

Dashboard for Controls

Design Reference

A Companion to the
Dashboard for Controls

Design Guide for the
Creation of Touchpanel
Control Interfaces



Acknowledgments

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Foreword

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The content in this document has been developed by industry volunteer experts working on behalf of InfoComm International®, in support of the “Dashboard for Controls” effort. While the “Dashboard” is about making AV controls easier to use for the individual user, the process leading to its creation is about individuals working together for a common cause. I hope you’ll find that cause, the Dashboard for Controls and its various elements, to be of benefit to your work and the industry as a whole.

More than 50 InfoComm member volunteers have contributed to the project since it began in the spring of 2001. Be it concept development, critical review, peer dialog or simply monitoring our activities, we owe thanks to all for the many, many contributions along the way. Space prevents listing all contributors; but perhaps you are one of those who contributed. If so, I (and the Dashboard for Controls Steering Committee) thank you. I’d offer that you should take satisfaction on those elements you can identify as “your own” and further consider those with which you may have taken exception. You’ll be in good company.

Special thanks, and credit, go to dedicated individuals who over the last year have given extra, as steering committee members, in the sprint to the “finish line.” Indulge me while I tell a few stories. Andrew Faunce was at the InfoComm End User Summit in March of 2002 when we first conceived of the Dashboard project. At key points

since then, he has continued to thoughtfully consider and contribute to shaping the Dashboard. Rick Nimtz and Rem Remington “raised their hands” when the InfoComm End User (Technology Manager) Council looked for sub-committee members to work on the Dashboard at our annual meeting. They’ve hung in there for years; and may think twice next time we’re looking for hands (just kidding)! Tim Cape and Dave Silberstein “returned my calls” in the summer of 2002 when I asked for their participation in the then newly developed “cross-council” work group for Dashboard. Sometimes advocates, sometimes voices of reason, they’ve been there throughout, contributing with the wealth of knowledge they have on this topic. Last, but not least, are Greg Maderic and Howard Nunes, both of whom participated as representatives of the fledgling InfoComm Programmers Council. Starting “cold” on the project in fall of 2004, they immediately immersed into “all things Dashboard.” Writing, and editing, the Dashboard Reference, they lent their expertise to add a dimension to the project that I hadn’t let myself dream would be achievable.

Thanks go to InfoComm , and its skilled staff, for providing a platform for this work to occur and shepherding the volunteer effort. If you believe there are errors or omissions in this work, or simply want to help further develop the concepts, please contact the InfoComm membership department. We welcome your input.

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Introduction

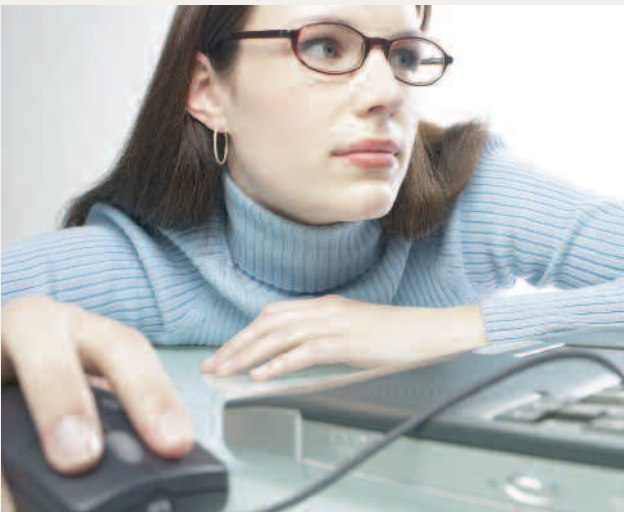
An AV system's success depends on how well it can be implemented to simplify our lives and increase our productivity. An AV system requires enormous resources in high-tech equipment and man hours to assemble, code and install it. If it is difficult to operate, the effort will be wasted.

This Design Reference Guide complements the InfoComm Dashboard for Controls Template document. The purpose of these documents is to help guide the creation of touchpanel control interfaces and to promote intuitive end-user operation of professionally installed AV systems.

The Design Reference Guide examines principles of design that enable the successful implementation of graphical user interfaces in AV control systems. While this document covers many theories of interface design, the first and foremost is the knowledge of the intended end-user. What will the end-user do with the system? How will he or she use it? When will it be used? What characteristics will the end-user(s) find most intuitive? Will there be one super-user or many novice users? In the end, system success will be measured by the end-user's satisfaction.

DESIGN TIP

Learn as much as you can about the intended end-user of the system; create an interface that addresses the needs of the user.



Human Factors: the Theory Behind Interface Design

The study of human interaction with technology, known as “Human Factors,” approaches design issues based on the use, rather than the potential, of the end product. By using principles determined through this study of Human Factors to guide their interface designs, designers can focus on what the client needs, rather than what the technology will allow. This is important because the control interface is the point of access to the AV system and the most critical element in determining success.

DESIGN TIP

Be aware of human capabilities and limitations; reduce needless complexity in the control system interface.

The study of Human Factors stems from three fundamental “laws”.

1 **Moore’s Law:**

The growth of technology is a function of time; there will be more technology tomorrow than there is today.

2 **Buxton’s Law of Promised Functionality:** The functionality promised by technology will grow proportionally with Moore’s Law; there is going to be more functionality promised or offered tomorrow, than there is today.

3 **God’s Law (Buxton’s interpretation):**

Human capacity is limited and does not increase over time; our neurons do not fire faster, our memory doesn’t increase in capacity, and we do not learn or think faster as time progresses. In fact, for individuals the opposite is true (Buxton 2001).

The interpretation of these “laws” is best described by Human Factors’ proponent and author, Alan Cooper, who concludes that when we combine a computer with anything, we create yet another computer with even greater complexity (Cooper 1999). While engineers may increase features to remain competitive, the human capacity to control technology remains constant and limited. This paper reviews some of the philosophies embraced by Human Factors’ proponents, expands upon their guidelines and extrapolates applicable elements to AV control interface design.

