

An Introduction to the ASM Guidelines *Effective Operator Display Design*

2009 ASM Webinar Communications Program



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Human Centered Solutions

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Webinar Presenters

- **Dr. Dal Vernon Reising**

- Senior partner, HCS, human factors consulting group
- Ph.D. in Industrial Engineering
- Participation in ASM program since 1999, including role as Principal Investigator



- **Dr. Peter Bullemer**

- Senior partner, HCS, human factors consulting group
- Ph.D. in Cognitive Science
- Participation in ASM program since 1993, including roles as Director and Principle Investigator



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ASM Poll Slide 1 (Placeholder)

- **How would you characterize your current employer in the industry?**
 - Operating company site
 - Operating company corporate
 - Consultant
 - Engineering firm
 - DCS vendor company
 - Advanced applications / tools vendor company
 - Other

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ASM Poll Slide 2 (Placeholder)

- **What is your experience level with the ASM® “Effective Operator Display Design” guidelines document?**
 - Only heard about it, but don’t know much about it
 - Have not read it, but have seen “ASM display” examples before
 - Skimmed through the document
 - Read it from cover to cover
 - Used the document in the context of my work

ASM Abnormal Situation Management® *A Joint Research and Development Consortium*

Founded in 1994

Creating a new paradigm for the operation of complex industrial plants, with solution concepts that improve Operations' ability to prevent and respond to abnormal situations.

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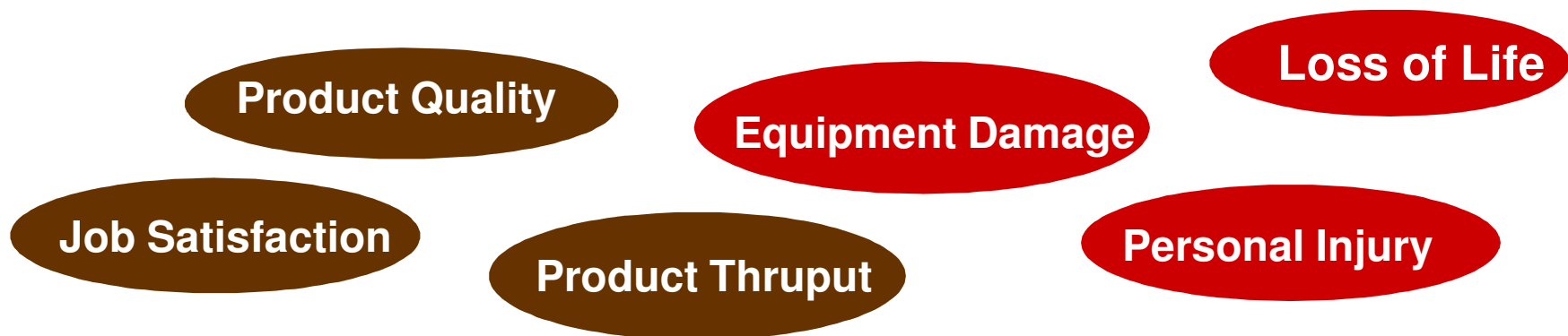
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What is an Abnormal Situation?

- An industrial process is being disturbed and the **automated control system can not cope...**
- Consequently, the operations team must intervene to supplement the control system.
- Impacts **profitability** in multiple ways:



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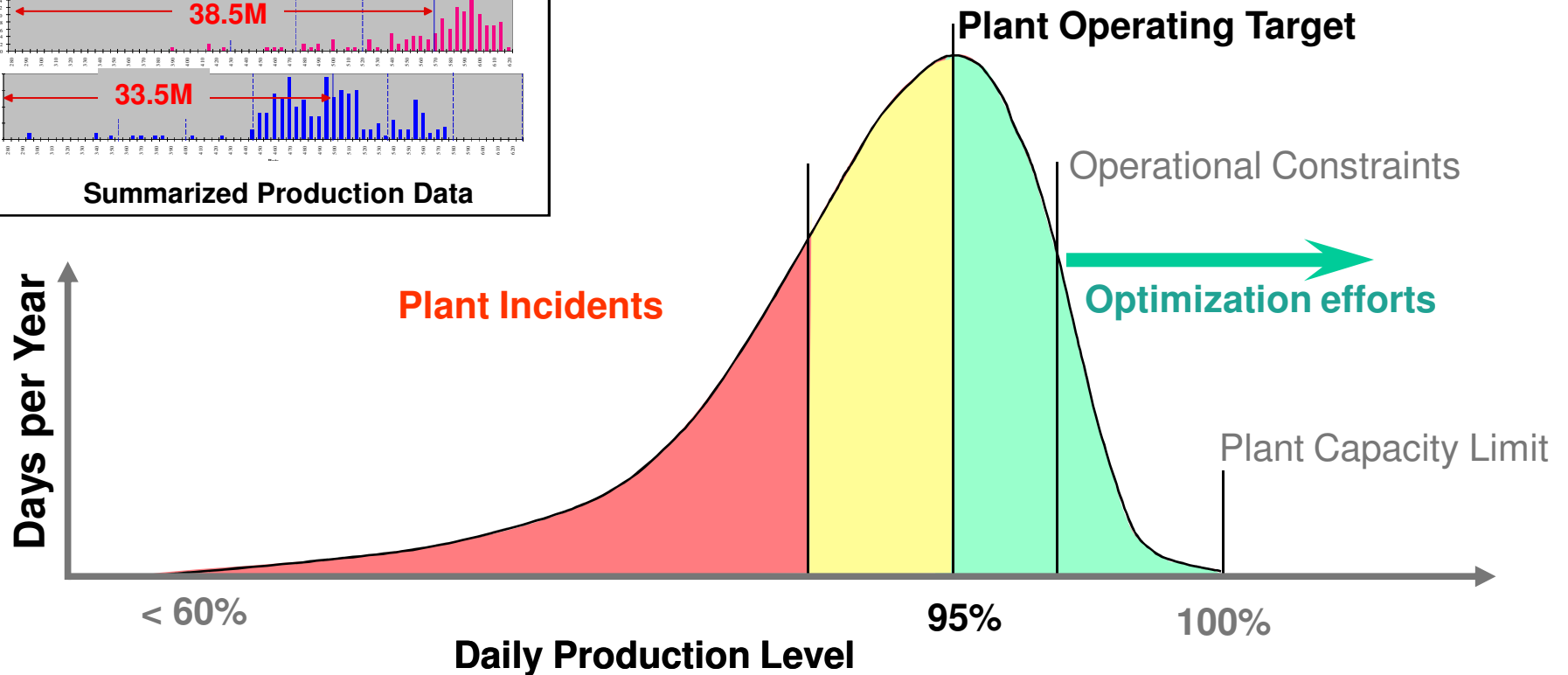
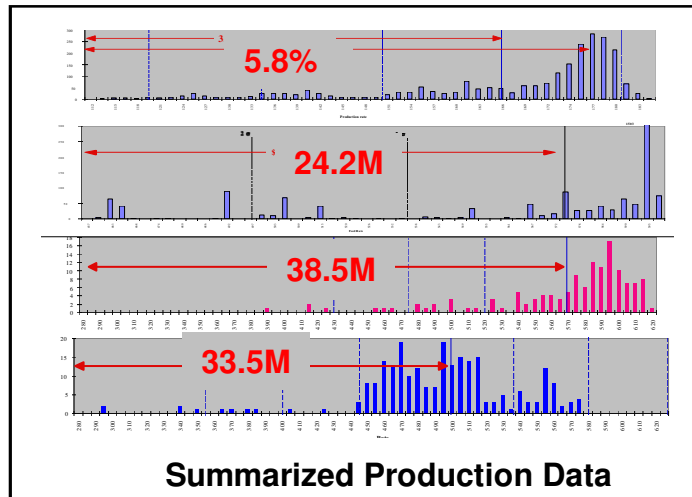


Making the Business Case

Unexpected Events Cost 3-8% of Capacity

~ \$10 Billion annually in lost production !

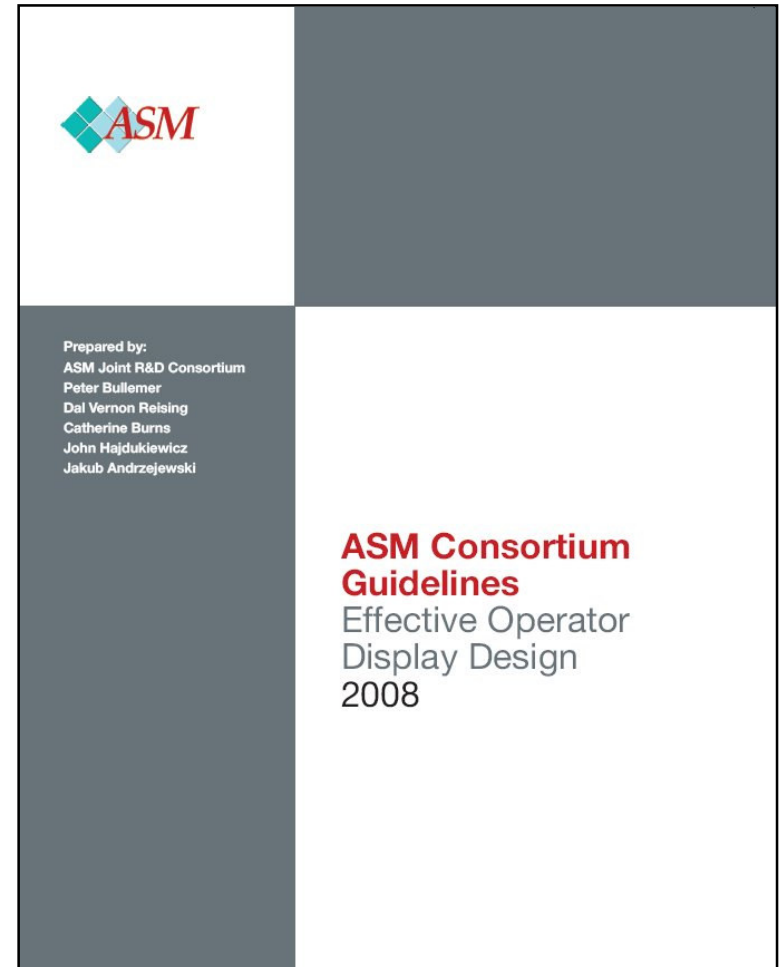
Source: ASM Consortium Research



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ASM Webinar Overview

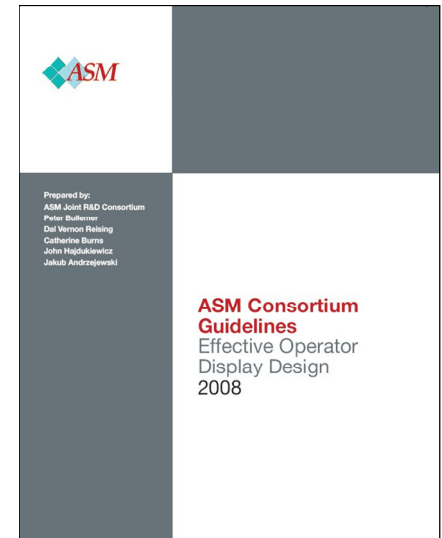
- This webinar aims to
 - Present a case study on the value of “ASM graphics”
 - Introduce people to the contents of *Effective Operator Display Design* guidelines document
 - Discuss some common pitfalls in using guidelines
 - Suggest how the document might be used



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ASM Purpose and Scope

- Communicate the ASM® Consortium recommendations for the effective design and use of operator graphics and field device displays
- Enable assessment of the quality of a company's operator displays and console configuration from the perspective of their potential impact on abnormal situation management
- While this document does describe “what to do,” it is not intended to be a “how to guide” to the design of the plant policy or work processes
- Examples are provided in the Guideline book to help explain the guidelines, but the examples might NOT provide the best implementation for your site



