a screen that consists of a special surface sensitive to fin- ger or stylus touch. Objects on the screen are pointed to and touched to select them.

**Advantages.** Touch screens possess a direct relationship between hand and pointer movement in terms of direction, distance, and speed. This relationship is direct, not indirect, because the control (finger or stylus) is on the same plane as the pointer. Another significant advantage of a touch screen is that it does not require any additional desk space.

**Disadvantages.** A disadvantage of touch screens is that they are fatiguing to use over an extended period of time. If a finger is the touch mechanism, it may obscure part of the screen and be too large to be accurate with small objects. A stylus is usually more accurate than the finger. Fingers may also soil the screen, and a stylus may damage it. Both finger and stylus require moving a hand from the keyboard, and if a stylus is used, it must also be picked up.

**Guidelines.** When using touch screens, larger screen objects should always be pro- vided to foster accuracy in use. Objects should be 3/4 square at a minimum and separated by at least 1/8. Visual, and perhaps auditory, feedback should be pro- vided in response to activation. When the consequences of selection are destruc- tive, require a confirmation to avoid inadvertent selection. Observational research indicates that touch screen devices placed in public places, for use by the general public, should possess an instructional invitation to begin their use.

Today, other forms of touch screen devices are being used. One type allows placement of a finger on the screen without item selection, selection being accomplished by lifting

the finger off the screen. This may allow more accurate item selection. Another method involves placing a cursor on the screen directly above one’s finger and moving the cur- sor as the finger is moved. The cursor permits better target visibility, as well as the de- tection of smaller targets.

##### Light Pen

* + - Description:
      * A special surface on a screen sensitive to the touch of a special stylus or pen.
    - Advantages:
      * Direct relationship between hand and pointer movement in terms of direction, distance, and speed.
      * Movement is direct, in the same plane as screen.
      * Requires minimal additional desk space.
      * Stands up well in high-use environments.
      * More accurate than finger touching.
    - Disadvantages:
      * Hand may obscure part of screen.
      * Requires picking it up to use.
      * Requires moving the hand far from the keyboard to use.
      * Very fatiguing to use for extended period of time.

**Description.** A light pen also utilizes a touch screen, but one that is sensitive in a specific way to one kind of pen or stylus. Advantages and disadvantages are sim- ilar to those of the touch screen.

**Advantages.** Light pens possess a direct relationship between hand and pointer movement in terms of direction, distance, and speed, and are also classified as di- rect pointing devices because the control (pen or stylus) is on the same plane as the pointer. Another advantage of a light pen is that it does not require any addi- tional desk space, except for a place for the pen to rest. A light pen is usually more accurate than the finger.

**Disadvantages.** A disadvantage is that they are also fatiguing to use over an ex- tended period of time. Light pens require moving a hand from the keyboard to pick up and use.

##### Voice

* + - Description:
      * Automatic speech recognition by the computer.
    - Advantages:
      * Simple and direct.
      * Useful for people who cannot use a keyboard.
      * Useful when the user’s hands are occupied.
* Disadvantages:
  + High error rates due to difficulties in:
* Recognizing boundaries between spoken words.
* Blurred word boundaries due to normal speech patterns.
  + Slower throughput than with typing.
  + Difficult to use in noisy environments.
  + Impractical to use in quiet environments.

**Description.** Automatic speech recognition technology has been under development for more than a quarter of a century. Its progress has been hindered by the disad- vantages listed below.

**Advantages.** Speech is a simple and direct communication medium. It is very useful for people who cannot use a keyboard, or whose hands are otherwise occupied.

**Disadvantages.** Speech recognition errors are fundamentally different from keying errors. Most keying errors result from a user’s inability to always press the correct key. Most speech recognition errors result from the computer speech recognizers’ inability to correctly recognize words. People can dictate to a computer at a fairly fast rate, about 105 words per minute (Karat, Halverson, Horn, & Karat, 1999 and Lewis, 1999). After making the required corrections, the input rate becomes about 25 words per minute when transcribing the input. New users had even lower tran- scribing rates. As summarized in Step 2 “Understand the User or Client*,*” typists, even those of the two-finger variety, have much higher keying rates. Error correc- tion also takes much longer with a speech recognition system. The most commonly used correction methods are: deleting and repeating the last phrase, deleting and repeating a specific word, deleting and selecting a correct word from a list of alter- native words, and retyping the selection.

Several research studies have shown that correcting voice recognition errors using a method other than additional voice recognition speeds up the correction process. Suhm, Myers, and Waibel (1999) found that fast typists made almost three times more corrections per minute than people who made corrections by voice only. Lewis (1999) and Karat et al. (1999) uncovered very similar results.