Design Principles

Taking into consideration the wide-ranging scope and customization of AV systems, it is clear that no single standard will suffice. AV control system interface design is an exercise in compromise that requires effective interaction with technology. The following are some of the Human Factors design principles that may be employed to promote ease of usage and the end-user's comprehension.

Advance Organizers

The Advance Organizer is a valuable tool in communicating to non-industry professionals.

Any end-user will have had some experience with technology prior to using an AV control system. An Advance Organizer includes information based on the end-user's previous experience. This is then used to contrast and compare new information (Lidwell, Holden, and Butler 2003).

For example, the mouse as a computer interface pointing/clicking device is a Comparative Advance Organizer used to contrast and segue into using the finger as a screen pointing/clicking device. Other Advance Organizers relevant to the AV industry are hand-held remotes or ATM machines, which can be used to draw parallels for touchpanel interfaces.



DESIGN TIP

Draw simple parallels to common objects, which will ease an inexperienced user's apprehension about new technology.

Affordances

An Affordance is the physical design characteristic(s) of an object or environment that communicate and influence its function. Psychologist J.J. Gibson originally coined the term "affordance" to reference the actionable properties of relationships between the physical world and humanity. Since then, the term has become a standard in the design community. Don Norman, author of *The Design of Everyday Things* (1988), coined the phrase "perceived affordance," as our willingness to believe that an image of an object has physical characteristics, for the screen environment.

In the touch screen control environment, the end-user must believe that touching images – rather than objects – is a useful action. The interface designer, making use of perceived affordance, must make images communicate their intended function, either verbally (textually) or metaphorically.

DESIGN TIP

Communicate the desired actions and available functions of a system for end-users with little or no training. Make the interface so transparent in its use that it could not possibly be interpreted as intended for any other purpose.

DESIGN TIP

Use “chunking” to substitute complex labels for simple, familiar ones and to keep menus short and manageable.

Verbal communication is certainly the most direct and understandable form of communication. However, as shown by the Aesthetic-Usability Effect (shown here), metaphors may be a more attractive, albeit problematic, alternative. In his essay, *Affordances and Design*, Don Norman outlines four goals for having an end-user understand the actions available on the screen interface:

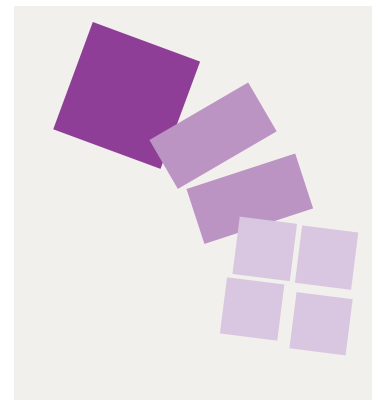
- Follow conventional usage, both in the choice of images and the allowable interactions.
- Use words to describe the desired action.
- Use metaphors.
- Follow a coherent conceptual model so that principles learned in one part of the interface also apply to other parts (Norman 2004).

Chunking

Due to the nature of the human brain and the way it processes and stores data in short-term memory, information is more likely retained if it is presented in small chunks. For example, U.S. phone numbers are chunked into three manageable pieces because it is easier to view and remember (456) 867-5309 than 4568675309. In the AV industry, chunking in the form of acronyms is commonplace. As a result, we control DVDs and VCRs rather than Digital Versatile Discs and Video Cassette Recorders.

When determining naming conventions and menu structures for an interface, chunking should be carefully considered – especially in cases where acronyms do not exist or could be misleading. For example, Video Conference Recording is long and unnecessary in the absence of any other recording option. It should not, however, be shortened to VCR, because that acronym is already commonly used.

In another example, “Audio Cassette” need only be called “Cassette” in the absence of any similar or conflicting device. In fact, if an audio cassette deck is the only recording destination available, the type of device or media it uses does not even have to be distinguished. Start and stop recording functions are all the end-user needs. In a system containing both a VCR and Audio Cassette deck for recording, the term “Audio Cassette” may be chunked simply to “Cassette”. Or the device type could be ignored entirely and the focus turns directly to the outcome of “video” or “audio” recording within a defined recording sub page.



Studies indicate that while very few people can remember a list of ten words beyond 30 seconds, a list of five words has a much greater chance of retention (Lidwell, Holden, and Butler 2003). Therefore, a large presentation system could make use of a menu structure that separates sources into smaller chunks for video, audio, auxiliary and computer sources or by location for podium, rack, or table sources. The selection of five components for ease of retention assumes a clean environment where the end-user will be able to focus and operate the interface without pressure or distraction. Since this type of environment is difficult to find, even fewer options make sense in busy environments.

Aesthetic-Usability Effect

Studies have concluded that aesthetic designs are perceived as easier to use than utilitarian ones (Lidwell, Holden, Butler 2003). This is known as the “Aesthetic Usability Effect.” It is similar to the “attractiveness bias” that causes most people to believe that individuals with symmetrical facial structures are considered more intelligent, sociable and competent.

To the interface designer, this means that a visually pleasing layout is perceived as easy to use and is therefore more likely to be used (whether it is in fact or not). This would indicate that creating an aesthetic interface will foster positive attitudes in the end-user. However, there are a number of issues to be considered when using aesthetics to draw in the end-user. First, it is difficult to benchmark the definition of “attractive and inviting,” since beauty is in the eye of the beholder. Second, the designer may have to sacrifice communicating core functionality for the sake of attractiveness. Finally, additional resources, unavailable in the given situation, may be required to produce a more aesthetic interface.

Defining “aesthetic” requires viewing mainstream design elements. The aesthetic elements in advertising, for instance, could be used in control interface designs. However, the still unresolved issue is who is responsible for the aesthetics. Because good design is a product of a talented artist, the average person runs the risk of doing it poorly. Therefore, the end-user should not become the artist. The result would be poor design and costs that are out of control.