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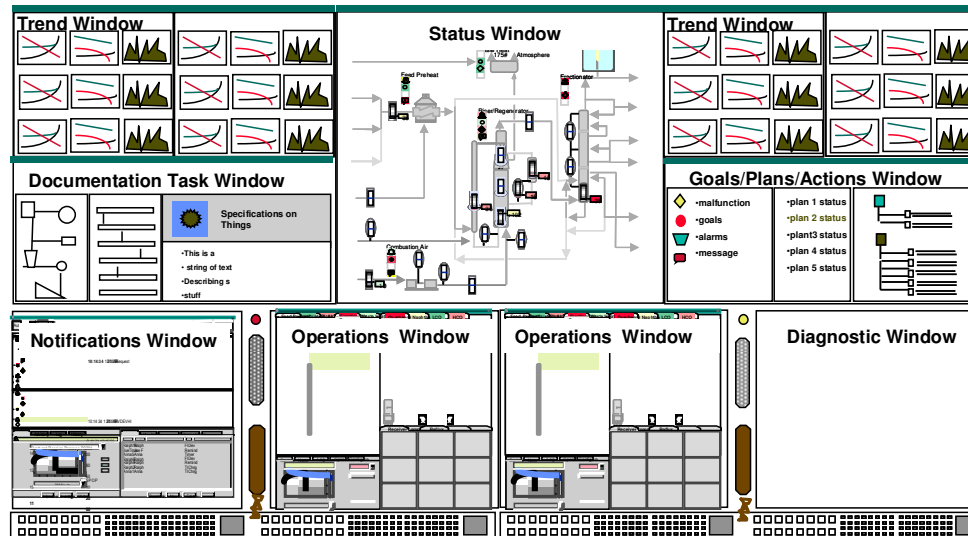


Guideline Development

- Operator interface design has been an important focus of the ASM Consortium since its origin in 1994
- During the NIST-funded Phase of the Consortium (1996-1998)
 - Conducted site practice assessments, identifying best practices including those for operator graphics and display design
 - Prototyped an advanced information system (AEGIS) that applied pacesetter concepts to operator graphics
- Drafted initial guidelines document in 2000, based on site practices
- Conducted an Operator Graphics Workshop in Fall 2000 to identify additional practices and solicit feedback on guidelines
- Published document for ASM member use in 2000
 - Project Team—Honeywell Labs, Consortium User Members & workshop attendees
 - Critical Review Team—ASMC User Members
- Major refinements to the document in 2003, 2004, 2007 and 2009

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ASM Some Initial ASM Concepts



Objective

- Define ASM-based user interface concepts and features that **improve usability and effectiveness of the human-machine interactions** in the process control operations environment

Key Solution Concepts & Innovations

- Single, Integrated View of Multi-Level Hierarchy
- Mixed Initiative Approach
- Effective Window Management and Layout
- Effective Navigation Scheme
- Visual Coding Scheme
- Interaction Objects
- Contextual Menus & Information presentation
- Task View Organization

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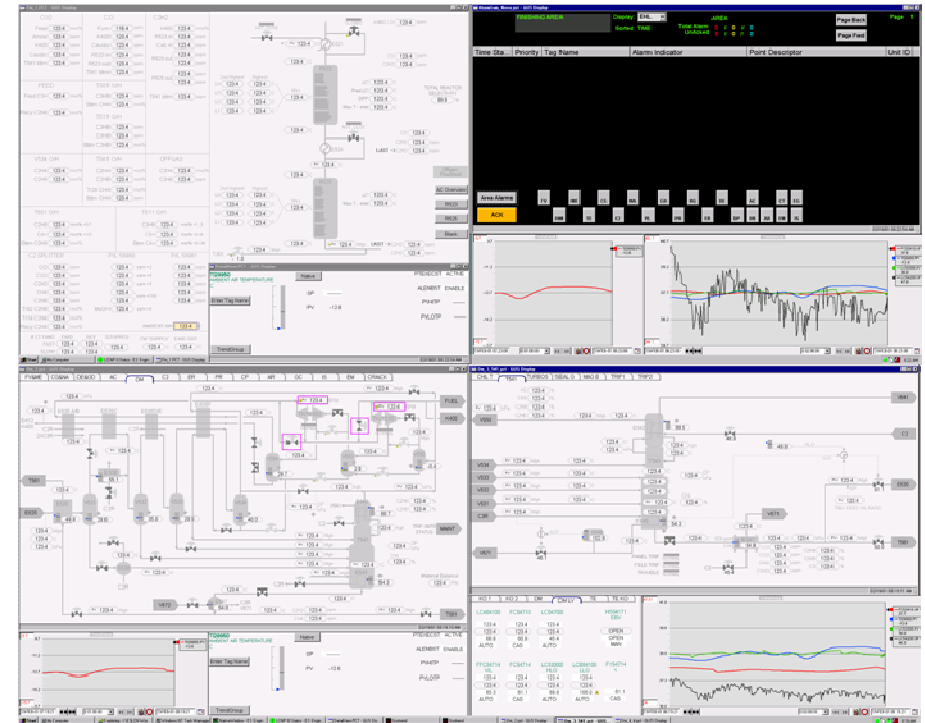
The Instantiation of the initial ASM Operator Interface Concept

For Proactive Monitoring:

- Simultaneous, integrated view of increasing plant detail
- Integrated Trending
- Integrated alarm management into graphics and navigation tabs

For Fast Response:

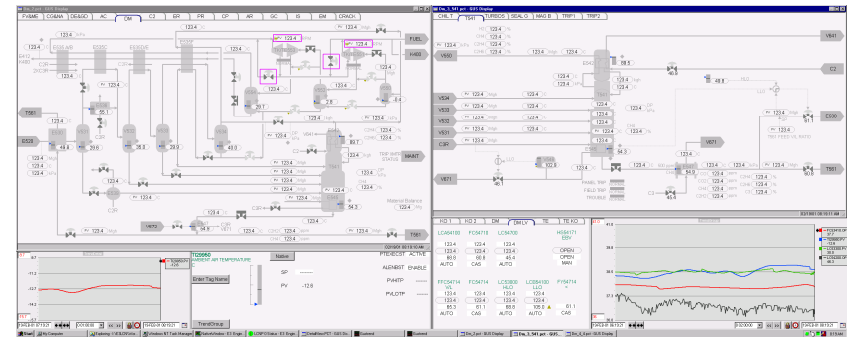
- Multi-windowing with controlled window management
- “Yoked” navigation between display levels
- Tabbed navigation within a display level
- Graphics design
 - e.g., Color-coding only for critical information – like alarms, No 3D graphical objects, etc.
- Right-mouse click access to online documentation
 - e.g., Alarm Objective Analysis documents, procedures, etc.



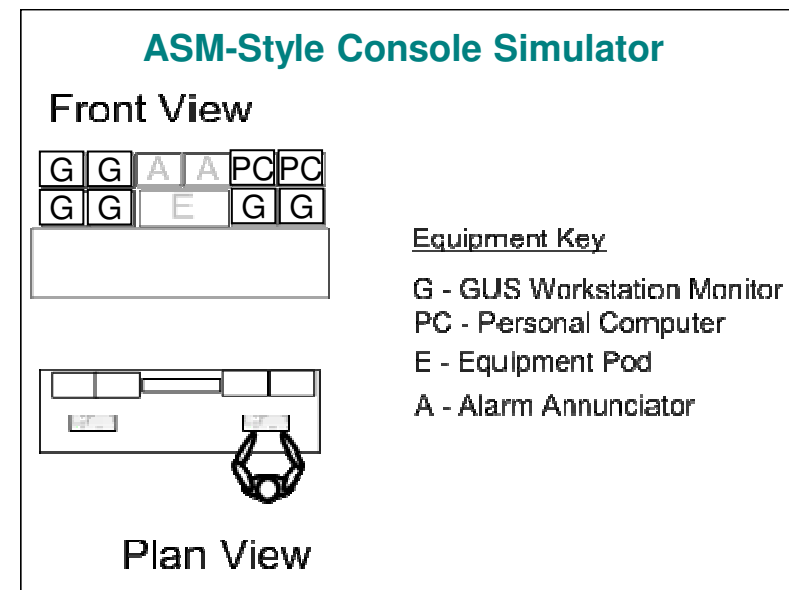
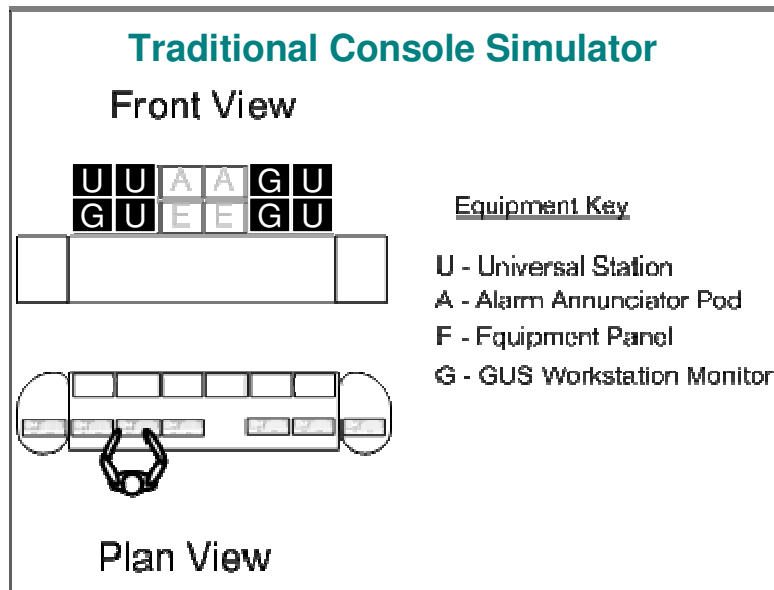
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ASM-style Operator Interface Case Study



VS.

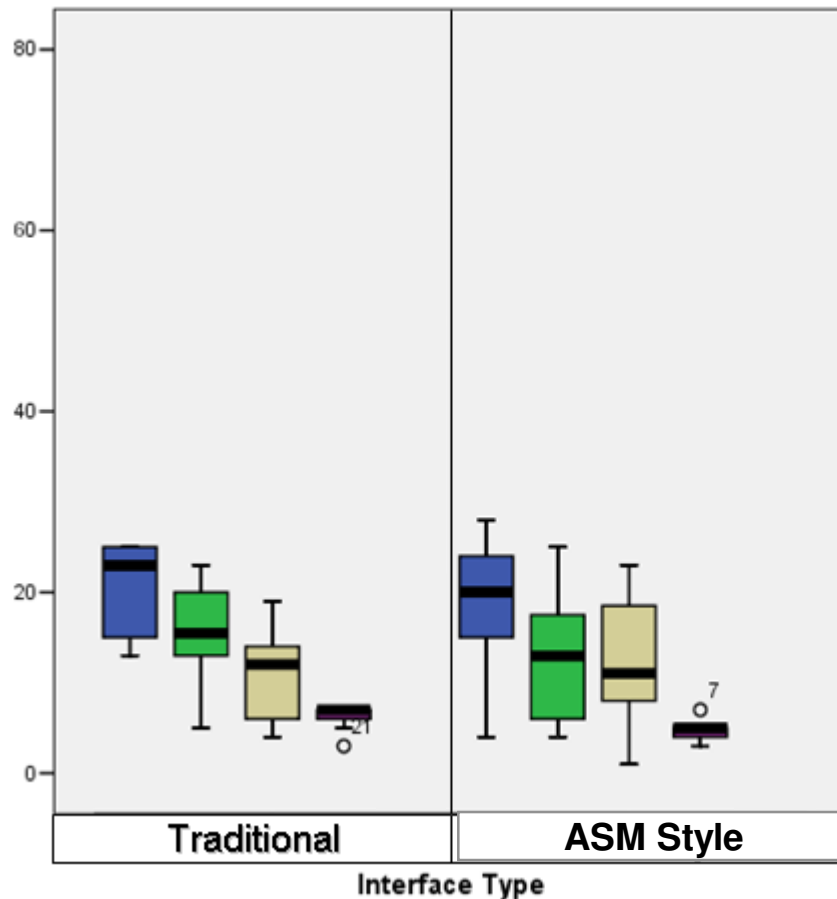


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Case Study Results

Pre-Test Results



Group Comparison Metrics

- No average differences between the two groups of operators for:
 - Years of experience as an operator
 - Years of experience as an operator at this company
 - Years of experience as a console operator
 - # of process areas qualified in