Speech recognition is also, of course, difficult to utilize in an improper environment. Noise can hinder the process, and it is very impractical, and disturbing, to try and use it in a very quiet location such as a library.

##### Mouse

* Description:
  + A rectangular or dome-shaped, movable, desktop control containing from one to three buttons used to manipulate objects and information on the screen.
  + Movement of screen pointer mimics the mouse movement.
* Advantages:
  + Direct relationship between hand and pointer movement in terms of direction, distance, and speed.
* Permits a comfortable hand resting position
* Selection mechanisms are included on mouse.
* Does not obscure vision of the screen.
  + - Disadvantages:
      * Movement is indirect, in a plane different from screen.
      * Requires hand to be removed from keyboard.
      * Requires additional desk space.
      * May require long movement distances.
      * Requires a degree of eye-hand coordination.

**Description.** A mouse is a rectangular or dome-shaped, movable, desktop control containing from one to three buttons used to manipulate objects and information on the screen. The movement of the screen pointer mimics the mouse movement. In 1968, Doug Engelbart, a researcher at the Stanford Research Institute, invented what became the mouse. While using a trackball, he was inspired to turn it upside down and let the ball become the bottom of a control that, attached to a cord, was moved across the desk. It was patented as the “x-y position indicator,” and finally christened the “mouse” by a colleague of Engelbart’s (a colleague whose name is lost in time). In 1997, Engelbart was at long last rewarded for his invention when he received the annual Lemelson-Mit Prize for American Innovation, including a well-deserved and very substantial monetary reward (cnn.com, 1997).

**Advantages.** There is a direct relationship between hand and pointer movement in terms of direction, distance, and speed. The mouse itself contains some basic controls (buttons) useful for manipulating screen objects. The hand position when using the mouse is generally fairly comfortable, and the mouse does not obscure the screen.

**Disadvantages.** Disadvantages are that they are also indirect devices, the control and its result being located in different planes. They require developing a skill to use and, when paired with keyboard tasks, they require movement away from the key- board and a shift in motor activity from keystrokes to finger/hand movement. The mouse also requires extensive additional desk space and long positioning movements. The mouse comes in a variety of configurations, performs some basic functions, and is operated in several ways.

**Configurations.** A mouse may possess one, two, or three buttons. Most, but not all, windowing systems permit operation using all configurations. Buttons are used to perform three functions to be described. When three mouse buttons are not available, the pointer location or keyboard qualifiers must be used to deter- mine the function to be performed. A multibutton mouse permits a more effi- cient operation, but a person must remember which button to use to perform each function. A multibutton mouse may usually be configured for left- or right- hand use.

**Functions.** The functions performed by a mouse are Select, Menu, and Adjust. The Select function is used to manipulate controls, to select alternatives and data, and to select objects that will be affected by actions that follow. *Select* is a mouse’s

most important function and is the function assigned to a one-button mouse. For a multibutton mouse, it is usually assigned to the leftmost button (assuming a right- handed operation).

The *Menu* function is typically used to request and display a pop-up menu on a screen. A menu appears when the button is depressed within a particular de- fined area of the screen. This area may be, for example, the entire screen, within a window, or on a window border. This button eliminates the need for a control icon, which must be pointed at and selected. The user, however, must remember that a menu is available. The *Adjust* function extends or reduces the number of items selected. It is the least used of the three functions and is usually assigned last and given the least prominent location on a mouse.

**Operations.** Several operations can be performed with a mouse. The first, *point*, is the movement and positioning of the mouse pointer over the desired screen ob- ject. It prepares for a selection or control operation. To press is to hold the button down without releasing it. It identifies the object to be selected.

To *click* is to press and immediately release a button without moving the mouse. This operation typically selects an item or insertion point, operates a con- trol, or activates an inactive window or control. To *double-click* is to perform two clicks within a predefined time limit without moving the mouse. It is used as a shortcut for common operations such as activating an icon or opening a file.

To *drag* is to press and hold the button down, and then move the pointer in the appropriate direction. It identifies a range of objects or moves or resizes items. To *double-drag* is to perform two clicks and hold the button down, and then move the pointer in the appropriate direction. It identifies a selection by a larger unit, such as a group of words.

###### Mouse Usage Guidelines

* Provide a “hot zone” around small or thin objects that might require extremely fine mouse positioning.
* Never use double-clicks or double-drags as the only means of carrying out essential operations.
* Do not use mouse plus keystroke combinations.
* Do not require a person to point at a moving target.

