



# 2017 Human Performance Conference

*Human Interface Design:  
Human Factors in the Control*

Ian Nimmo - User Centered Design Services Inc.



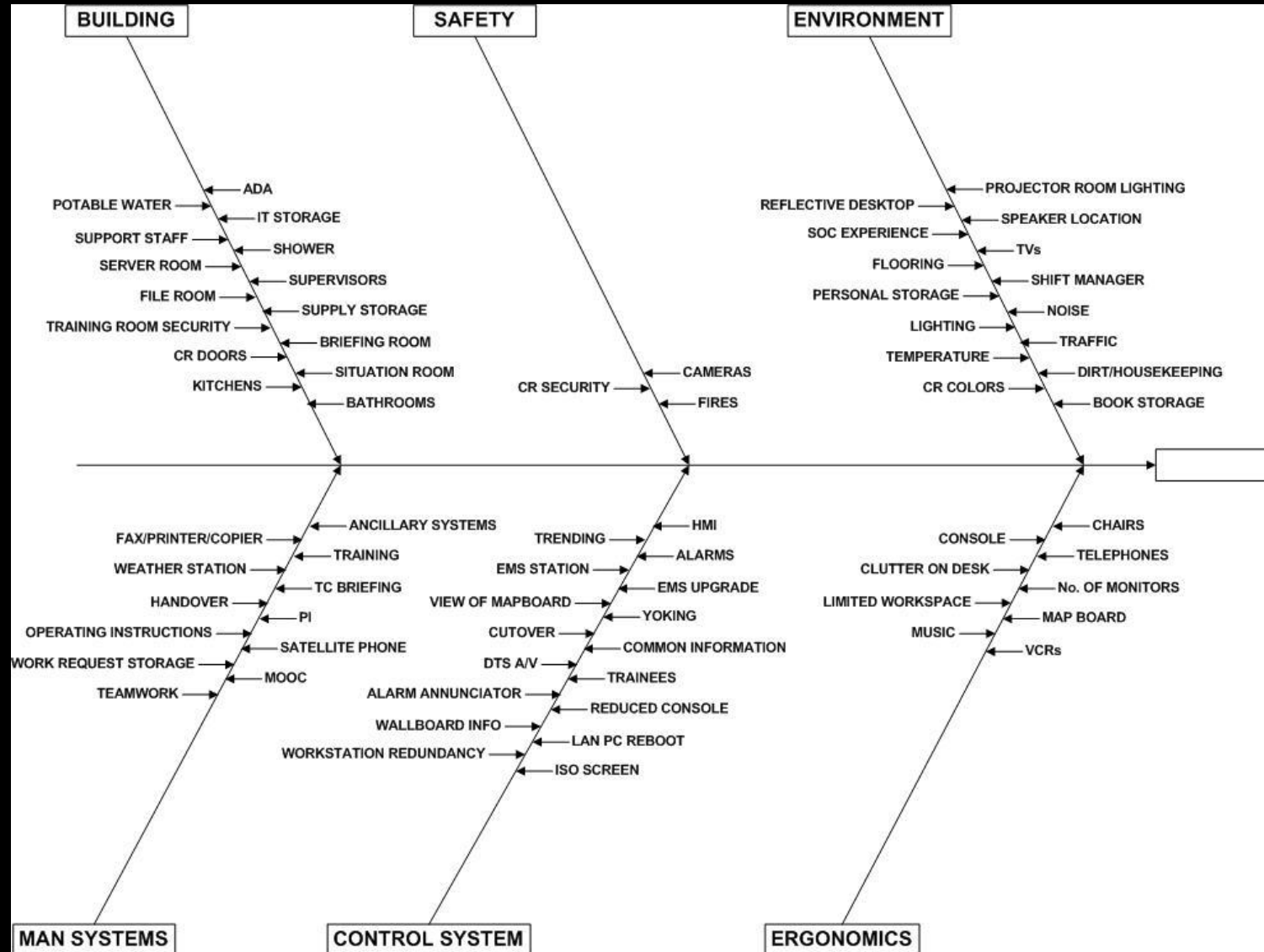
# CONVEX Control Room Project

- Connecticut Valley Electric Exchange
- Formed – January 1, 1964
- Mission
  - Safe, reliable & economic operation of the transmission system

# Operations

- Operate Transmission System
  - Connecticut and Western Massachusetts
  - ~220 substations
  - ~198 generators
  - ~34 345 kV lines, ~237 115 kV lines, ~12 69 kV lines, 1 138 kV cable, 1 150 kV DC cable.
- CONVEX is about 31% of New England load. Peak of 8,878 MW 8/2/2006 (New England peak 28,048 MW 8/3/06.)