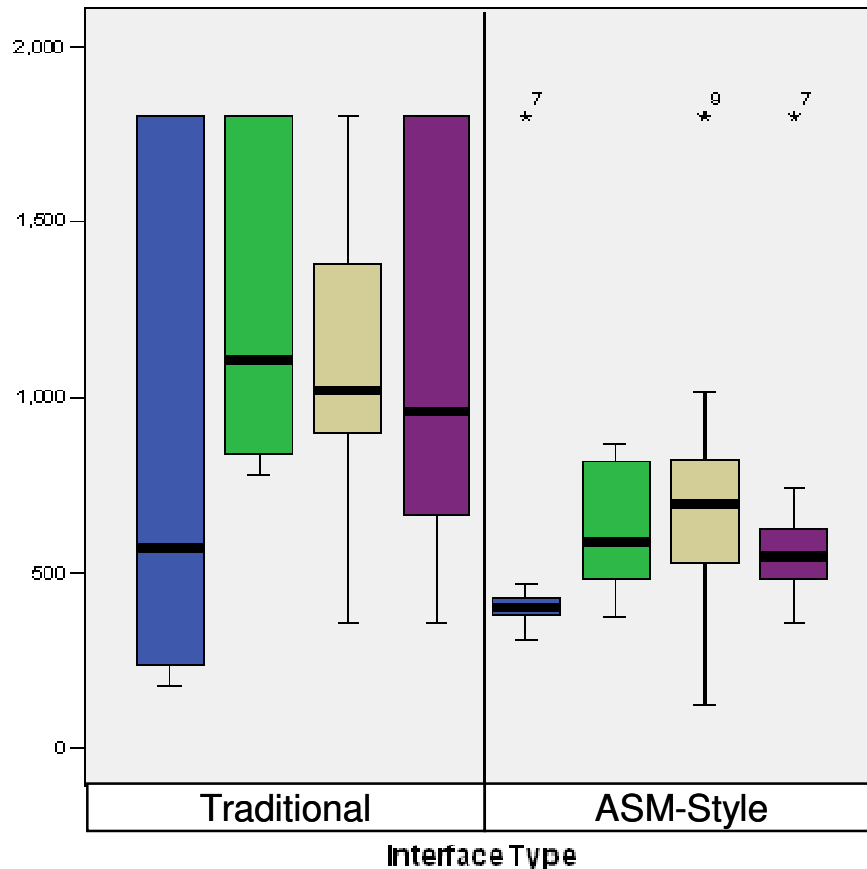
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Case Study Results

Scenario Evaluation Results

Operator performance measure: **Total Completion Time**



- The operators using the ASM-style interface took significantly less time to deal with the event and as a group, were more consistent in doing so!
 - An average of 10.6 minutes vs. 18.1 minutes for those using the traditional console
 - **A 41% improvement**

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Case Study Results

Scenario Evaluation Results

Operator performance measures:

- **Detecting the event BEFORE the first alarm**

- On average, operators using the ASM-style interface detected an event before the alarm 48% of the time
- **A 38% improvement**

Scenario	Interface Type	
	Traditional	ASM-style
1	0%	27%
2	10%	82%
3	10%	82%
4	20%	0%
Mean	10.0%	47.7%

- **Successful completion of the scenario**

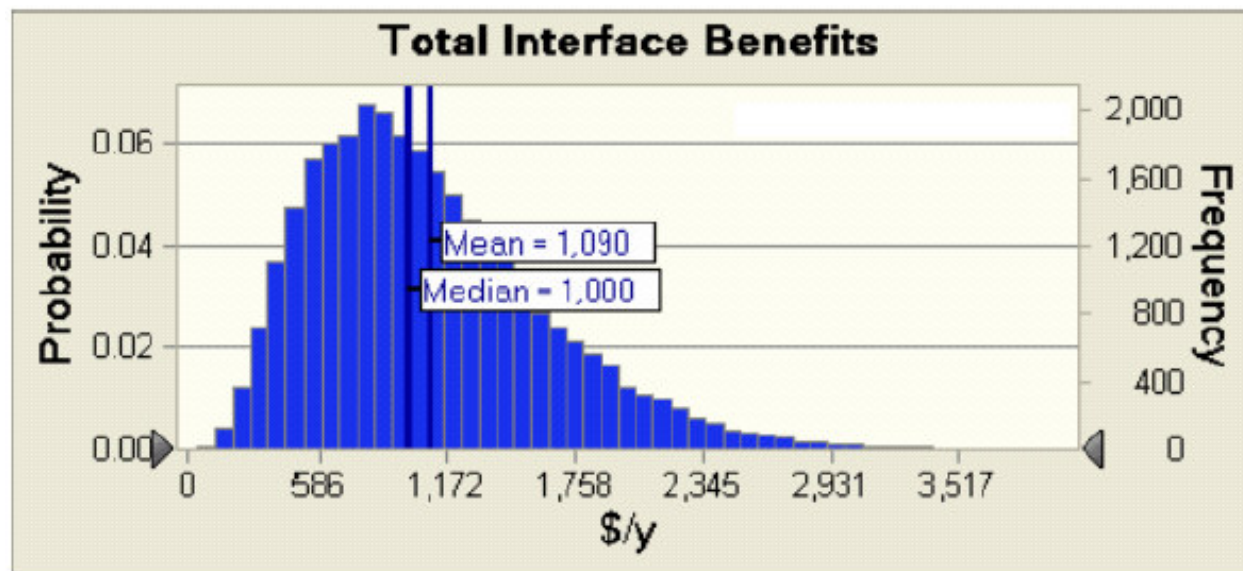
- On average, operators using the ASM-style interface successfully dealt with the situation 96% of the time
- **A 26% improvement**

Scenario	Interface Type	
	Traditional	ASM-style
1	60%	100%
2	70%	100%
3	80%	91%
4	70%	91%
Mean	70.0%	95.5%

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ASM Economic Impact Estimation

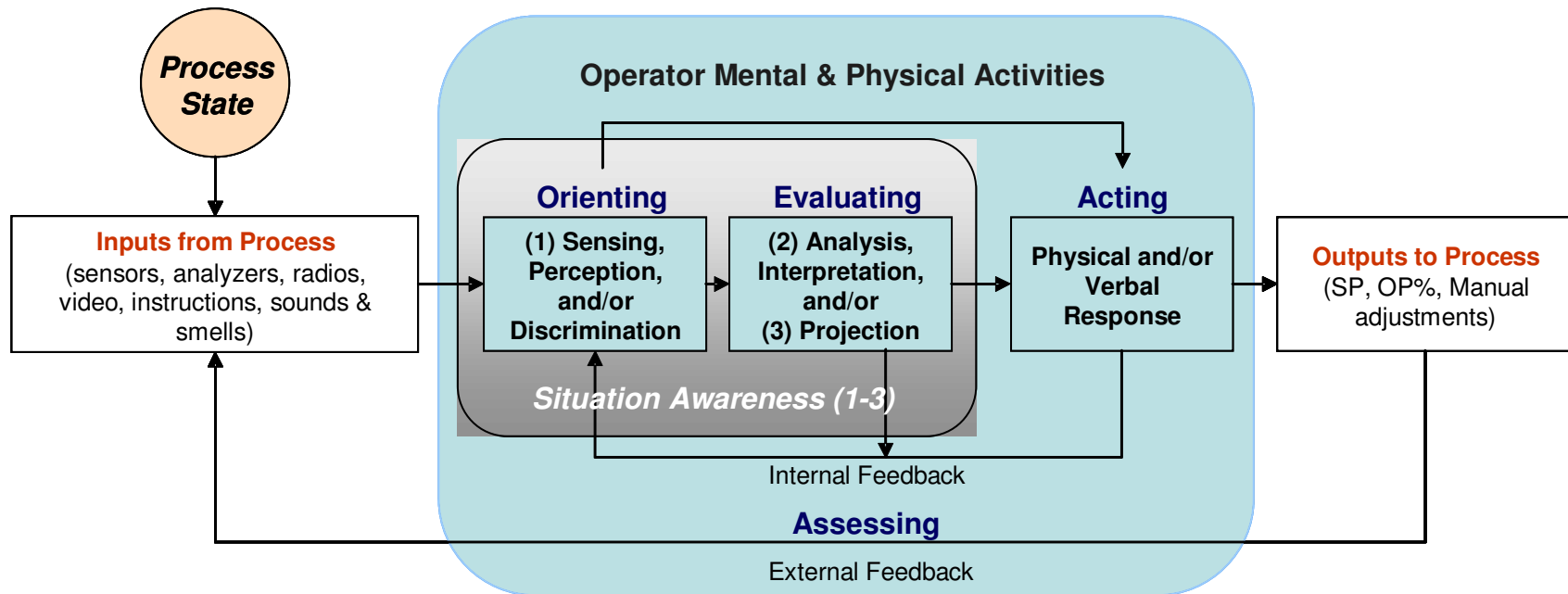
- The **estimated total economic savings** for the unit with the traditional console (a 1.8 Blb/year ethylene plant), were it to adopt the ASM-style interface was
 - On average, \$1,090K CAD/year (~\$870K USD/year, circa 2005)
 - The median (considered most likely) was **\$1,000K CAD/year** (~\$800K USD/year, circa 2005)



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ASM ASM Supervisory Control Model

- Based on traditional Human Information Processing model
- Includes Psychological stages of Situation Awareness



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Managing Abnormal Situations

Some Influences on Intervention Success

Orienting

- Information overload
- Missing information
- Inappropriate level of detail
- Vigilance decrement
- Difficult navigation
- Distracting environment

Evaluating

- Inconsistent information
- Inaccurate information
- Conflicting priorities
- Lack of knowledge
- Inappropriate detail
- Poor information accessibility

Acting

- Inadequate communications
- Deficient / complex procedures
- Fail to follow procedures
- Inappropriate actions
- Lack of experience
- Inadequate feedback

Assessing

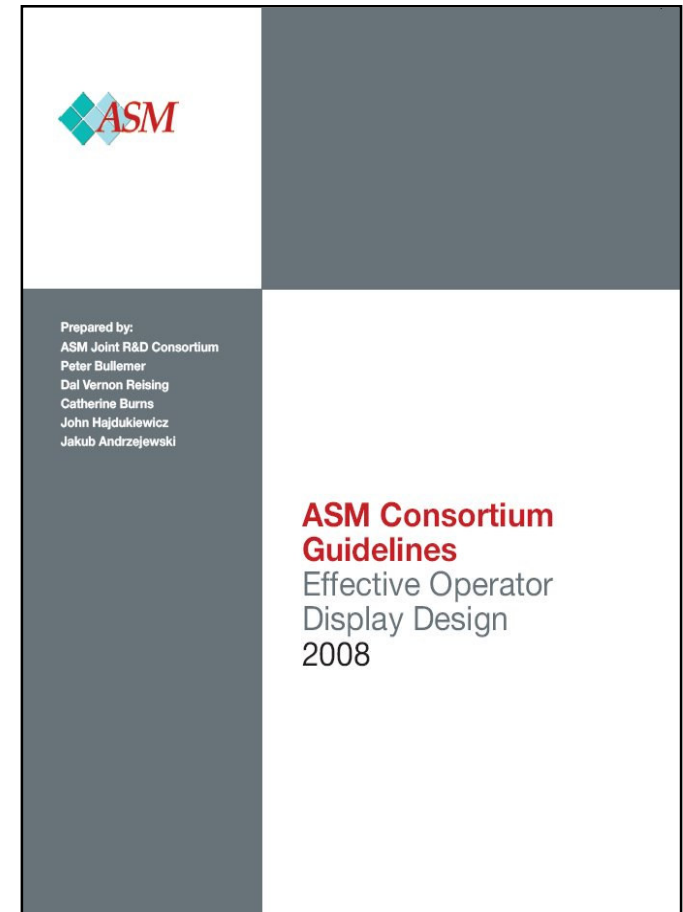
- Lack “big picture” view
- Inaccurate information
- Inadequate information
- Erroneous conclusions

