Human Machine Interface Standards: A critical review and help for users

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User’s perspective

– I want to build “good” HMIs, where can I get help?
  • Are there any resources I can use myself?

– Yes, there are many sources of guidance, but…
  • Considerable variation in level of detail
  • Can be hard to know if or how it applies to your situation
  • Some guidance is technical, hard to interpret
  • Implementation can be challenging
This presentation...

Compares the major guidance sources for the process industry

Attempts to clarify / explain the guidance for display style and format
Current Process Industry Guidance

Standards
- ISA 101 (in progress)

Guidelines
- EEMUA publication No. 201 (2002) – update coming soon?

Handbooks
Other Relevant Guidance

  - Detailed guidance for ‘office’ workstations and displays
- NUREG/CR-6633 – Advanced Information Systems Design
  - Focus on advanced display concepts
- DOT/FAA/TC-7/11 – Human Factors criteria for displays
  - Focused on hardware characteristics; aviation-oriented
- NORSOK I-002 rev2 – Safety and Automation System
  - Norwegian Oil Industry standard; brief
- EN 894 (-1,-2,-3) - Ergonomics requirements for the design of displays and control actuators
  - EN 894-2 (rev 2008) covers visual, auditory and tactile displays; very brief
Why do standards/guidelines look like they do?
- Authors have to confront some difficult issues that directly impact the final product

Generality vs Specificity
- If you’re very broad and general…
  - Applies to largest number of potential users
  - Large gap between the advice and implementation
- If you’re very specific and concrete…
  - High-value advice to a few users
  - Guidance is highly conditional – many users left out
  - Document becomes complex and lengthy
Standards vs other guidance

Conservative bias

- Temptation to document current practice, not best practice
- “Shall” vs “Should”
- Consensus process pulls opinions in towards the middle, up towards the general
  - “But if we write it this way, all of these plants will suddenly be non-compliant”
  - “The technology to do things this way is too expensive / not available”
  - “Users are too invested in current practice – they’ll never do it this new way”

- Hard-edged or specific advice often ends up in Guidelines, Technical Reports or Recommended Practice documents
Beware of Commandments

Efforts to be concise can lead to lists of ‘tips’, ‘rules’, or ‘laws’

- HMI design as a table look-up exercise??...what about automated???
- Proposing guidance as gospel minimizes the need for justification of explanation
- Over-simplifies design by ignoring the context, tradeoffs
There’s no free lunch…

- You can’t apply principles intelligently without understanding something about their basis
  - Is it relevant to my situation?
  - What are the bounds of applicability? Assumptions?
  - What are the interactions, alternatives and tradeoffs?
  - How strong is the supporting evidence?

If you want good HMI design – you need to invest in somebody (internal or external) who can bridge the knowledge base about HMI and the context of your particular design situation.
Guideline ‘cannibalism’

- Sometimes the creation of new guidelines is done by culling and stitching together the most ‘relevant’ parts of existing guidelines
- Guidance may look new and current, but in fact it is often recycled and potentially out-of-date
- Know the sources of the material (not always easy)

Underspecified advice

- “Ensure text has sufficient contrast with the background”
- “Colors should be visually distinct”
Comparing the major sources

Dimensions of variation:

- Scope
- Detail
- Presentation style
Scope

All relatively similar

- ASM, EEMUA guidelines and HMI Handbook are all in the same ‘family’ – ASM Consortium is source of much material
- NUREG 0700 and ISO 11064 also cover the same basic topics
  - Display format issues (color, text, lines, etc.)
  - Console configuration (number and layout of screens, etc.)
  - Navigation
  - Interaction with alarms
  - Control room / environmental design
  - Design process
  - Evaluation

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Page counts are a good clue...
  - NUREG 0700: ~650
  - HMI Handbook: ~200
  - ASM Guidelines: ~150
  - EEMUA: ~50
  - ISO 11064: ~50