If an object is very small and might require fine mouse positioning, provide a large “hot zone” around it. This will increase target size and speed selection. Do not require double-clicks or double-drags as the only way to carry out essential operations. Rapid double-pressing is difficult for some people. Do not use mouse plus keystroke combi- nations to accomplish actions. This can be awkward. One exception: multiple selections of items in a list. Do not require a person to point at a moving target, except, of course, for a game.

##### Keyboard

* Description:
  + Standard typewriter keyboard and cursor movement keys.
* Advantages:
  + Familiar.
  + Accurate.
  + Does not take up additional desk space.
  + Very useful for:
    - Entering text and alphanumeric data.
    - Inserting in text and alphanumeric data.
    - Keyed shortcuts—accelerators.
    - Keyboard mnemonics—equivalents.
  + Advantageous for:
    - Performing actions when less than three mouse buttons exist.
    - Use with very large screens.
    - Touch typists.
* Disadvantages:
  + Slow for non-touch-typists.
  + Slower than other devices in pointing.
  + Requires discrete actions to operate.
  + No direct relationship between finger or hand movement on the keys and cursor movement on screen in terms of speed and distance.

**Description.** Christopher Latham Sholes invented the standard typewriter keyboard in 1870. Commonly called the QWERTY layout, Sholes’ placement of letters was intended to slow down a typist’s keying movements so that the potential for key jams was minimized. From a strictly human-engineering perspective, its layout inadequacies included a dominance of the left hand in making keystrokes, frequent successive keystrokes with the same hand, frequent movement between keyboard key rows, and frequently used letter pairs being placed far from each other. In 1936, August Dvorak created a revised and well-human-engineered keyboard that overcame many of these deficiencies. The advantages of the DVORAK layout, as it came to be called, included a right-hand dominance in keying, much less frequent row changes, and more systematic alternation between the right and left hand. With this new layout, finger travel distances were reduced by at least one order of magnitude. Acceptance of this new keyboard was, and continues, to be slow. Most users have seemed unwilling to invest the time and effort to change.

In the 1980s, IBM performed a series of studies comparing the QWERTY key- board with various sequential key layouts such as ABCDEF or JIHGFE (starting from the upper left or QWERTY location). IBM wanted to determine if a sequen- tial layout was better for users who professed to be non-touch-typists. Their find- ings were surprising. Non-touch-typist performance results were as good, or better, using the QWERTY layout as using the various systematic layouts. IBM’s conclusion: Why change? So they didn’t. IBM researchers could only speculate as

to why the new systematic layouts fared so poorly. Perhaps, they said, while non- touch-typists profess no knowledge of the QWERTY layout, through experience they have learned the layout, at least well enough to permit effective two-finger typing to be accomplished. Another possibility, they said, was that perhaps some characteristic of the QWERTY layout makes it easy to scan and find needed keys. Speculation number one seems to be the most reasonable explanation, but we may never know for sure.

**Advantages.** The standard keyboard is familiar, accurate, and does not consume additional desk space. It is useful and efficient for entering or inserting text or alphanumeric data. For tasks requiring heavy text or data entry, shifting the hands between a keyboard and an alternative control, such as a mouse, can be time- consuming and inefficient, especially for a touch typist. The keyboard is flexible enough to accept keyed shortcuts, either keyboard accelerators or mnemonic equivalents. Some systems also permit navigation across a screen through use of keyboard keys such as the space bar, arrows, Tab, and Enter.

Inefficiencies in using other graphical device-based controls can occur, making it advantageous to use a keyboard. A mouse with a limited number of buttons will require use of the keyboard to accomplish some functions, possibly causing frequent shifting between devices. When operations are being performed on very large screens, the user may also find keyboard window management preferable to the long mouse movements frequently required. Therefore, to compensate for these possible inefficiencies, many windowing systems provide alternative key- board operations for mouse tasks.

**Disadvantages.** Disadvantages of a keyboard include its requiring discrete finger ac- tions to operate instead of the more fine positioning movements. As a result, no direct relationship exists in terms of speed and distance between finger or hand movement on the keys and cursor movement on the screen. Depending on the layout of the keyboard cursor control keys, direct-relationship direction problems may also exist, because fingers may not move in the same direction as the cursor. Keyboards will also be slower for non-touch-typists and slower than other controls in pointing tasks.

###### Keyboard Guidelines

* Provide keyboard accelerators.
  + Assign single keys for frequently performed, small-scale tasks.
  + Use standard platform accelerators.
  + Assign Shift-*key* combinations for actions that extend or are complementary to the actions of the key or key combination used without the Shift-*key*.
  + Assign Ctrl-*key* combinations for:
* Infrequent actions.
* Tasks that represent larger-scale versions of the task assigned to the unmodi- fied key.
* Provide keyboard equivalents.
  + Use standard platform equivalents.
* Use the first letter of the item description.
* If first letter conflicts exist, use:
  + Another distinctive consonant in the item description.
  + A vowel in the item description.
    - Provide window navigation through use of keyboard keys.