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Effective Operator Display Design Document Overview

- Sixteen Guideline Categories
 - Display Types, Display Content, Display Style, Display Layout
 - Color, Symbols and Process Connections, Text and Numbers
 - Navigation, Interaction and Displays
 - Alarm Configuration Scheme, Audible Annunciation for Alarms, Visual Annunciation for Alarms
 - Training Program, Online Guidance, Design Methodology, Management of Change
- 81 guidelines in total across these 16 categories
- Guidelines are prioritized
 - Priority “1” – rated as one of the **minimum** set of guidelines for achieving an ASM good quality practice.
 - Priority “2” – one of the **comprehensive** set of guidelines for achieving an ASM high quality practice.
 - Priority “3” – one of the **advanced** set of guidelines for achieving an ASM best practice



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ASM Guideline Structure – p. 1

6.1	Use a minimum of color codes consistently across display hierarchy levels.	Priority 1
Why?	Consistent, distinguishable color codes allow operators to learn the codes and the meaning behind them.	
How it Works	<p>The number of colors used to code categories of objects should be kept to seven or less, and be consistently applied. Seven corresponds to the number of items that can generally be kept in short term memory (Wickens and Hollands, 1999). The seven color codes do not limit the coding of other information separate from the category information. For example, an unacknowledged, high alarm could be a brighter, more saturated yellow, which is distinct from an acknowledged high alarm that would be a paler, less saturated yellow. These two 'states' of high alarms are distinct from red color-coded emergency alarms, which are either more or less saturated depending on their state of acknowledgement.</p> <p>In general, color coding to indicate materials in process lines is not recommended in normal display view because it can draw the operator's attention away from more critical information. If one insists on showing lines colored based on material they contain, then colors should be implemented such that they can be toggled on and off (or show this representation in a view generated by the IT system supporting the plant).</p>	

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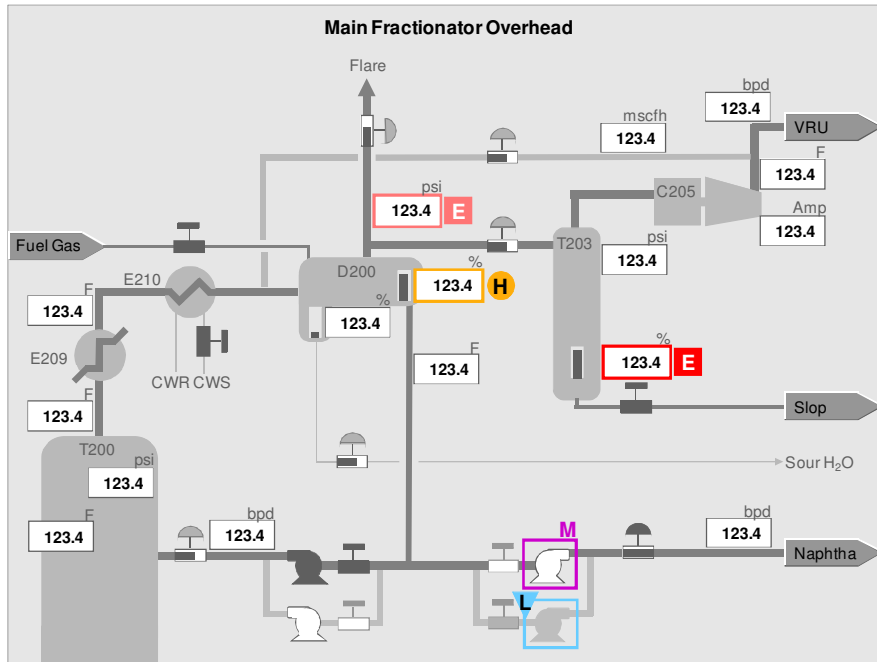
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ASM Guideline Structure – p. 2

Example	<p>The example shows a very simple but effective color scheme. Gray and half-tones are used for piping and equipment. Three priorities for alarm – low, high, and emergency priority – are shown in half-saturated light blue (acknowledge), saturated orange-yellow (unacknowledged), and saturated red (unacknowledged), respectively. This clear color scheme can be used consistently and will be easily remembered. In addition, off-normal operating conditions are also highlighted with a non-alarm color.</p>
	<div data-bbox="693 584 1564 1242">  </div> <p>Figure 6.1. Color codes in this example include: Light blue for low-priority alarms, orange-yellow for high-priority alarms, red for emergency-priority alarms (and pale red for acknowledged emergency-priority alarms, magenta for off-normal operating conditions.</p>

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ASM Guideline Content Review

- Next few slides show:
 - Guideline statement for each of the sixteen categories
 - Indications where significant pitfalls occur
- Presenter will speak to
 - **Intent of category**
 - **Key aspects of significant pitfalls**
- Expect audience to
 - Read guideline statements
 - Ask clarification questions
 - Save detailed questions and comments for later discussion

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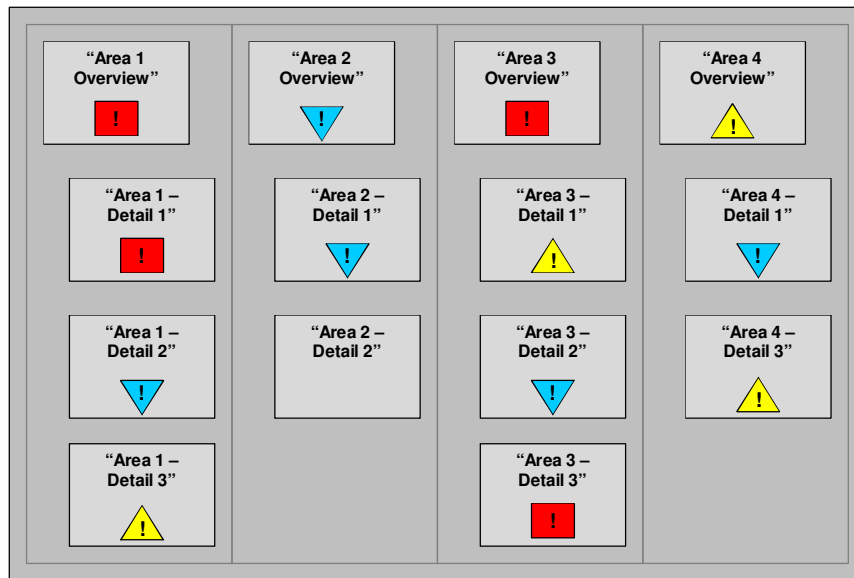
ASM Guideline Category One

Display Types - Support the range of operator tasks and interactions through various display types		
#	Priority	Guideline
1.1	1	Use a process overview display for operator span of control.
1.2	2	Use a standard display hierarchy to represent the multi-level views necessary for monitoring and control.
1.3	2	Use multi-level views based on the process equipment hierarchy for monitoring and control.
1.4	2	Use multi-level views based on important functional relations for monitoring and control.
1.5	2	Use dedicated displays to support response to critical upset conditions.
1.6	2	Ensure that each console has at least the minimum number of screens to effectively support different operating modes, such as startup, shutdown, grade transition, and significant upset.
1.7	3	Use dedicated displays to support routine activities, such as mode or product transitions.

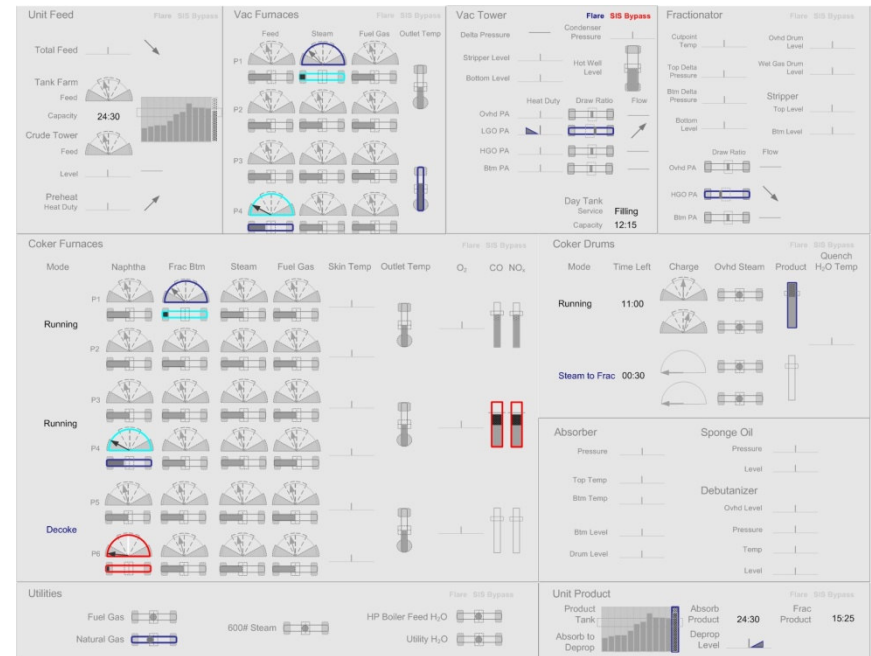
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ASM Use of Overview Display

Not Recommended



Recommended



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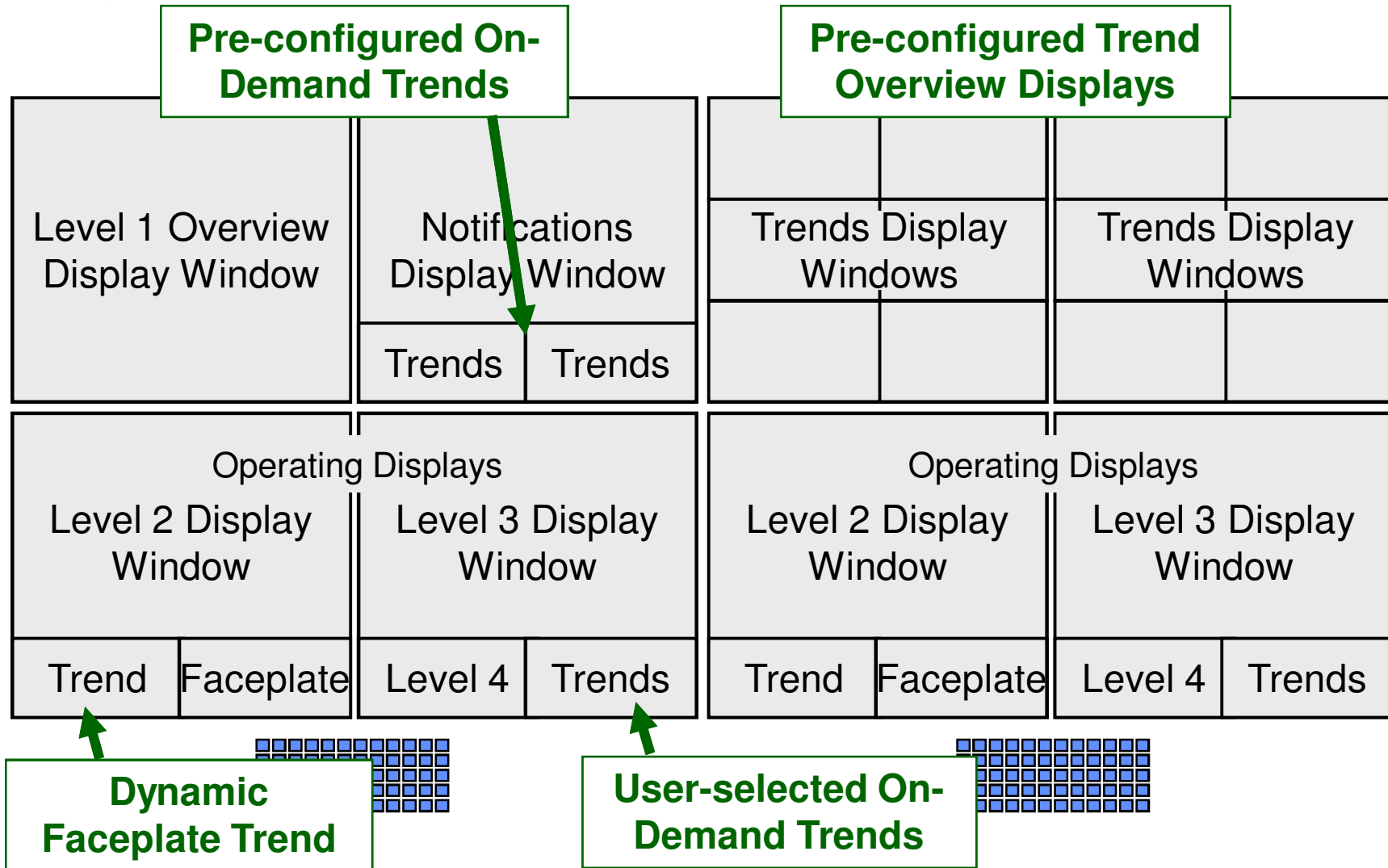
ASM Guideline Category Two

Display Content - Support all operator monitoring, troubleshooting and control activities with all essential information

#	Priority	Guideline
2.1	1	Ensure that display content supports all operator activities.
2.2	1	Ensure that the display refresh rate is appropriate to the dynamics of the system being monitored and is at least twice the dominant process time constant but not more than ½ second.
2.3	1	Use trend displays when operators must make decisions about the performance of a variable or variables over time.
2.4	2	Ensure that trend displays provide the operator with the flexibility to change the display features.
2.5	2	Ensure that the number of displays is at a minimum and appropriate for operator tasks.
2.6	2	Ensure that interlock and permissive status with supporting information is available as required.
2.7	3	Use context sensitive techniques to access information that is conditionally relevant.