Ex – color usage:
  - EEMUA: “The use of color can add significantly to a display but should not dominate”
  - ASM: devotes an entire chapter to color usage
Different sources vary greatly in “user-friendliness”

Only some use examples, pictures
  - ASM, HMIH include many pictures, good/bad examples
  - Others are almost exclusively text
    • NUREG is particularly dense

Explanation of rationale
  - Educates users and allows them to evaluate guidance in their own context
  - ASM, HMIH, NUREG are good
    • But ASM and HMIH offer limited citation of source material
  - EEMUA, ISO very poor
    • “Thou shalt...”
Making sense of the guidance

Display style and format

- Typically what most people focus on in an HMI standard or guideline

  • Color
  • Texts, fonts, readability
  • Process lines
  • Animation and 3D
  • Graphical widgets (valves, controllers etc)
Common theme is to use color sparingly

Trend towards use of grayscale palettes (ASM)
  - salient colors reserved for alarms and/or abnormal conditions

This is a major topic for some and not for others.

It is important to remember that using color this way is a “design choice”. There are good reasons for doing it this way, but there are alternatives and tradeoffs to consider.
Reason #1: A light gray background reduces glare from room lighting
- This allows room lighting levels to be increased
- Vigilance benefits
- Interaction with control room design
  - e.g., reflective surfaces behind console?
Reason #2: To direct operators’ attention to alarms and abnormal conditions

- Human attention is drawn to objects that differ from their surroundings
  - Color differences are “pre-attentively” processed – the “pop out” effect
  - Effect is diluted by presence of other colors
  - Counteracts “tunnel vision” under stress
  - Color is not the only attribute that can be used to draw attention!
    - Size, shape, orientation, motion, texture
- Color is not processed well in peripheral vision
  - Need to combine with other attributes – e.g., motion/blinkin
Color Deficiency

aka “color blindness”
- ~8% of men and ~1% of women have some form of color deficiency

Red-green deficiency is most common
- What do you see?
Color Deficiency

How many people here see ‘74’?  
How many see ‘21’?  
How many don’t see any numbers?

Do you test your operators for color deficiency?
How can we design to account for color deficiencies?

- Minimize use of color
- By using carefully chosen colors
  - e.g., avoid red-green color codes
- Do not rely exclusively on color to indicate critical information like alarms
  - Shape, size, motion, labeling, etc.
Another reason for limiting the use of color is to reduce eye-strain

- Different wavelengths of light are focused at different distances behind the lens of the eye
- Your eye has to re-focus slightly when moving between different colors, esp. blue/red
- Constant re-focusing leads to fatigue, headaches
- Type style -
  - Serif vs Sans Serif
  - fixed-width vs. variable-width,
  - Color,
  - USE OF ALL CAPS,
  - Use of italics,
  - Size...
Serif or Sans Serif?
- Most sources say sans serif
- Research shows no significant difference in legibility
- Not as important as other factors (color, size)

Color
- Most important factor is luminance contrast with background
  - Black text on light background is ideal
  - Grey text for less important information (e.g., static labels)
- Saturated (pure) blue should be avoided

All caps decreases readability
- But can be an effective way to draw attention (if surrounding text is mixed case)

Italics
Fixed vs Variable width fonts

Use fixed-width fonts for data values to ensure good alignment (e.g., Lucida Console)
- 123.45
- 678.90

Variable-width fonts are more readable for text (e.g., Arial, Helvetica)
How Big should text be?

What is the best font size for text / numerals?
- 10pt, 12pt, 14pt?

Wrong Question…
- What matters for legibility is the “visual angle”
  - angle subtended by text at a given viewing distance
  - $\Theta = \frac{H}{D} \times 3438$
Standards vary widely for Recommended Text Heights

- 10min to 30min of arc (NUREG-0700: 16-24 min)
- Sensitive to viewing conditions and tasks
- Assumes viewers with 20/20 vision

What exactly are we measuring?