In the commercial environment, the interface design can be borrowed from the customer’s branding identity. In residential situations, samples can be provided from which the end-user can select or, at least, form the aesthetic foundation of the design – a simple way to minimize time spent on aesthetic issues.

DESIGN TIP

Use aesthetics to invite the user to interact with the interface. Make the user comfortable with it without impairing usability.

DESIGN TIP

Constraints applied to on-screen objects should replicate the constraints that apply to the physical object that they mimic or most resemble.

DESIGN TIP

Graying or dimming objects (rather than causing them to disappear) will assure the end-user that the system is functioning correctly and that he or she has not caused an error. The function is simply no longer available for use...

Constraints

The function of constraints is not to increase the steps to a desired goal, but to simplify usage by eliminating all unnecessary or unavailable functions or processes. Employing constraints will focus an end-user on the core functions of a system, eliminate confusion and reduce the probability or perception of error. Whether using physical or psychological constraints, the goal is to provide only what the end-user needs or the system design dictates.

While the “wizard mode” (often found in control interfaces and commonly associated with computer software) is constraining, it is actually a tree hierarchy. This hierarchy is designed only for one-time-use and for a novice. Repeated exposure to the tree hierarchy can create frustration and raise the probability of error while dramatically formalizing and increasing the amount of time it takes a user to reach a desired function (mean time to use).

Physical Constraints

Physical constraints are the affordances of physical design that restrict the use of a particular object in paths, axis and barriers (Lidwell, Holden, Butler 2003). For example, mixing-board sliders will only travel along a single path because they have upper and lower barriers that prevent further motion. Knobs that control audio balance, base, treble and other audio aspects, rotate on a fixed axis with similar limits. Don Norman’s four goals of conventional usage (previously cited) would dictate that the screen simulation of these objects follows the same limits.

The most common physical constraints used in the interface design are omission barriers. If a function becomes unavailable in a modal situation, the function can be grayed out or omitted entirely. However, caution is advised in modal situations. Generally, it is better to dim an object than to remove it altogether. The end-user may think he or she (or the system) made an error if functions suddenly disappear.

Dimming or “graying” functions are also standard software conventions that more effectively communicate to the user that the system is still operational, but the functions are simply unavailable. Dimming objects can be a disadvantage because their continued presence will capture the end-user’s attention. In addition, they require time for the user’s eye to scan, to determine their unavailability and, ultimately, the course of action. The solution may be to dim objects that are within the user’s direct view at the time of a given action. For functions that are not directly visible, omission barriers may be more appropriate.

Psychological Constraints

Psychological constraints consist of conventions, mappings and symbols to communicate the limits of actionable functions available to the end-user (Lidwell, Holden, Butler 2003). One typical convention is the distinct shape of a “play” icon. This shape is a conventional constraint because it is widely used in the electronics industry. When presented with related transport functions, it is immediately recognizable. In order to maintain the play convention, similar functions that could be metaphorically defined by this shape must be presented in other contexts. That means the same button should not be used for “play” and “increase” in the same vicinity.

“Mapping” is the grouping of objects and functions in order to communicate a relationship. Common examples of mapped functions in an AV system would be transports, raise and lower, or increase and decrease. We maintain the proximity of these functions to communicate their relationship; we present all related functions simultaneously, as they are mutually supportive.

The concept of mapping would seem logical, but there are good examples of poor mapping. Typical flaws include separating next and last buttons, having only one direction available at a given time, or using a vertical bar graph to represent progress while using horizontal arrows to indicate direction.

Symbols communicate meaning through metaphor. A skull and crossbones could call to mind numerous meanings: pirates, danger or poison. When viewed in context, however, on a solvent container, the meaning is clear. For this reason, symbols and visual metaphors must have a clear meaning – within a context. Presenting a symbol inappropriately will interrupt the end-users’ thought process and force a conscious effort to decipher the meaning.

Entry Point

The truth is people are judged by their appearance and books by their cover. For this reason, all the attention to detail that goes into the system design, the programming and the interface may be diminished by a poor entry point. By creating a splash page or entry point with a focus on attractiveness, a good first impression is made. In fact, the entry point should receive the most aesthetic attention. While it may have no bearing on the effective functionality of the interface, it has great bearing on the initial perception.

An exception to the aesthetic rule involves clearly communicating to the end-user how to proceed beyond the entry point. In multi-room commercial or educational environments, the splash page may identify the end-user or location or focus on aesthetics, as well as give clear instructions on what to do next. Some larger organizations may also want to select customized options, based on end-user preferences.

DESIGN TIP

Conventions and symbols are context sensitive. Locate them appropriately to keep their meanings clear.

DESIGN TIP

Create an attractive entry point or splash screen to draw the user into the system. Be sure to convey any important information, such as room location or user group, and to tell the end-users what to do next.

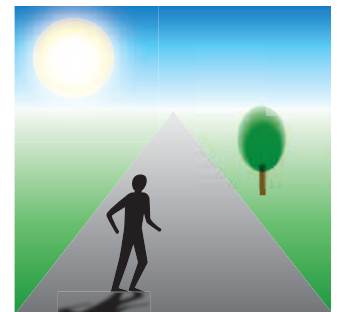
There are several ways to help create a good first impression. In the residential market, an end-user's personal photographs can be incorporated or a custom layout designed with the owner's name prominently displayed on the screen. In the commercial environment, company branding, a group designation or department name can be used to create corporate pride at the system entry point. Some designers, integrators or programmers include their logo on the splash screen to promote their interests (if permitted by the customer). In this instance, a notation that the Dashboard for Controls template has been integrated with the system will help support the propagation of the industry guideline.

Figure-Ground Relationship

One of the Gestalt rules of perception (see Perception), the Figure-Ground Relationship breaks visual perception into two parts: objects of focus and the perceptual field. Published in the Universal Principles of Design, there are five visual cues to determine the perception of objects as either figure or ground (Lidwell, Holden, Butler 2003).