# Control Rooms have issues!



# Demons of Situation Awareness



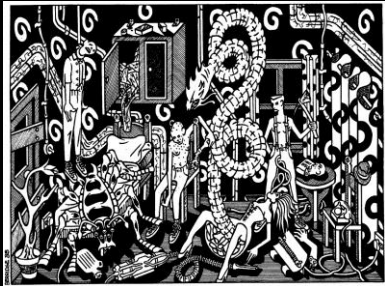
- Attention tunneling
  - Fixating on one set of information to the exclusion of others
- Memory trap
  - Relying on limited short-term memory
- Workload, anxiety, fatigue and other stressors
  - Reduction of a person's capacity to process information
- Data overload
  - Overwhelming amounts of data



Mica Endsley - Designing for Situation Awareness:  
An Approach to User-Centered Design



- Misplaced salience
  - Salience: the compellingness of certain information
  - Being drawn to the wrong information



- Complexity creep
  - Too many features make it difficult to develop an accurate mental model



- Errant mental models
  - Use of the wrong model leads to misinterpretation of information

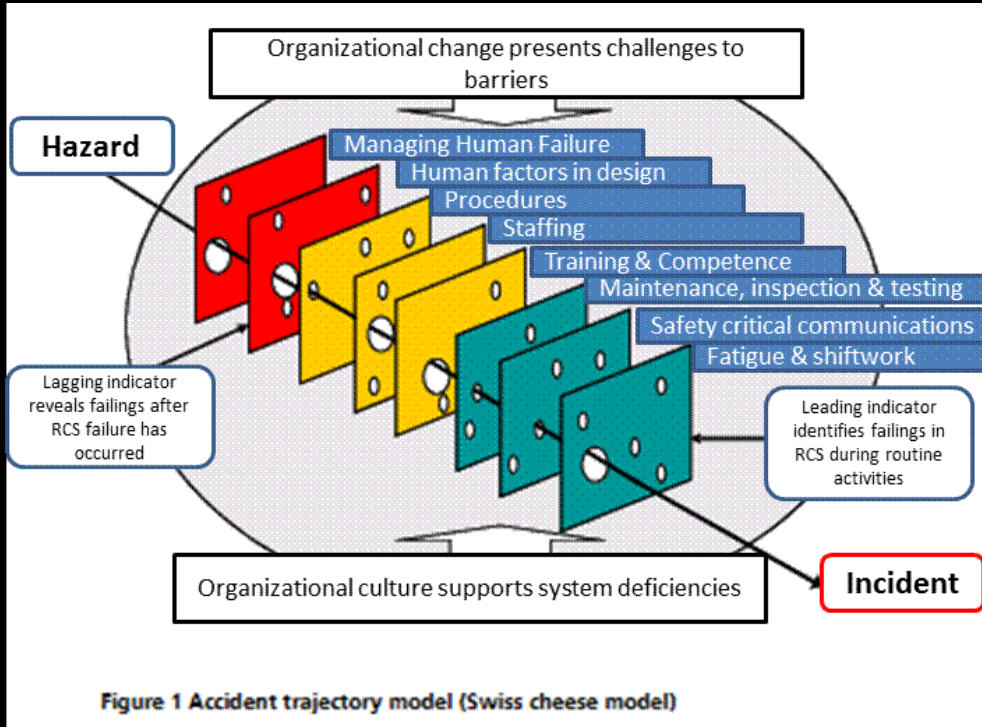


- Out-of-the-loop syndrome
  - Automation can undermine SA

Mica Endsley - Designing for Situation Awareness:  
An Approach to User-Centered Design



# Control Rooms have issues!



Control Room Conceptual Design  
Control Room Detail Design  
Console Design  
Console Mockup for operators  
HMI Workshop  
High Performance HMI Philosophy  
High Performance HMI Style Guide  
Generic & Emerson Ovation

# Data is Not Information!



- Let's illustrate the difference between data and information. Here are the results of a blood analysis of Fluffy – a pet cat. What can be determined from this information? Is Fluffy sick?