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ASM Use of Trends



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ASM Guideline Category Three

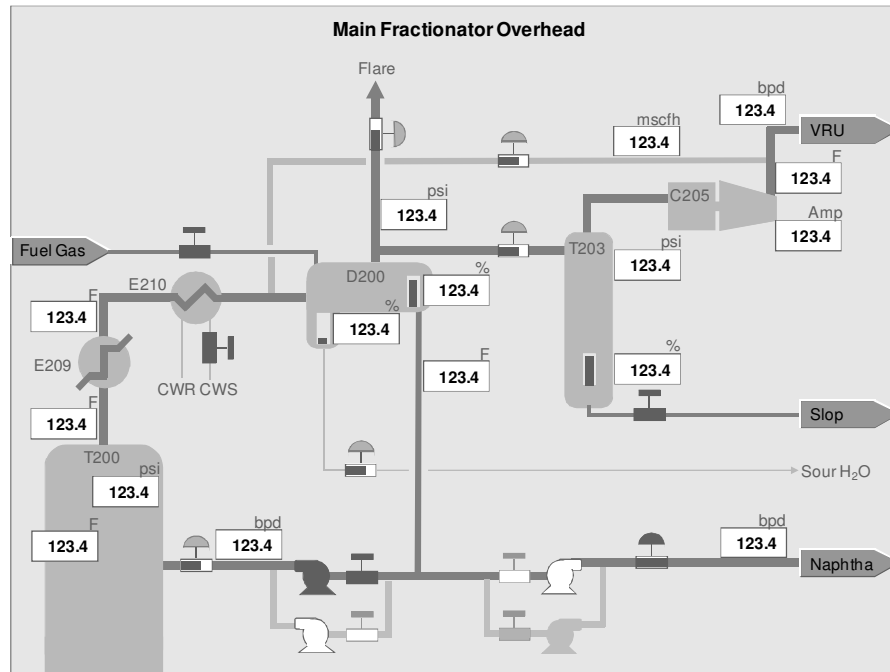
Display Style - Ensure that displays are not overly complex or cluttered due to the inappropriate use of full intensity colors and graphical details

#	Priority	Guideline
3.1	1	Ensure that the overall style incorporates an effective use of half-intensity colors to allow equipment and flow lines to appear as part of the display background.
3.2	1	Ensure that the overall style uses animation effectively, where appropriate, to communicate process-critical or safety-related activity.
3.3	1	Depict equipment without excessive detail to facilitate quick identification.
3.4	2	Minimize the complexity of equipment and control relationships, presenting them in a single view.
3.5	2	Make detailed information, such as tag names, available if needed.
3.6	2	Ensure that the overall style depicts 3D objects effectively.

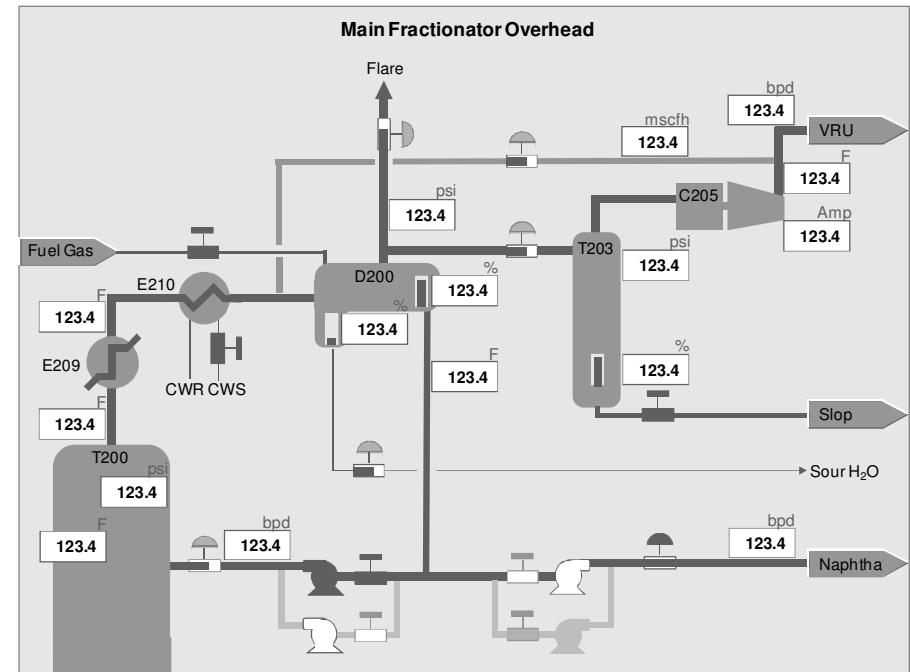
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ASM Use of Half-Intensity Color

Recommended



Not Recommended

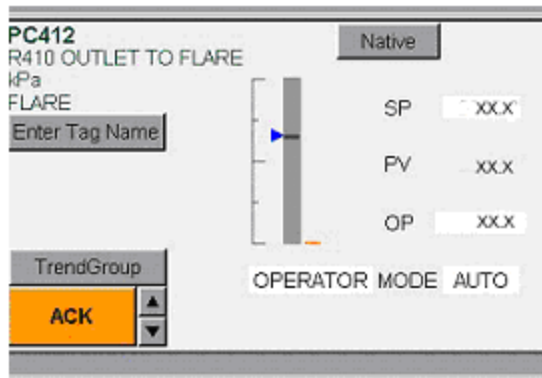


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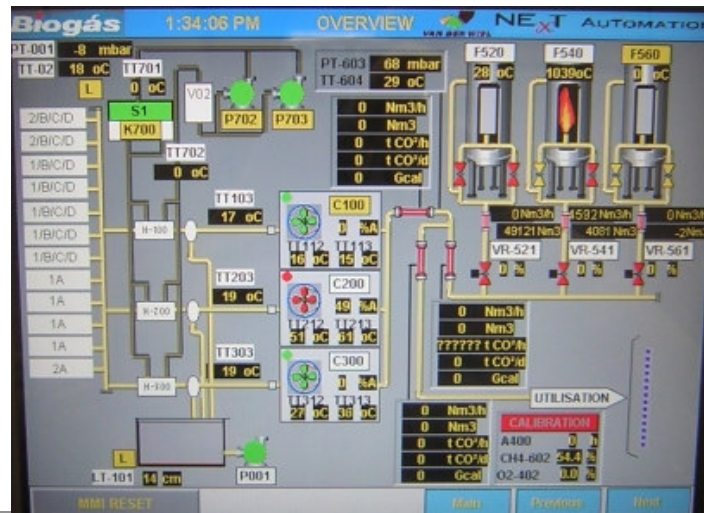
ASM Use of 3-D technique

- 3-D brings objects to foreground

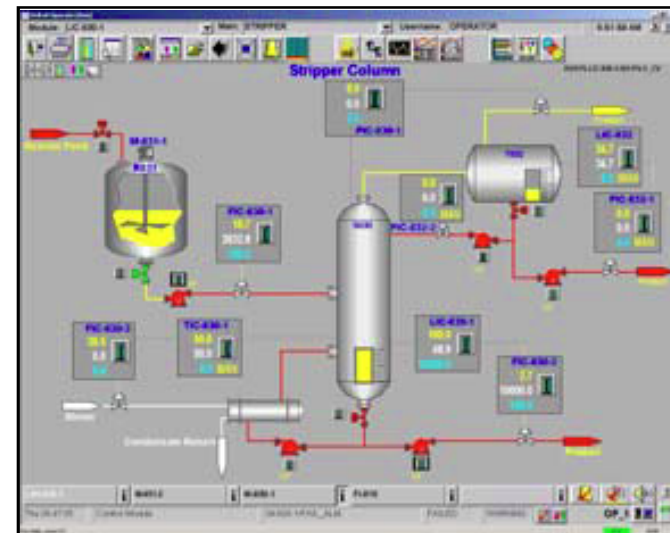
Recommended



Not Recommended



Not Recommended



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ASM Guideline Category Four

Display Layout – Use a consistent arrangement of objects and information across similar displays that is appropriate to process behaviors

#	Priority	Guideline
4.1	1	Develop consistent display layouts that are appropriate to process behaviors.
4.2	1	Ensure that the direction of flow is consistent to improve readability of the displays.
4.3	2	Ensure that the display layout emphasizes important information.
4.4	2	Distinguish similar processes in parallel trains with visual coding.
4.5	2	Ensure that layouts capitalize on maximizing operator retention of information in short-term memory.

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ASM Guideline Category Five

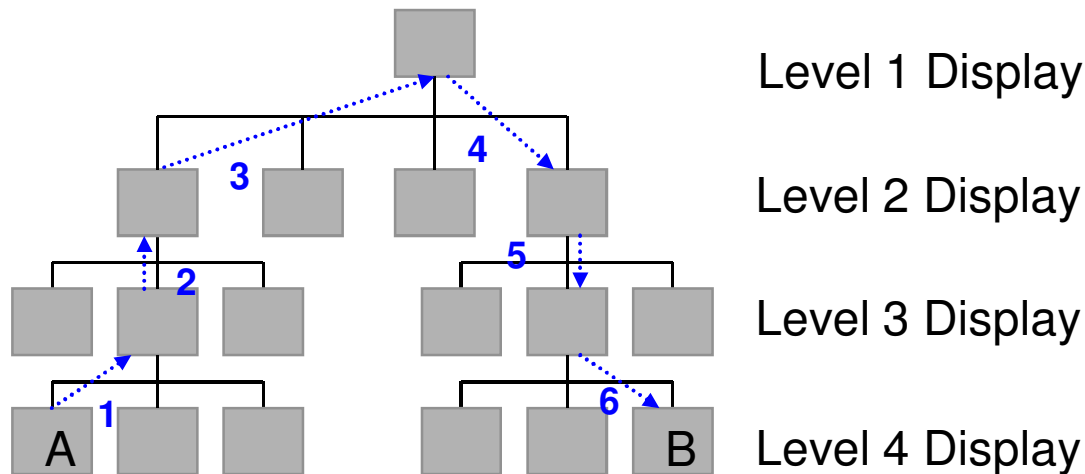
Navigation - Facilitate quick, direct access to primary displays and minimal keystrokes to secondary and associated displays

#	Priority	Guideline
5.1	1	Ensure that the navigation scheme is fairly simple and flat.
5.2	1	Ensure good organization to allow for direct access to primary displays and intuitive access to non-primary displays.
5.3	1	Ensure that navigation to primary displays is possible without the use of a display menu directory.
5.4	1	Ensure the soft-key configuration follows a systematic, conceptual organization for position layout and grouping if soft keys are used for calling up displays.
5.5	1	Ensure that the display call-up time averages 1 second and does not exceed 3 seconds in supporting navigation to operating displays (for real-time monitoring and control).
5.6	3	Use yoking to automate navigation to corresponding objects or information across simultaneous views in multi-level displays.