- The figure has a definite shape, whereas the ground is shapeless.
- The ground continues behind the figure.
- The figure seems closer with a clear location in space.
- Elements below a horizon line are more likely perceived as figures.
- Elements in the lower region of designs are more likely perceived as figures.

The identification of a figure is also based on other Gestalt laws, such as closure and proximity (see Gestalt Laws of Organization). It is important to take advantage of our natural inclinations to separate figure from ground and to remember objects of focus when designing the interface.



DESIGN TIP

Design objects of focus so they will not blend into the background as a result of similar colors, textures, repetitive shapes, or directional patterns.

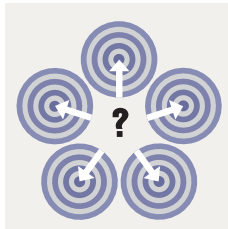
Fitts' Law

The Fitts' Law equation mathematically accounts for the amount of time it takes to reach a target based on the distance to the target and its size. (Lidwell, Holden, Butler 2003). This formula is applicable to all manner of physical movement and is based on both ballistic movement (one large rapid motion to the target) and homing (the fine adjustment that follows and accounts for most of the time required to acquire a target). In the context of interface design, this formula pertains to a target that has been visually acquired, with the movement to a target being based on eye/hand coordination and physical attributes. Fitts' Law concludes that the time to acquire a target and the error rate will increase as the target distance increases and as the target size decreases.



Hick's Law

Hick's Law states that the time required to make a decision will increase with the number of alternative options (Lidwell, Holden, Butler 2003). Four factors influence the process of any task: 1) goal identification, 2) option evaluation, 3) decision-making and 4) taking action. Fitts' Law applies to taking action, while Hick's Law applies to the decision-making process. Hick's Law is also expressed as a mathematical equation, but only applies to simple tasks that require minimal stimuli-response time. In the simplest terms, the equation determines the amount of time it takes to visually recognize an object, search long-term memory for the correct reference and decide that the stored reference is accurate.



To keep the interface design within the Hick's Law paradigm, the designer must use simple conventions, language constraints, and strong figure-ground relationships. These prerequisites reduce the decision-making process from conscious and focused analysis to simple response. There are additional graphic design elements that should also be considered, such as font use, colors, contrast and size that all influence the amount of time it takes to perceive the available options.

To put this in perspective, a typical presentation system end-user (with no external pressure, distractions or visual barriers) will take over three seconds to make a choice from ten possible options. Additionally, he or she will take one or more seconds to physically make the selection. Add to this all the other possible variables and interruptions, it becomes clear that the interface designer directly influences the success, not only of the system but, by extension, the presentation itself.

DESIGN TIP

Using larger objects makes it easier for interface users to "target" with their fingers. This can reduce the time required to use the system and errors due to missed targets.

DESIGN TIP

Use simple conventions, language constraints and strong figure-ground relationships to reduce the decision-making process from conscious and focused analysis to simple response.

DESIGN TIP

Keep the end-user's needs in mind when deciding how much complexity to include in your interface. Removing unnecessary features and functions will increase usability.

Flexibility-Usability Tradeoff

An increase in flexibility can lead to a decline in usability. The universal remote control is a good example of lost usability as the quantity of features and functions increases. Decades ago, the hand-held remote would do little more than change channels, adjust volume or open a garage door. These devices were simple to operate because their use was constrained to a very short list of options. The modern universal remote not only strives to control an ever-growing list of device types, but also an increasing list of features. Unfortunately, the all-in-one design philosophy behind universal remote controls leads to complexity, increased time to use and overall frustration.

In part, the complexity of the universal remote is due to the use of modal operations – a single button with multiple uses based on the device configuration. In many cases, it is necessary to use modal operations to decrease the number of physical buttons on the remote, but this only works when devices share common functions, such as keypad entry.

The end-user becomes confused by modal operations when the same button controls two or more completely unrelated functions, based on the hardware selected. The universal remote does little to indicate which device is currently selected or even the current state of, or changes to, functional options based on the device selected.

The lack of communication and information from the typical push-button remote makes the touchscreen interface a much stronger solution, as long as the interface designer does not mimic or duplicate the shortcomings of the universal remote. Having a clear understanding of the end-user's needs will eliminate unnecessary features and options and, in turn, increase usability.



Navigation Hierarchies

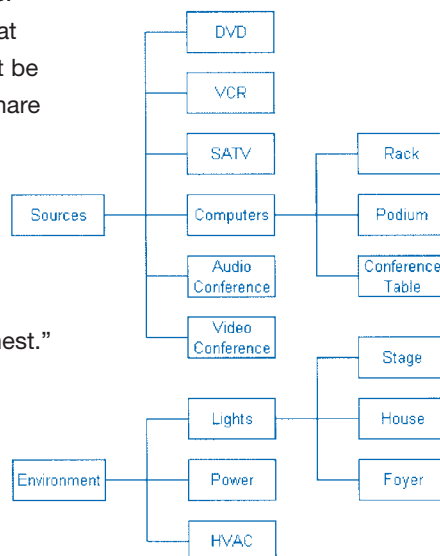
In complex AV systems, it is sometimes necessary to create a menu structure that will operate modally and to nest functions or categories due to limitations on available space. A good example would be a room used for various kinds of presentations, recordings, and video- or audioconferencing, with numerous sources and destinations. The principle behind this type of system is flexibility. That, however, can lead to complexity in use. In order to accommodate this complexity, a visual hierarchy can organize and simplify the interface. Again, the first goal is to understand the needs of the end-user. For example, if one person will repeatedly use a complex system, the designer may use fewer constraints to simplify it. If, however, a highly complex system is being designed for non-repetitive or novice end-users, all the rules and devices that could possibly apply will not eliminate the complexity. Hierarchies may help.