# A cat's blood work results: Good or bad?

Test	Results
HCT	= 31.7 %
HGB	= 10.2 g/dl
MCHC	= 32.2 g/dl
WBC	= 9.2 x10 <sup>9</sup> /L
GRANS	= 6.5 x10 <sup>9</sup> /L
%GRANS	= 71 %
L/M	= 2.7 x10 <sup>9</sup> /L
%L/M	= 29 %
PLT	= 310 x10 <sup>9</sup> /L



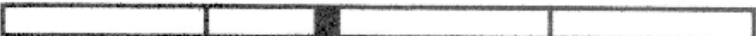
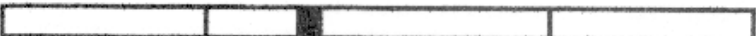





# A cat's blood work results: Good or bad?

Test	Results	Reference Range
HCT	= 31.7 %	24.0 - 45.0
HGB	= 10.2 g/dl	8.0 - 15.0
MCHC	= 32.2 g/dl	30.0 - 36.9
WBC	= 9.2 x10 <sup>9</sup> /L	5.0 - 18.9
GRANS	= 6.5 x10 <sup>9</sup> /L	2.5 - 12.5
%GRANS	= 71 %	
L/M	= 2.7 x10 <sup>9</sup> /L	1.5 - 7.8
%L/M	= 29 %	
PLT	= 310 x10 <sup>9</sup> /L	175 - 500

By carefully (and tediously) examination, you can get an slight idea as to whether each number is “good” or “bad” (based on the position within the range) – even without knowing what the individual values mean to feline physiology.

# And now?

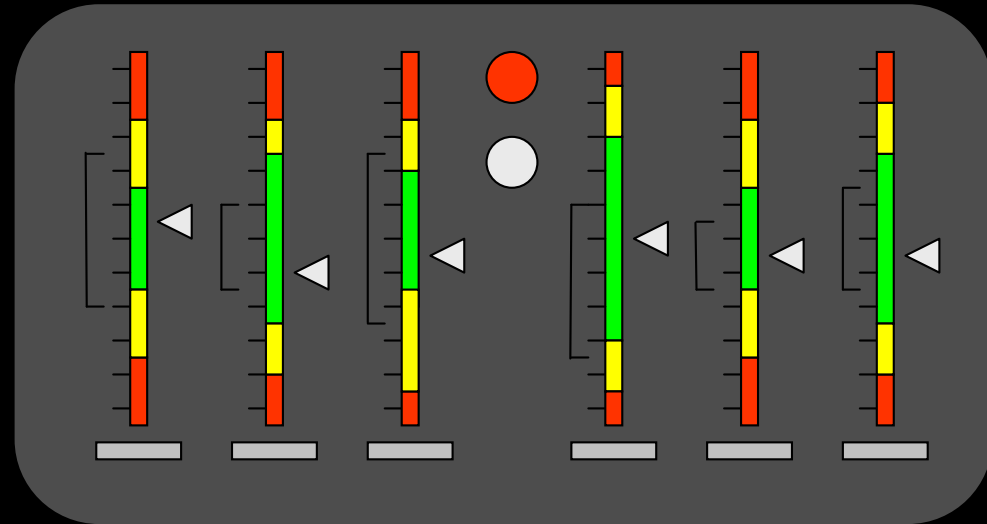
A much better presentation is as follows – where far less time is needed to understand the numbers

Test	Results	Reference Range	Indicator		
			LOW	NORMAL	HIGH
HCT	= 31.7 %	24.0 - 45.0			
HGB	= 10.2 g/dl	8.0 - 15.0			
MCHC	= 32.2 g/dl	30.0 - 36.9			
WBC	= 9.2 x10 <sup>9</sup> /L	5.0 - 18.9			
GRANS	= 6.5 x10 <sup>9</sup> /L	2.5 - 12.5			
%GRANS	= 71 %				
L/M	= 2.7 x10 <sup>9</sup> /L	1.5 - 7.8			
%L/M	= 29 %				
PLT	= 310 x10 <sup>9</sup> /L	175 - 500			