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ASM Effective Navigation Schemes

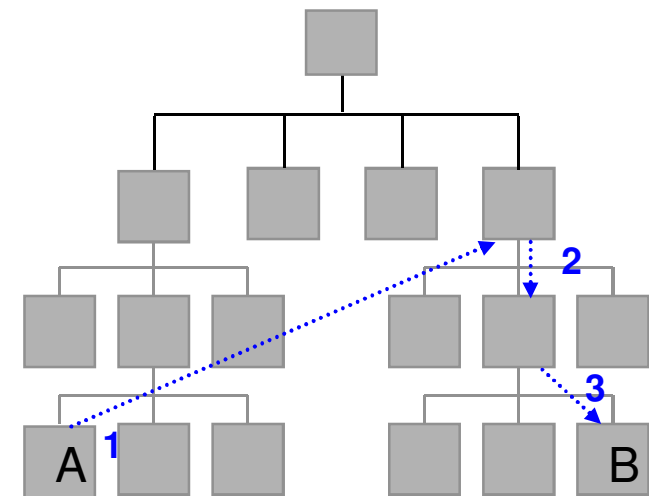
Deep Navigation Scheme with 4 Display Levels



Not Recommended

This navigation scheme is a strict drill-down and –up scheme from the current display; requires 6 mouse clicks to get from a to b.

Shallow Navigation Scheme with 4 Display Levels



Recommended

All level 2 displays accessible from any location; level 3 and 4 displays context dependent on location; per tab navigation scheme

Blue lines indicate number of mouse clicks to navigate to display levels

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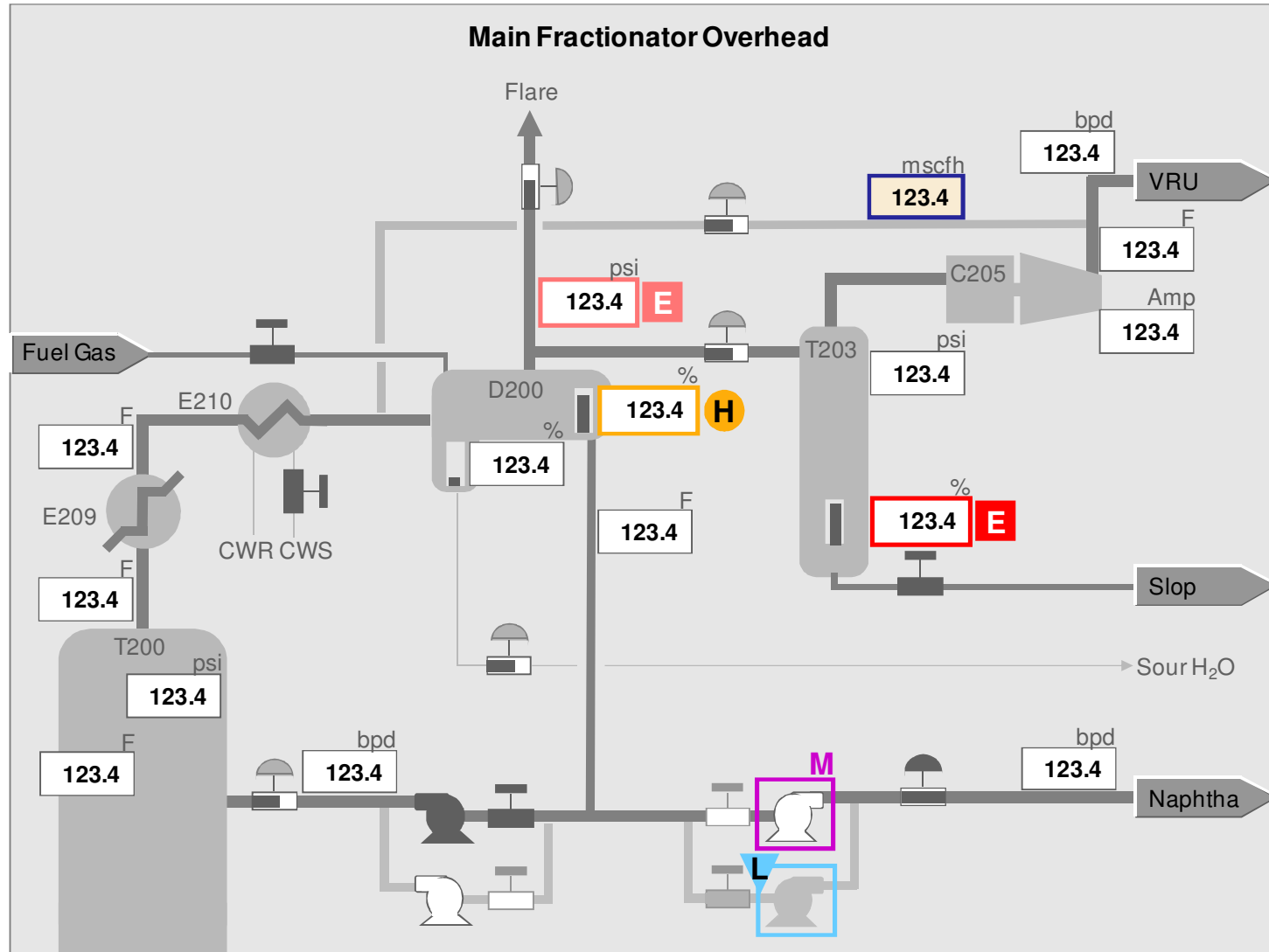
ASM Guideline Category Six

Color – Use color to facilitate the discrimination of the most important information and conveys the information consistently throughout the control room work environment

#	Priority	Guideline
6.1	1	Use a minimum of color codes consistently across display hierarchy levels.
6.2	1	Use red and yellow for alarms only.
6.3	1	Ensure that color combinations provide acceptable and sufficient contrast.
6.4	1	Avoid color combinations that are confusing for colorblind perception.
6.5	1	Use brightness coding sparingly for salience coding.
6.6	2	Use a display background color that maximizes the overall readability without causing unnecessary eyestrain or fatigue over time.
6.7	2	Ensure that color is a redundant, visual coding of information.
6.8	2	Ensure that color codes avoid conflicts with cultural stereotypes and industry standards.

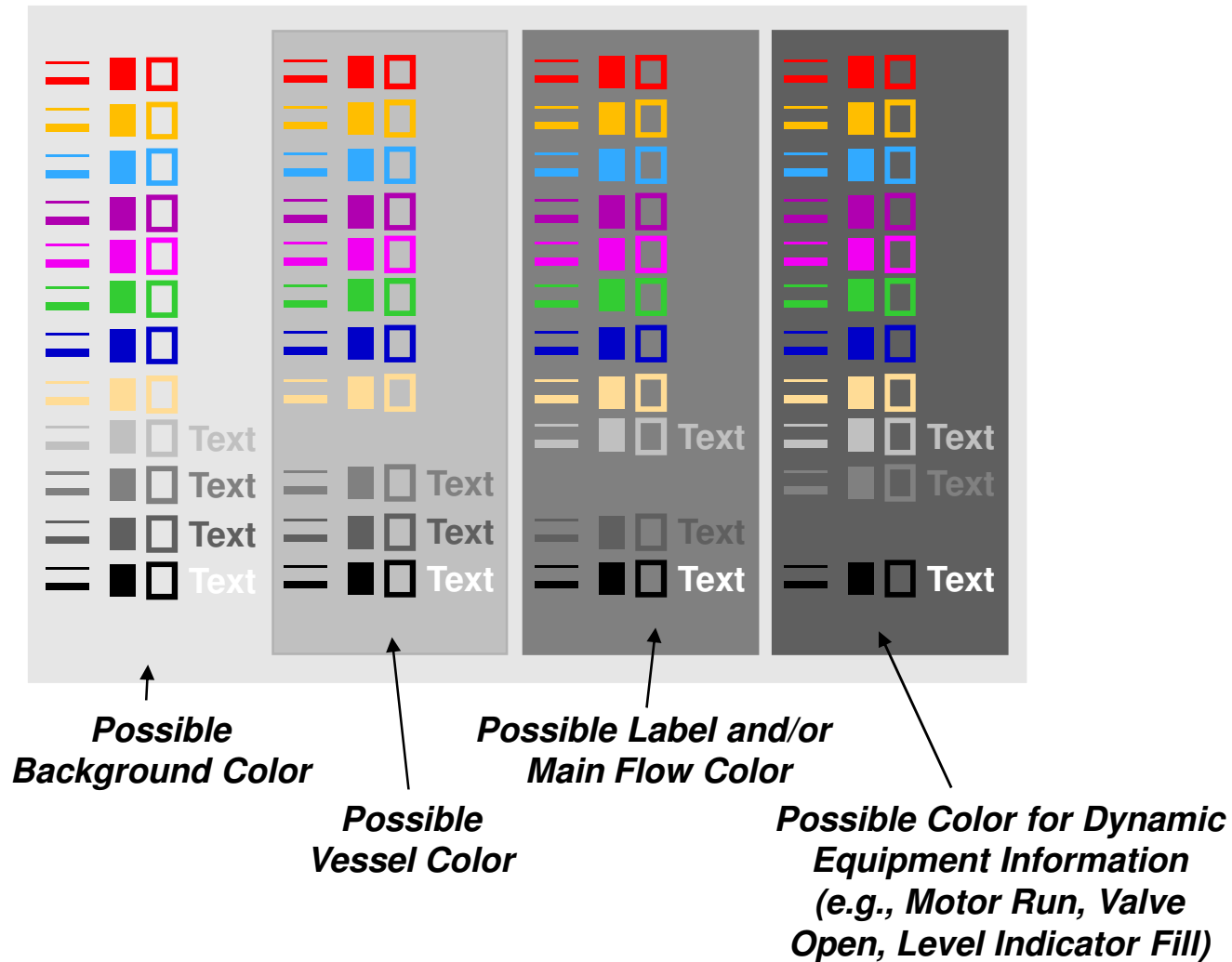
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ASM Use of Minimum Color Codes