Font size is an archaic term referring to the size of the printing blocks used in typesetting.

Assuming 72pt/in, if you select a 72 pt font size it doesn’t mean your characters are going to be 1” tall.

Also, it is possible for two 72pt fonts to have quite different physical letter sizes.

When you’re defining your text size in the HMI, there’s no menu for visual angle – you have to pick a font size.
OK – how do I set my font to get X min of arc?

- Not as simple as it sounds…
  - What is “font size”?
  - Font choice
  - Font version (TrueType, OpenType, Postscript)
  - Viewing distance
  - Screen resolution
  - dpi setting

…Use a ruler and place it on the screen
Importance of line coding is domain dependent

Do not use color to code line contents
  - Instead, use attributes like thickness, texture, gray levels
  - Cf. NORSOK
  - Options:
    • Allow users to turn line colors on/off
    • Use tooltips

Minimize the number of line types
  - Identify the major operationally relevant differences
    • E.g., code by primary / secondary flows
Avoid birds-nest displays

- Well-organized displays with consistent direction of flow (left-to-right, top-to-bottom)
- Minimize line use on overview displays
Depiction of process values, controllers, valves, pumps, etc.

- Emphasis on analog representation
- Importance of placing data in context
- Integration with color strategy

HMIH includes many examples, however…

- Most users do not have the option to (re-)design the appearance and behavior of the basic object set
- Advice geared for designers of object libraries??

Acuite APG Object Library
Animation

- Use only for Alarms to draw attention
- Too much of a good thing becomes a bad thing

3D

- Very few justifiable uses
  - unless you’re in marketing
- Separate hype from substance
Today we **can** do almost anything...

- Realistic 3D equipment
- Millions of shades of color
- Animated flames, flows, motors
But should we?

What is the value?

What is the cost?
Remove the Flash
I once was asked for some guidelines for when to use 3-D pipes and vessels. My response was to use 3-D if all or most of the following conditions were met. Otherwise use simple thin lines.

1. The operator would not normally know whether a pipe was round or square.
2. The operator needs to know whether a pipe is round or square
3. A pipe changes from round to square.
4. If (3) is true, there is a way of detecting the pipe shape and that information is available as an input to the control system.

I was thanked, but my comments were not used.

Example pulled from an actual on-line forum by somebody who was asked by their management to provide advice on use of 3D in displays
Issues in application of guidance

Legacy problems
  – e.g., hardwired panels that contradict color standards

DCS graphics libraries
  – Do not support some of the design recommendations without extensive customization or 3rd party extensions

Developing content
  – How do I design a good overview display?
    • Format + Content
    • How do you identify the right content?
    • some form of Task Analysis is required

Compliance vs Performance
  – Following the guidance is no guarantee of success
Guidelines for guidelines?

Good guidelines should...

- Synthesize:
  - What is the current state of knowledge and what does it mean for practice

- Teach:
  - Provide the key concepts, categories and distinctions
  - Increase the expertise of the reader
  - Provide many examples, illustrations

- Help avoid and/or detect and correct design errors
  - Show typical problems
  - Provide strategies and techniques (not commandments!)

- Be sensitive to realities of design and implementation
  - Conflicting priorities, time and resource constraints
Tell me what, tell me why, tell me how

These are things to look for as you sift through the guidance that’s out there
Resource constraints include design budget, hardware and DCS platform, etc.
Acuite approach with sites:

- Workshop to educate and align
- Style guide provides general guidelines
- Site Configuration document to provide specific details about how the site is going to incorporate standards and guidelines into project execution – includes
  - Workstation configuration
  - Display structure and hierarchy
  - Workstation configuration
  - Graphic Development tools and documentation
  - Graphic Design and workflow
Summary

Major guidance sources cover similar ground but have vastly differing utility.

Proper application of guidance is not simple.

When done properly, results can be excellent.
Where To Get More Information

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