**Keyboard accelerators.** Accelerators provide a way to access menu elements without displaying a menu. They are useful for frequent tasks performed by experienced users. Keys assigned for accelerators should foster efficient performance and be meaningful and conceptually consistent to aid learning.

Microsoft suggests that frequently performed, small-scale tasks should be as- signed single keys as the keyboard alternative. Actions that extend or are com- plementary to the actions of a key (or key combination) should be assigned a Shift key in conjunction with the original action. Microsoft, for example, uses a single key, F6, as the key to move clockwise to the next pane of an active window. To move counterclockwise to the next pane, use Shift-F6.

Infrequent actions, or tasks that represent larger-scale versions of the task as- signed to the unmodified key, should be assigned Ctrl-*key* combinations. The left arrow key in Microsoft Windows, for example, moves the cursor one character; Ctrl-left arrow moves it one word.

**Keyboard equivalents.** Keyboard mnemonics enable the selection of a menu choice through the keyboard instead of by pointing. This enables a person’s hands to re- main on the keyboard during extensive keying tasks. Keyboard mnemonics should be chosen in a meaningful way to aid memorability and foster predictability of those things that may be forgotten. Mnemonics need only be unique within a menu. A simple rule is always to use the first letter of a menu item description. If the first letter of one item conflicts with that of another, choose another distinctive conso- nant in the item description, preferably, but not always necessarily, the second in the item word (occasionally another consonant may be more meaningful). The last choice would be a vowel in the item description. If standard platform equivalents are available, use them. Standard equivalents were shown in Table 4.6 in Step 4.

**Window navigation.** Also provide ways of navigating through windows by the use of keyboard keys.

#### Selecting the Proper Device-Based Controls

A number of studies have been performed comparing the various controls for assorted office tasks. Significant findings include the following.

##### Keyboard versus Mouse

Why do many skilled typists prefer a keyboard to a mouse? Speed is obviously one rea- son. An experienced typist, through kinesthetic memory, has memorized the location

of keyboard keys. The keying process becomes exceptionally fast and well learned. The mouse is slower, and it has a tendency to move about the desk. Its location cannot be memorized. The keyboard keys always remain in the same spot.

Consider the following: When using the mouse, the time to move one’s hand from the keyboard, grasp the mouse, and point at a screen object ranges from 1.5 to 2 seconds. A very skilled typist can type 13 to 15 characters in that amount of time; an average typ- ist can type 4 to 6 characters. No wonder the keyboard is often preferred.

##### Control Research

Which devices work better for which tasks and under what conditions has been ad- dressed by a number of investigators. A survey of the research literature comparing and evaluating different devices yields the following summarization concerning tasks involving pointing and dragging:

The fastest tools for pointing at stationary targets on screens are the devices that permit direct pointing: the touch screen and light pen. This is most likely due to their high level of eye-hand coordination and because they use an action famil- iar to people.

In terms of positioning speed and accuracy for stationary targets, the indirect pointing devices—the mouse, trackball, and graphic tablet, do not differ greatly from one another. The joystick is the slowest, although it is as accurate as the others. Of most importance in selecting one of these devices will be its fit to the user’s task and working environment.

A separate confirmation action that must follow pointer positioning increases pointing accuracy but reduces speed. The mouse offers a very effective design configuration for tasks requiring this confirmation.

For tracking small, slowly moving targets, the mouse, trackball, and graphic tablet are preferred to the touch screen and light pen because the latter may obscure the user’s view of the target.

Another common manipulation task is dragging an object across the screen. Using a mouse, graphic tablet, and trackball for this task, as well as pointing, was studied by MacKenzie, Sellen, and Buxton (1991). They report the following:

The graphic tablet yielded best performance during pointing. The mouse yielded best performance during dragging.

The trackball was a poor performer for both pointing and dragging, and it had a very high error rate in dragging.