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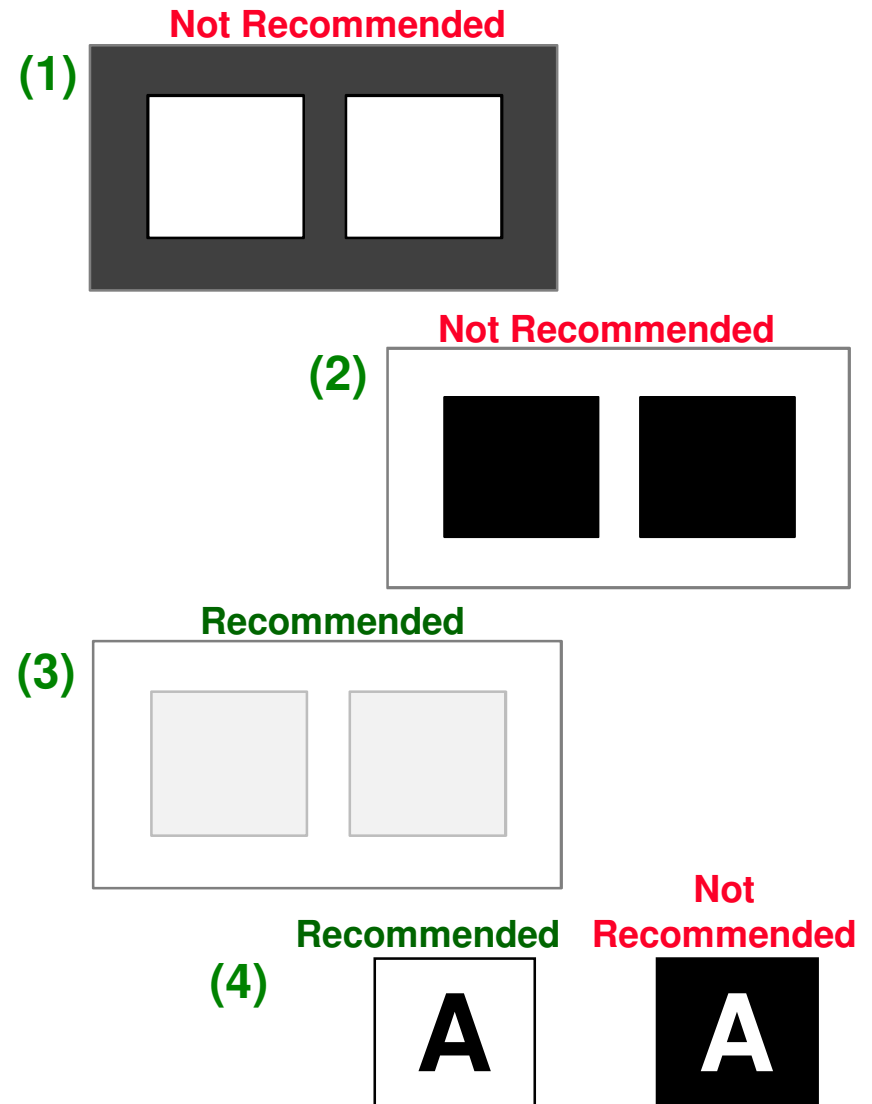
ASM Effective Color Combinations



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ASM Effective Background Colors

- Drive towards appropriate ambient light levels to support
 - Support circadian rhythms
 - Support visual Acuity for non-display tasks
 - Reduce eye strain
 - Align with ISO standards for ambient light levels
- Interacting issues
 - Luminous Contrast – (1) vs. (2) vs. (3)
 - Visual acuity as a function of background color (4)



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ASM Guideline Category Seven

Symbols and Process Connections - Symbols and process connections are depicted in a meaningful and consistent manner

#	Priority	Guideline
7.1	1	Use symbol and line coding that is easily understood with appropriate salience.
7.2	2	Use a consistently coded, minimal number of line types.
7.3	2	Use a minimalist approach when using lines to show controller and output relations.
7.4	2	Use symbols that are consistent with industry standards and site conventions.

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ASM Guideline Category Eight

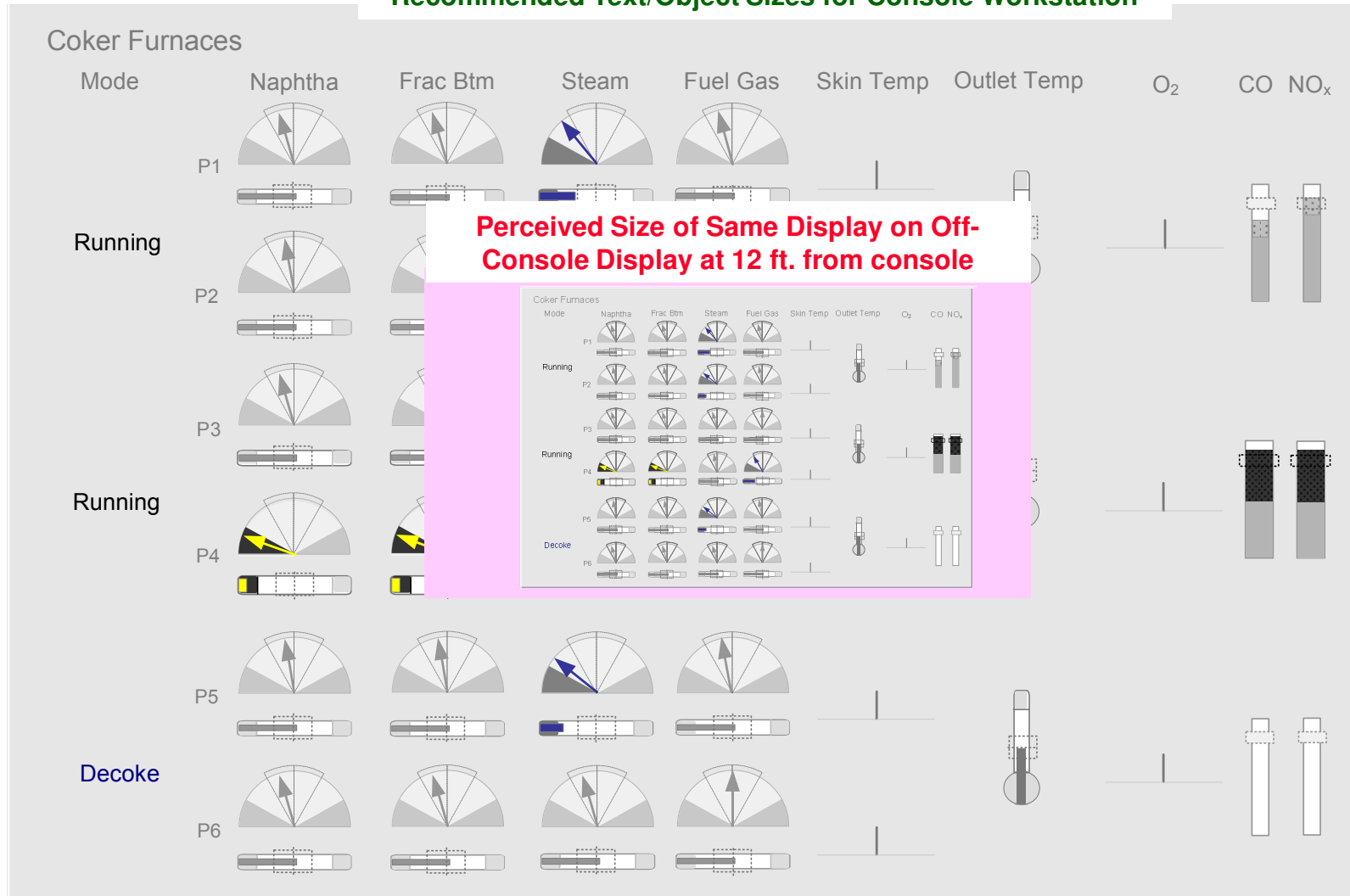
Text and Numbers - Information presented with text and numbers should be legible and easily understood from the operator's typical position

#	Priority	Guideline
8.1	1	Use text and numbers that are legible for the user's typical position.
8.2	1	Use coding and abbreviations that are consistent and understandable to users.
8.3	1	Ensure that users easily understand messages.
8.4	2	Use mixed-case lettering for text messages.
8.5	2	Use consistent numeric formats to enable quick reading.
8.6	2	Use numbers that have the appropriate level of precision.

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ASM Effective Text/Object Size

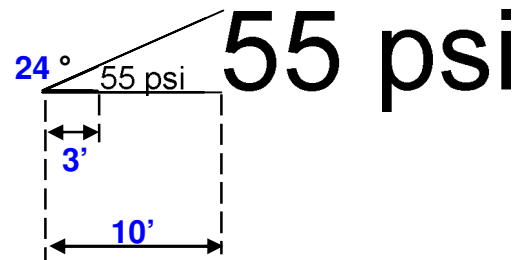
Recommended Text/Object Sizes for Console Workstation



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ASM Effective Text/Object Size

- 12 point font has ~24° visual angle at 3ft
- 42 point font has same visual angle at 10 ft



ASM Guideline Category Nine

Interactions with Displays - Input mechanisms are accessible with minimal keystrokes and with appropriate error avoidance techniques

#	Priority	Guideline
9.1	1	Use error avoidance techniques to prevent order of magnitude data entry errors on control actions.
9.2	1	Ensure that accurate, timely feedback is given for data entry and control actions.
9.3	1	Ensure that modal dialog boxes are not used.
9.4	1	Ensure that field devices incorporate password protection.
9.5	1	Minimize the amount of typing that is required with field devices.
9.6	2	Use input dialogs that are simple, consistent, and reliable.
9.7	2	Ensure that the size and distance between selectable display objects is appropriate to the precision enabled by the pointing device.
9.8	3	Ensure that an auditory indication is given when an invalid entry is detected when error avoidance techniques are applied.

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ASM Guideline Category Ten

Alarm Configuration Scheme - Make appropriate use of a priority scheme through rationalization with criticality of the plant condition and urgency of the operator response

#	Priority	Guideline
10.1	1	Ensure that displays are available to view disabled and inhibited alarms.
10.2	2	Use a formal process to define and maintain alarm configuration.
10.3	2	Use appropriate integration of DCS and hard-wired panel alarms.
10.4	2	Provide information on alarm configuration settings that deviate from the designed values.
10.5	3	Provide access to alarm rationalization information.

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ASM Guideline Category Eleven

Audible Annunciation of Alarms - The audible annunciation of alarms effectively orients operators within their workspace without unnecessarily disturbing them or distracting others working near them

#	Priority	Guideline
11.1	1	Ensure alarms have the appropriate intensity to be audible.
11.2	2	Have a priority-based, audible bypass for upset conditions.
11.3	2	Have distinctive tones for priority with effective console isolation.
11.4	3	Use modulating pitch and intensity to indicate duration/recurrence.
11.5	3	Use a vibrate mechanism to indicate an alarm for field environments or for process control operators who carry mobile or paging systems.

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ASM Guideline Category Twelve

Visual Annunciation of Alarms - The visual annunciation of alarms effectively orients users to the nature, status and location of abnormal process conditions

#	Priority	Guideline
12.1	1	Ensure that critical information, such as the alarm summary process overview, is within a 30 degree maximum angle on the horizontal plane.
12.2	1	Use redundant indication of critical alarms in control/monitor displays.

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ASM Console View Angles

- **Dimensions influencing effective viewing**

- a. **Eye height of viewer**

- » **Sitting and standing height**
 - » **95th percentile male & 5th percentile female**

- b. **Distance from viewer**

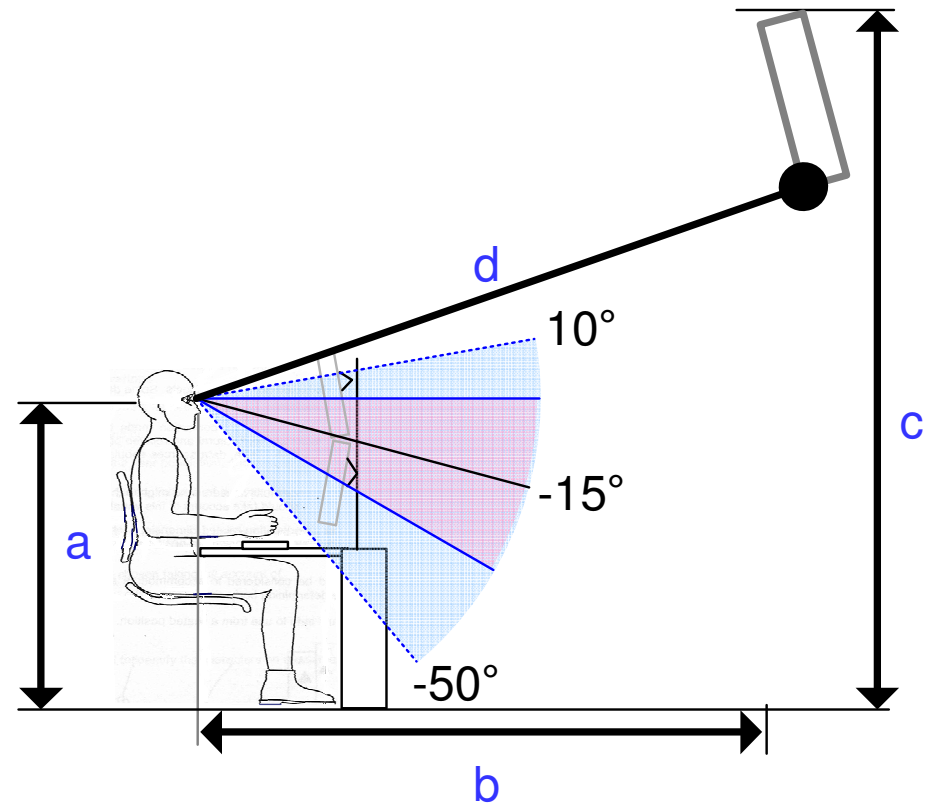
- » **also determines appropriate display object and text size**

- c. **Height of screen**

- » **Ceiling height is a limiting factor**

- d. **View angle over console screens**

- » **>10° outside primary and secondary view angles requires head movement**
 - » **Exceeds viewing angle for critical information, i.e., will not draw attention**



ASM Guideline Category Thirteen

Training Program - Users of the console information system and devices receive adequate training appropriate to their required use to perform job-related activities

#	Priority	Guideline
13.1	1	Ensure that all console- and field-certified users receive training or change notices on their respective operating display modifications/additions.
13.2	2	Ensure that all users of information display systems (console or mobile devices) receive initial and refresher training and qualification testing appropriate to their job activities.
13.3	3	Ensure that simulation-based training is provided for task-specific learning: upset management, startup, and shutdown.