Hierarchal parent-child structures are the simplest way to navigate complex systems. Consider the menu structure of a hypothetical system with the features previously mentioned. Under the category of “presentation sources,” video, audio, computer, auxiliary, rack, podium, control booth, table and wall inputs can be found. Under the category “video conference,” similar sources are found, in addition to dialing, onscreen navigation, recording functions and various microphone or camera positions. It would then become necessary to create parent categories for presentation and videoconferencing and, therefore, have the child categories appear only when the parent is selected.

Perhaps the most recognized hierarchal structure is the “tree.” This structure is familiar in the visual presentation of a family genealogy where children are visually positioned below the parents.

The difficulty with this structure is that parent-to-child relationships may not be linear because some children may share multiple parents. An example of this would be an AV system in which presentations and video conferencing share the same, but not identical, sources.

Another hierarchal structure is the “nest.” In this structure, the children reside within the parent category. The disadvantage to this structure is that the size of the visual presentation grows with the levels

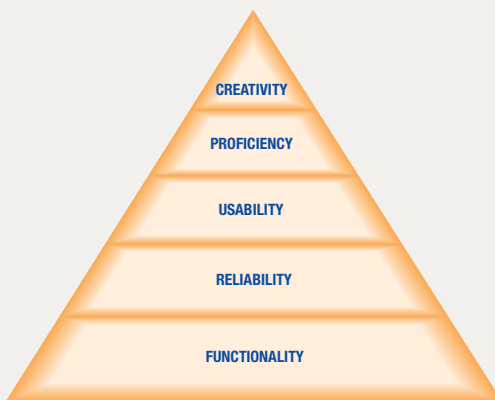


DESIGN TIP

Simplify complex systems by using hierarchies; group “child” functions under “parent” categories – visible when applicable, but otherwise hidden.

DESIGN TIP

In this order, focus on Functionality, Reliability, Usability, Proficiency and, then, Creativity. The value of the system increases as each next step is attained.



of complexity, such as rings indicating the age of a tree. The stair model of hierarchy is the structure most commonly found in the Windows operating environment. The stair structure may be the most appropriate solution for that environment because the end-user is operating in a defined mode and will not be simultaneously presented with two identical menu options, such as source selection under presentation and videoconferencing.

Hierarchy of Needs

Using Maslow's Hierarchy of Needs, which prioritizes basic human needs for survival against higher-level ego needs for self-actualization, the end-user's needs can also be prioritized when interacting with technology (Lidwell, Holden, Butler 2003). Although the Aesthetic-Usability Effect explains that a person is more likely to use technology that looks good, the technology will be quickly abandoned if it does not live up to the advertising.

- **Functionality:** Before even considering advanced features and specialization, the most rudimentary system functions must operate properly. In and of itself, this can be a sizable task considering the difficulty coping with incompatibilities among manufacturers, finding serial or infra red drivers for new equipment or overcoming end-user expectations when the installed equipment simply does not perform to expectations.
- **Reliability:** The system will remain under examination until the end-user is satisfied with the system's continued function over time. Another consideration of reliability is quality. An AV system may function reliably, but be considered unreliable if quality falls short of expectation. This may be a result of missing features, questionable picture or poor sound.
- **Usability:** If the technology is difficult to use or consequences resulting from mistakes are too severe, the system will be devalued.
- **Proficiency:** Over time, an end-user should be able to perform tasks better, faster and easier than expected or previously encountered. Proficiency represents the ability of technology to satisfy the needs of end-users who vary in experience and capability. Systems that achieve this degree of acceptance are considered highly valuable.
- **Creativity:** This is the highest level in the hierarchy of needs and allows for the end-user's creative input and innovative use. This is not a typical achievement for the custom control system because custom designs by nature often translate to utilitarian and have no other attainable goal without adding unnecessary complexity.

Interface Design

Interface design in recent years has become a science unto itself. The following are some basic rules and observations that major proponents of human factors have discovered from their pursuits. Of course, the touch screen interface has only recently become a focus of attention in the human factors arena. Therefore, the bulk of studies and theories to date are generic but they remain applicable.

Shneiderman's Rules for Interface Design

Based on years of study, Ben Shneiderman has written many books about human/computer interaction. As a result, he published these eight “golden rules” of interface design related to the screen environment:

- **Strive for consistency:** Consistent sequences of actions should be required in similar situations; identical terminology should be used and consistent commands should be employed throughout.
- **Enable frequent users to use shortcuts:** As the frequency of use increases, so does the user's desire to reduce the number of interactions and to increase the pace of interaction.
- **Offer informative feedback:** For every operator action, there should be some system feedback. For frequent and minor actions, the response can be modest, while for infrequent and major actions the response should be more substantial.
- **Design dialogs to yield closure:** Sequences of actions should be organized into groups with a beginning, middle, and end. The informative feedback at the completion of a group of actions gives the operator a satisfaction of accomplishment, a sense of relief, the signal to drop contingency plans and options from their minds, and an indication that the way is clear to prepare for the next group of actions.
- **Offer simple error handling:** As much as possible, design the system so the user cannot make a serious error. If an error is made, the system should be able to detect the error and offer simple, comprehensible mechanisms for handling the error.
- **Permit easy reversal of actions:** This feature relieves anxiety, since the user knows that errors can be undone; it thus encourages exploration of unfamiliar options. The units of reversibility may be a single action, data entry, or a complete group of actions.

- **Support internal locus of control:** Experienced operators strongly desire the sense that they are in charge of the system and that the system responds to their actions. Design the system to make users the initiators of actions rather than the responders. If the user does not feel in control, he or she will feel anxiety and dissatisfaction.
- **Reduce short-term memory load:** Too much information is bad information. The limitation of human information processing in short-term memory requires that displays be kept simple, multiple-page displays be consolidated, and window-motion frequency be reduced (Shneiderman 1992).