##### Guidelines for Selecting the Proper Device-Based Control

* Consider the characteristics of the task.
  + Provide keyboards for tasks involving:
* Heavy text entry and manipulation.
* Movement through structured arrays consisting of a few discrete objects.
  + Provide an alternative pointing device for graphical or drawing tasks. The follow- ing are some suggested best uses:
    - Mouse—pointing, selecting, drawing, and dragging.
    - Joystick—selecting and tracking.
    - Trackball—pointing, selecting and tracking.
    - Touch screen—pointing and selecting.
    - Graphic tablet—pointing, selecting, drawing, and dragging.
  + Provide touch screens under the following conditions:
    - The opportunity for training is minimal.
    - Targets are large, discrete, and spread out.
    - Frequency of use is low.
    - Desk space is at a premium.
    - Little or no text input requirement exists.
    - Consider user characteristics and preferences.
      * Provide keyboards for touch typists.
    - Consider the characteristics of the environment.
    - Consider the characteristics of the hardware.
    - Consider the characteristics of the device in relation to the application.
    - Provide flexibility.
    - Minimize eye and hand movements between devices.

Selection of the proper device for an application, then, depends on a host of factors.

**Task characteristics.** Is the device suited to the task? Standard typewriter keyboards are always necessary for tasks requiring text entry and manipulation; Keyboards (cursor control keys) are usually faster when moving through structured arrays consisting of a few discrete objects.

For graphical and drawing tasks, alternative pointing devices are easier and faster. Use a mouse, joystick, trackball, or graphic tablet for pointing, selecting, drawing, dragging, or tracking. The devices best suited for each kind of task are summarized above.

Provide touch screens when the opportunity for training is minimal; targets are large, discrete, and spread out; frequency of use is low; desk space is at a pre- mium; and little or no text input requirement exists. Touch screens also work well when the usage environment is dirty.

**User characteristics and preferences.** Will the user be able to easily and comfortably operate the control? Are the fine motor movements required by some devices ca- pable of being performed? Is the user familiar with the standard keyboard? What are the user’s preferences? While preferences do not always correspond to per- formance, it is important that the user be comfortable with the selected device.

**Environmental characteristics.** Will the device fit easily into the work environment?

If desk space is necessary, does it exist and is it large enough?

**Hardware characteristics.** Is the device itself of a quality that permits easy perfor- mance of all the necessary tasks? Joysticks, for example, are quite variable in their movement capabilities.

**The device in relation to the application.** Is the device satisfactory for the application?

**Flexibility.** Often task and user needs will vary within an application. Providing more than one kind of device will give the user choices in how to most efficiently accomplish whatever tasks must be performed. A keyboard paired with another kind of pointing device is almost always necessary.

**Minimizing eye and hand movements.** When multiple devices are used, eye and hand movements between them must be minimized. Structure the task, if possible, to permit the user to stay in one working area. If shifts must be made, they should be as infrequent as possible. It is estimated that, for a good typist, it costs 3 to 8 key- strokes for each jump between the keyboard and a mouse. The general rule is that more than 80 percent of the tasks should be doable using only one device.

##### Pointer Guidelines

* The pointer:
  + Should be visible at all times.
  + Should contrast well with its background.
  + Should maintain its size across all screen locations and during movement.
  + The hotspot should be easy to locate and see.
  + Location should not warp (change position).
* The user should always position the pointer.
* The shape of a pointer:
  + Should clearly indicate its purpose and meaning.
  + Should be constructed of already defined shapes.
  + Should not be used for any other purpose other than its already defined meaning.
  + Do not create new shapes for already defined standard functions.
* Use only as many shapes as necessary to inform the user about current location and status. Too many shapes can confuse a person.
* Be conservative in making changes as the pointer moves across the screen.
  + Provide a short “time-out” before making noncritical changes on the screen.
* Animation should not:
  + Distract.
  + Restrict one’s ability to interact.

**Pointer.** The focus of the user’s attention in most device operations is most often the pointer. Therefore, the pointer image should be used to provide feedback con- cerning the function being performed, the mode of operation, and the state of the system. For example, the pointer shape image can be changed when it is positioned over a selectable object, signaling to the user that a button action may be per- formed. When an action is being performed, the pointer can assume the shape of a progress indicator such as a sand timer, providing an indication of processing status.

A pointer should contrast well with its background and be visible at all times. The user should always be in control of its location on the screen. The shape of a pointer should clearly indicate its purpose and meaning. Always use predefined shapes pro- vided by graphical systems. Microsoft Windows, for example, provides about two dozen standard shapes. To aid learning and avoid user confusion, never create new shapes for already defined standard functions or use a shape for any purpose other than its pre- viously defined meaning. Also, use only as many shapes as absolutely necessary to keep the user informed about current position and status. Too many shapes can also confuse a person.

Be conservative in making changes as the pointer moves across the screen. Excessive changes can be distracting to a person. To avoid frequent changes while crossing the screen, establish a short time-out before making noncritical pointer changes. Any pointer animation should not distract the viewer or restrict one’s ability to interact with the system.