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ASM Guideline Category Fourteen

Online Guidance - Users are able to easily access information about console usage to learn or remember infrequently used functions

#	Priority	Guideline
14.1	1	Ensure that on-line user guidance is provided for task-specific applications.
14.2	3	Ensure that on-line user guidance is provided for infrequently used functionality.

ASM Guideline Category Fifteen

Design Methodology - The system developers follow a formal, user-centered design methodology that includes user participation and assessment of information requirements of important user activities

#	Priority	Guideline
15.1	1	Ensure that there is user involvement in development activities.
15.2	1	Use task analysis to determine functional organization and content.
15.3	1	Use design specifications for consistent implementation.
15.4	2	Use human factors and Best Practice design guidelines.
15.5	3	Ensure there is site-wide collaboration in development and maintenance of information systems.

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ASM Guideline Category Sixteen

Management of Change - The plant Management of Change procedure addresses major changes to the information displays and input devices

#	Priority	Guideline
16.1	1	Ensure that MOC covers major changes in design of operator displays and devices.
16.2	1	Ensure that MOC covers permanent changes in alarm configuration.

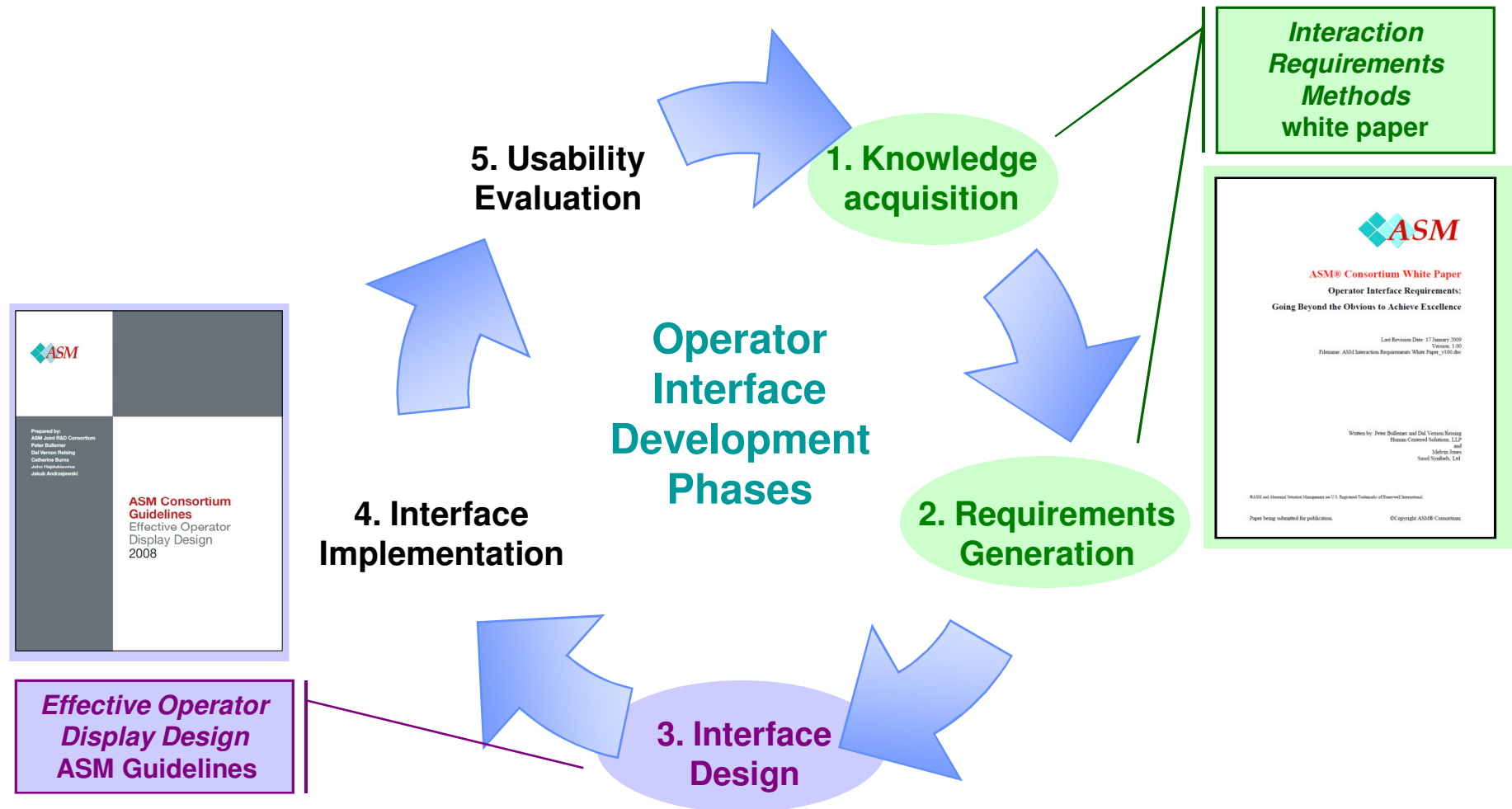
ASM How to Use these Guidelines

- **Auditing existing practices**
 - Gap analysis for opportunities for improvement
- **Establishing consistent operator interface practices**
 - Incorporation into a company's own guidelines or style guide
 - A guide to setting up or improving a site's operator graphics and console configuration
 - A guide for evaluating DCS information system capabilities
- **Educating site personnel on effective operator interface design practices**
 - Management, Engineering, and Operations;
 - Individuals that design the DCS graphics and other information systems (e.g., site intranets / business applications for Operator use)

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Effective Operator Interface Development Life Cycle



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ASM User Interface Design

Human Factored Design

- **Syntactics of UI**
 - Defining the consistent, human-friendly grammar for dialog in the system interactions
- **Emphasis on human capabilities and limitations, i.e., memory, selective attentions, calculation skills, reading skills**
- **Impacts appearance of information presentation and input protocol**
- **UI features**
 - Screen Layout and Density
 - Use of visual coding
 - Font Conventions

Human Centered Design

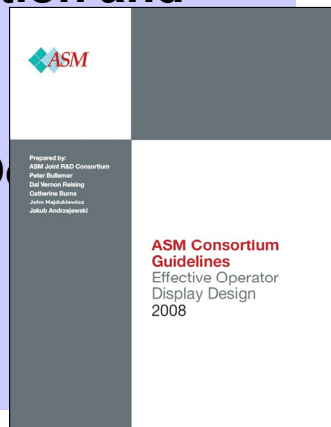
- **Semantics of UI**
 - Defining the meaningful dialog in the human-machine system interactions
- **Emphasis on user- and task-modeling**
- **Impacts system functionality**
- **UI features**
 - Functional decomposition
 - Navigation scheme
 - Visualization techniques
 - Information content

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ASM User Interface Design

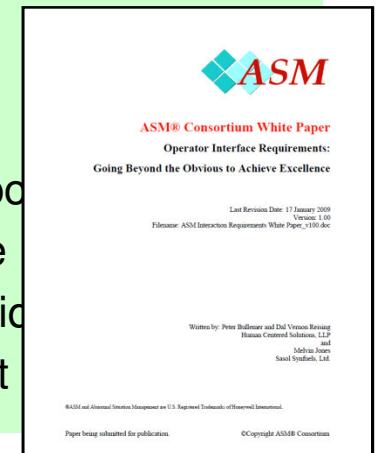
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Human Centered Design

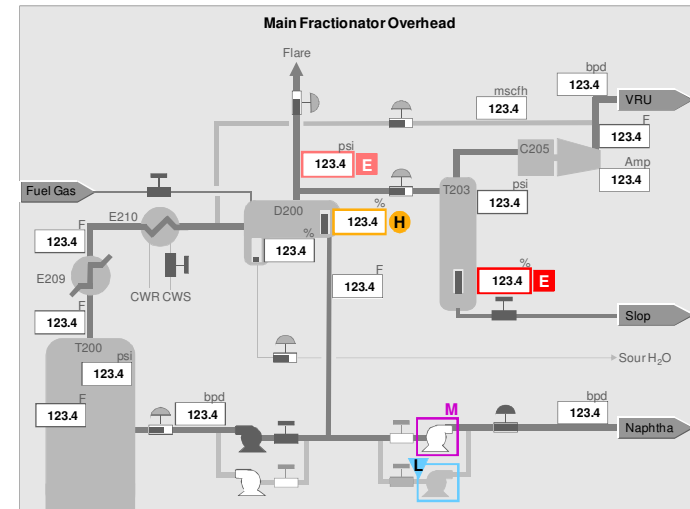
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ASM Concluding Comments

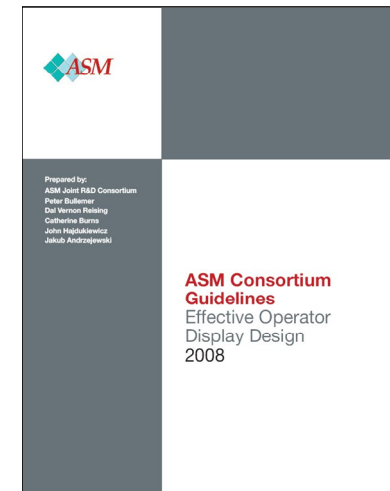
- ## *The Whole is Greater than the Sum of the Parts*



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ASM Webinar Discussion Time

- Any additional questions and/or comments on the Webinar coverage of the *Effective Operator Display Design* Guidelines
- The guidelines document is available on the ASM web site at
 - <https://www.createspace.com/3355979>
 - Or
 - <http://www.amazon.com>



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ASM Poll Slide 3 (Placeholder)

- **How much value was there for you in attending today's webinar?**
 - **Significant value** – worth my time and I would recommend it to others
 - **Moderate value** – worth my time but not sure I would recommend it to others
 - **Marginal value** – probably worth my time
 - **No value** – was not worth my time today

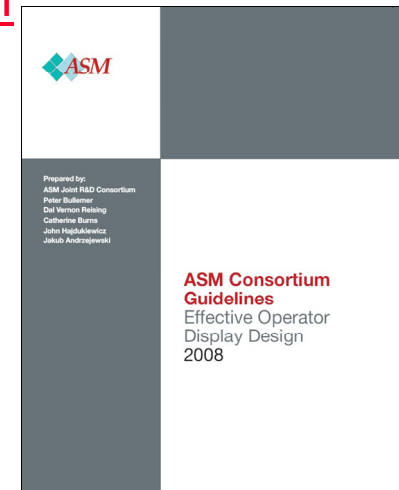
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ASM® Webinar: *Effective Operator Display Design Guidelines*

Thank you for your attendance.

- **For follow up questions please contact:**
 - Dal Vernon Reising – dreising@applyhcs.com
 - Peter Bullemer – pbullemer@applyhcs.com
 - Jason Laberge – jason.laberge@honeywell.com
 - **The guidelines book is available on:**
 - <https://www.createpace.com/3355979>
- Or
- <http://www.amazon.com>



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