The Myth of the Metaphor

One of the most important indications of a good user interface is how easy it is to learn. Making the interface easy to visually decipher not only affects the speed with which first time operators may use the system, but also how quickly repeat end-users recognize functions that they need. Common tools to influence the simple and speedy recognition of functions are conventions, images and the visual metaphor. (See Psychological Constraints.)

Metaphors are an analogy in which the contrast or comparison of two things yields a visual definition. In the world of computer operating systems, numerous icons of folders, file cabinets and clip boards are used to compare the actual functions of these physical objects to the electronic equivalent. Some of the most prominent minds in the world of interface design strongly denounce or, at least, strenuously warn against the use of metaphors. In his article, *The Myth of Metaphor*, Alan Cooper, well known author and founder of Cooper Consulting, stated that “searching for that guiding metaphor is like searching for the correct steam engine to power your airplane, or searching for a good dinosaur on which to ride to work.” In other words, the use of metaphors keeps us rooted in the past (Cooper 1995).

The goal of the metaphor is to boost the ability to learn, which is negated by using metaphors of devices that have changed form or outlived the audience. For example, the rotary telephone is a widely used metaphor to indicate modems, dialing or telephones in general. However, a younger audience, which has never encountered a rotary dial, is forced to assume or learn the meaning of the metaphor. This defeats the metaphors intended purpose. The same applies to audiences of different cultures, for whom a given metaphor may have a different meaning or no meaning at all.

On the other hand, a metaphor can become a convention after long-term use and acceptance. The end-user may have no choice but to learn metaphors that have become conventions in the realm of highly specialized technology.

DESIGN TIP

AV systems usually do little error tracking and reporting. Conduct post-operational studies to determine end-users reactions to the system or problems they may have encountered.

The Dashboard for Controls is itself based on a comparative metaphor, which suggests that the (nearly) universally accepted common features of a car dashboard may provide a model for uniformity in AV control layouts. The intent of Dashboards for Controls is to examine how a common or conventional control layout can help promote user comfort in much the same way as a driver can navigate an “unknown” rental car without looking at an operator’s manual.



By using conventions, the interface can also take advantage of the strength of human recall. It is easier for people to recognize objects based on previous short-term experience than to remember through long-term memory. Searching long-term memory greatly expands the list of possible meanings for an image, symbol or icon, while recall of an object within a specific context provides the needed cues that make recall more like a multiple-choice question.

Images

Images in the form of photographs, illustrations and line art offer strong aesthetic appeal and should be considered by the interface designer for the entry point or page backgrounds. The use of images presents several issues. Unless the designer has created the images or has obtained permission by the rightful owner to use them, federal copyright laws may apply. The designer must also consider the effectiveness of images. Electronic devices, for instance, with their black box designs all look similar. In comparing images of a CD and DVD player, the form and function for these devices and media are identical. Therefore, what visual representation would the interface designer use that would strongly distinguish one device from another?

Perception

The study of perception on a psychological and physiological level exposes rules that an interface designer may employ to appeal to the subconscious. This approach emphasizes that objects are perceived as well-organized patterns rather than separate components. The “whole” that is seen is more structured and cohesive than a group of separate parts. This concept of an integrated whole is described by the German word, “Gestalt.” Gestalt psychology can be understood by examining the Gestalt Laws of Organization, which describe the ways in which a person’s experiences are organized in a simple and coherent way.

DESIGN TIP

If you use metaphors, be sure they conform to convention. If not, be sure that they can be understood by all end-users of the interface, accounting for various age and cultural differences.

DESIGN TIP

Communicate related functionality and purpose by using similar properties, by grouping together and by separating from unrelated items using “negative” or “white” space.

Gestalt Laws of Organization

Proximity: Tendency to group things together that are closest together in space.

Similarity: Tendency to group things together that are similar in shape, size and color.

Good Continuation: Tendency to perceive things as complete in form or structure.

Closure: Completing objects by closing gaps and completing unfinished forms.

Figure and Ground: Tendency to organize perceptions by distinguishing between a figure and a background (Benjafield 1996; Wertheimer 1978).

The application of Gestalt Laws of Organization can help direct the end-user’s focus by grouping and weighting functions consistent with the mechanics of visual perception. They can be used to create an effective representation of a three-dimensional world on a two-dimensional plane, i.e. a touchpanel.

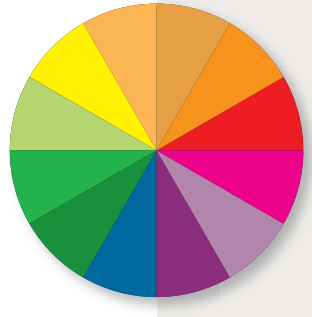
Maintaining a consistency of size, shape, color and proximity of objects will result in the end-user automatically perceiving a group as related. But groups can be formed by similarity in purpose, such as lighting, volume and HVAC all being “environmental.” By using groups this way, relationships can be communicated among objects, as well as in the resulting action.

A group of functions may be too numerous to display simultaneously, so it becomes important to use location to communicate similarity by having them appear, when they appear, in the same place. To be effective, using groups to communicate similarities and differences often requires “negative space” or separation in proximity, also known as “white space.” Separation is required to define a group and also to give the eye a rest while scanning the control interface. This requires that negative space sometimes be incorporated into what is generally considered prime real estate. For this reason, a larger control interface is preferred.



Color Theory

Color Theory is a set of principles used to create harmonious color combinations. Color relationships can be visually represented with a color wheel, which is the visible color spectrum in the form of a divided circle. According to color theory, harmonious color combinations are any two colors that appear opposite each other on the color wheel, any three colors equally spaced around the color wheel forming a triangle or any four colors forming a rectangle (actually, two pairs of colors opposite each other).



The harmonious color combinations are called color schemes, though the term “color harmonies” is also used. Color schemes remain harmonious regardless of the rotation angle. Color theory analyzes only the relationships of pure colors; it does not take color lightness and saturation into account. While your color scheme can use any tints, shades and tones, color theory pays attention only to the hue component.

Monochromatic color schemes use variations in lightness and saturation of a single color. This scheme tends to look clean and elegant. Monochromatic colors go well together, producing a soothing effect. The monochromatic scheme is very easy on the eyes, especially with blue or green hues. It can be used to establish an overall mood. The primary color can be integrated with neutral colors such as black, white or gray. However, it can be difficult when using this scheme to highlight the most important elements.

Analogous color schemes use colors that are adjacent to each other on the color wheel. One color is used as a dominant color, while others are used to enrich the scheme. Analogous schemes are similar to monochromatic ones, but offer more nuances.

Complementary color schemes are made of two colors that are opposite each other on the color wheel. This scheme looks best when you put a warm color against a cool color, for example, red versus green-blue. The complementary scheme is intrinsically high-contrast. When using the complementary scheme, it is important to choose a dominant color and use its complementary color for accents. Using one color for the background with its complementary color to highlight important elements achieves color dominance combined with sharp color contrast. Using a color with the two colors adjacent to its complementary color achieves high contrast without the strong tension that can result from a complementary color. This is known as a split complementary scheme.

DESIGN TIP

Use colors that are close together on the color wheel to give the design a calm appearance and use pure hues to create movement.

DESIGN TIP

When complementary colors, such as blue and orange, are used side by side, the eye has trouble focusing on both at the same time.

DESIGN TIP

Take advantage of the natural relationships among colors, based on color theory, to create harmonious schemes, or emphasize strong contrasts or highlights.

Triadic color schemes use three colors equally spaced around the color wheel. This scheme is popular among artists because it offers strong visual contrast while retaining balance and color richness. The triadic scheme is not as contrasting as the complementary scheme, but it looks more balanced and harmonious.

Tetradic (or double complementary) schemes are the richest of all the schemes because they use four colors arranged into two complementary color pairs. This scheme is difficult to harmonize, however. If all four colors are used in equal amounts, the scheme may look unbalanced. One color should be chosen to be dominant or all the colors should be subdued.

The preceding discussion of color theory comes from the web site of Color Wheel Pro, www.color-wheel-pro.com. The use of products such as Color Wheel Pro can greatly simplify the task of the graphic designer in selecting appropriate colors for the user interface.

Color Applied

Color has a strong impact on emotion and personality traits. In fact, moods can be described in terms of color. Psychological and social/cultural responses to color are important aspects of establishing the end-user's comfort level with a control interface. Color perception limitations of the human eye must also be considered.

The color "red" is a strong example of what color can mean to an effective interface design. Red is the color of blood. Red is also the color of many poisonous insects, reptiles and fruits. As a result, certain shades of red can cause a measurable physiological response, such as elevated blood pressure and pulse rate. Because of this, red may best be limited to alerts and alarm situations in interface design, unless there are overriding reasons to use it, such as professional conventions, local cultural practices or corporate branding requirements.

**DANGER
HIGH VOLTAGE**

While individuals may have innate, social and cultural responses to color, everyone perceives color differently. Perception of color grows even more

complex when the meaning is abstracted from colors, such as the color of success or the color of spring. A number of reliable general perceptions of color exist:



The hues of **violet** and **purple** suggest opulence, grandeur, royalty and intelligence.



Blue is an imperial color that suggests peace; the stronger shades like cobalt add a striking electric touch. Rich blues create a quiet drama and melancholy.



Green is a soothing tone of nature. It represents health, cheerfulness, liveliness and friendliness. Most greens suggest tranquility. Darker greens invoke forests.



Yellow is a stimulating color. It is bright, lively and energetic. It inspires happiness and creativity, but also cowardice and caution.



Red, and its related colors, are warm and vibrant. Bright red is hot, passionate and urgent. It stimulates the metabolism. Deeper reds are more aristocratic.



Pink is a nurturing color. It also encourages rest and relaxation.



Orange offers an upbeat and friendly tone.



White enhances and amplifies the effect of other colors.

Remember that most colors carry emotional and psychological implications. Colors have “moods.” Color choice has other effects as well. Warm colors appear larger and heavier than cool colors. Warm colors seem to move toward the viewer and appear closer, while cool colors seem to recede from a viewer and fall back. One should consider the implications of color selection on the attitude of end-user and the environment where the touchpanel will be located (Litt 2004).

DESIGN TIP

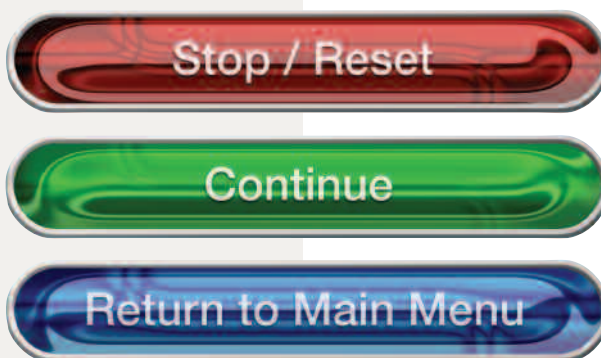
Excessive use of numerous colors can be distracting and can diminish impact.

Graphic Design



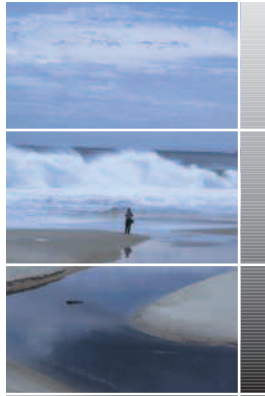
Effective communication in any medium requires trust and belief. “Suspension of disbelief” is the term used to describe the phenomenon in which an individual is willing to accept as reality that which is not real. A fictitious environment must be believable as a prerequisite to accommodating the “willing suspension of disbelief.” For technology, suspension of disbelief is a bridge that spans the gap between an end-user’s action and a perceivable outcome. An end-user knows, for instance, that the act of pressing a button on a control system interface is not directly performing an operation. The action begins a processed sequence. Moreover, the button itself is not real, but in fact a three-dimensional representation of a button on a two dimensional plane.

The sure way to defeat this willing suspension is to carelessly expose the production behind the medium. A control system typically interrupts the seamless use of a system – and defeats the willing suspension of disbelief – in two ways: ineffective programming and poor interface design.



Light Source

One obvious graphic design error is the use of multiple light sources. By nature, humans are accustomed to seeing the world lighted by a single source: the sun. Because of this, people have developed a bias to a single light source and top-down lighting. Top-down lighting translates on a two-dimensional plane as upper left lighting. In graphic design software, the option to select a lighting direction is available when creating bevels and drop shadows. These are important effects because they give objects a three-dimensional look. This effect is what gives a button graphic the affordance of being pressed. Having bevels, drop shadows and embossing appear lit from more than a single direction or from a direction other than top-down will interrupt the end-user's willing suspension of disbelief.



Another common way to interrupt the willing suspension of disbelief is to have button label text extend beyond the usable space within the button graphic. The disruption discloses that the text and graphic are separate objects.

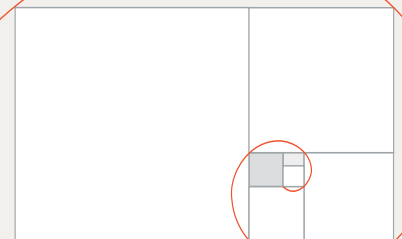
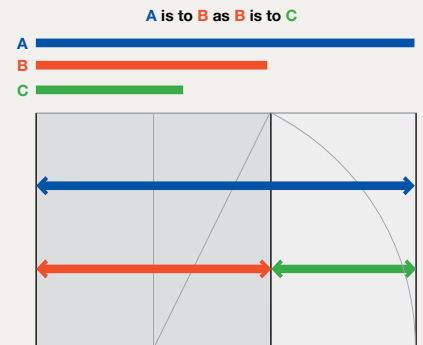
The Phi Ratio (Golden Mean)

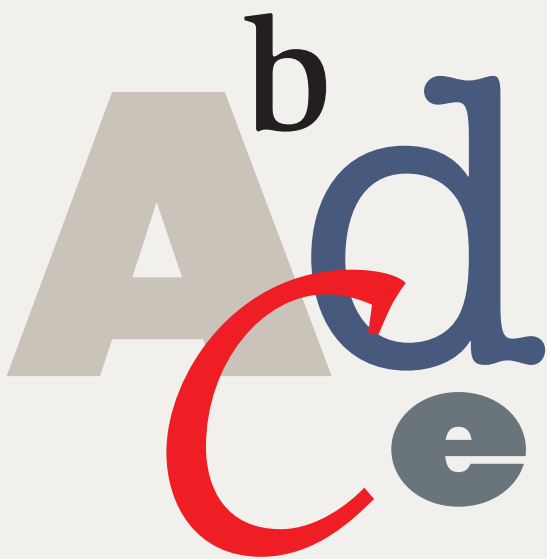
The Golden Mean, represented by the Greek letter phi, is an irrational number, like e or pi, which seems to arise out of the basic structure of nature. It is defined as a ratio of height to width of 1:1.618. The Phi Ratio appears regularly in the proportions of plants, animals, DNA, the solar system and, even, population growth. Since early mankind, the phi ratio has been represented in the design of structures, tools and creative arts. Its use in early societies that had no formal understanding of mathematics leads scholars to believe that phi is a fundamental subconscious aesthetic preference.

The Phi Ratio is applied more commonly today in graphic arts, photography and design as the "Rule of Thirds." The Rule of Thirds states that people have a strong visual attraction to objects that reside at the intersections of hypothetical lines on a page or in a photograph that is divided into thirds vertically and/or horizontally (Lidwell, Holden, Butler 2003). The rule of thirds is simply a representation of the world in which we live. Whether natural as in beach, water and sky or manmade as in floors, walls and ceilings, these horizontal divisions are so innate to our nature that they are barely, if ever, consciously perceived.

DESIGN TIP

Simulated screen lighting is more realistic and, therefore, more believable if it follows the natural single-source, top-down rules of solar lighting. Use the same light direction throughout.





Language and Fonts

Fonts are the technical representation of verbal communication in a graphical interface. The designer must keep both the readability and the content of the message in mind when selecting fonts and determining the final text. Language that is very clear to one person can be ambiguous to another.

Here are a few rules for language and font use in the graphic interface: (Additional information may be found at the following site, needsite.com (Litt 2004)).

- Use grammatically correct sentences, with accurate syntax, punctuation and verb forms.
- Use words that are more likely to be understood by the system end-user, regardless of your personal preference.
- Reading skills influence design. Page layouts and language should not be intimidating for people who don't read well or who don't like to read.
- Many people find serif type easier to read than sans serif because the serifs provide more information for the eye and draw the eye from character to character.
- Sans-serif fonts give a cleaner or modern appearance.
- Using numerous font styles in one design makes scanning and reading difficult.
- People read by the shapes of words, not letter by letter. Do not use all capital letters; ascenders and descenders are what make it easy to quickly identify the shape of a word.
- Make sure that there's enough contrast between text and background for the text to be readable. Avoid light or bright colors in text, as well as busy or patterned backgrounds.
- Readers over 40 often have eyesight problems; keep font sizes large enough to help them read.
- Use elements with visual weight, intensity or color to create focus, such as large, bold typeface and graphics.
- Draw the reader's attention to important elements by contrasting size (scale), color and shape.

Conclusion

Interface designers should always remember that they are not designing for their personal use. The end-user does not care how creative the system design may be, what gear is involved, how well the cables are dressed or if the wiring is certified. The end-user has a job to do that requires the easy use of an AV system controlled from one central point: the touchpanel. If the control system interface is small, overcrowded, hard to understand or needlessly complex, the system as a whole fails to achieve its most important goal.

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