# Analog is Often Better

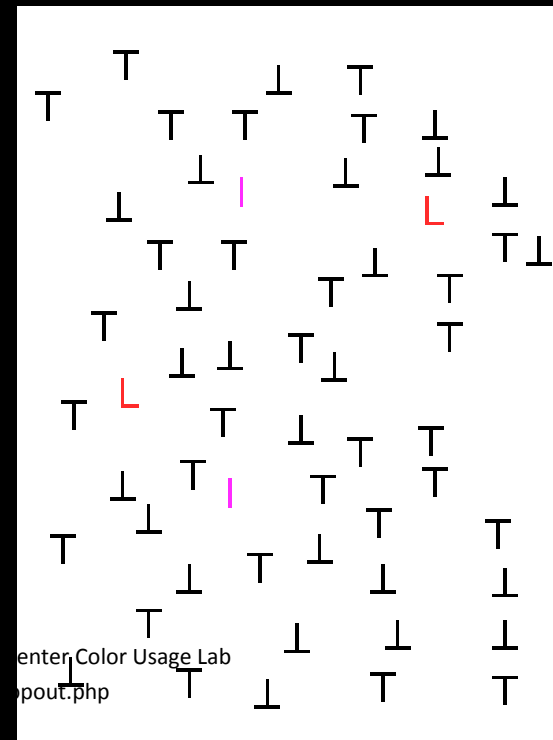
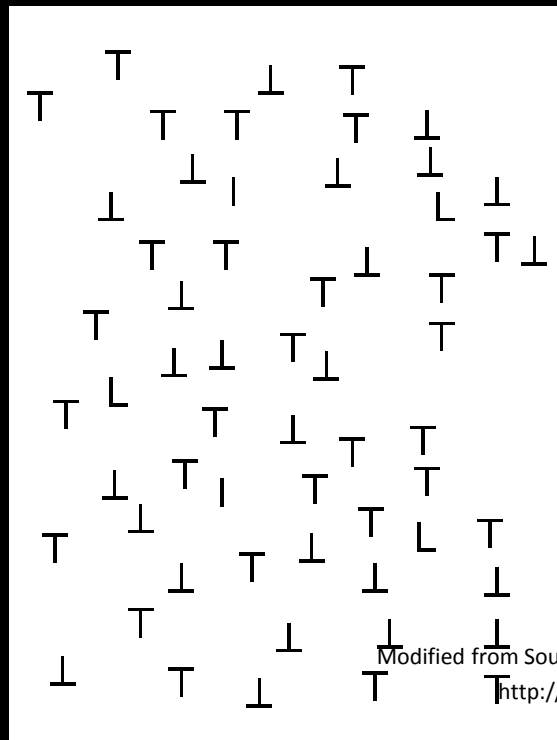
- Here is an example many of us are familiar with – the sickbay medical readout, from the classic 1960's *Star Trek*:



Is the guy in the red shirt dead yet ?

# Color is a Powerful Way to Guide Attention. How Many I's & L's Can You Find?

- The red and magenta coding's on the right make them stand out instantly, without having to inspect each symbol.

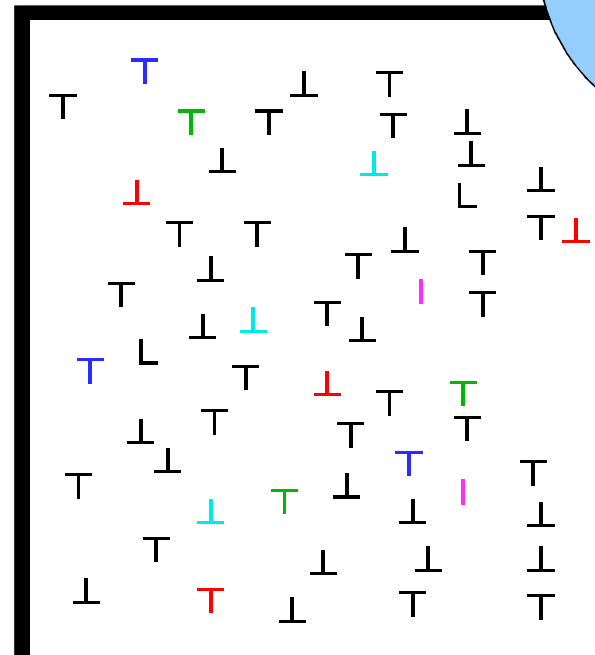


# Color and Attention

Your eye is automatically drawn to colored objects.

This is called the “ **pop-out** ” effect.

Here the "I"s are still magenta, but they are slightly harder to locate due to the addition of three more hue coded subsets.





# Clarity

- Provide instantaneous understanding of information by putting **data** into **context**.
- If color is used for priority coding it needs to be simple and consistently used.
- NASA also highlight that some color mixes should be avoided due to color deficient operators inability to differentiate color combinations such as Red and Green.

# Firm Rules

- The NASA information provides very important insight into some of the many mistakes we have made in the past while using color without any rules and not using consistent coding techniques. If we are going to use color as a coding system it demands firm rules and enforcement for that coding to be effective.

# Background Color

- NASA also talks about the use of Grey as a background color and how it is the most effective background color to use for contrasting other colors and enhancing the color coding system and ability to detect or find the needed information.

# Luminance

- The minimum luminance ratio between symbols and background shall be 3:1. Various forms of this guideline are nearly universal in guidance documents, differing mainly in the quantity required and in which statistical measure of luminance contrast is used. This is one of the most important usability issues related to color choices.

# Here is the Problem!

- The problem it addresses is easily demonstrated.

In spite of  
contrast  
and the  
very legibility  
of text and background luminances are equal.



ic  
of text  
one is  
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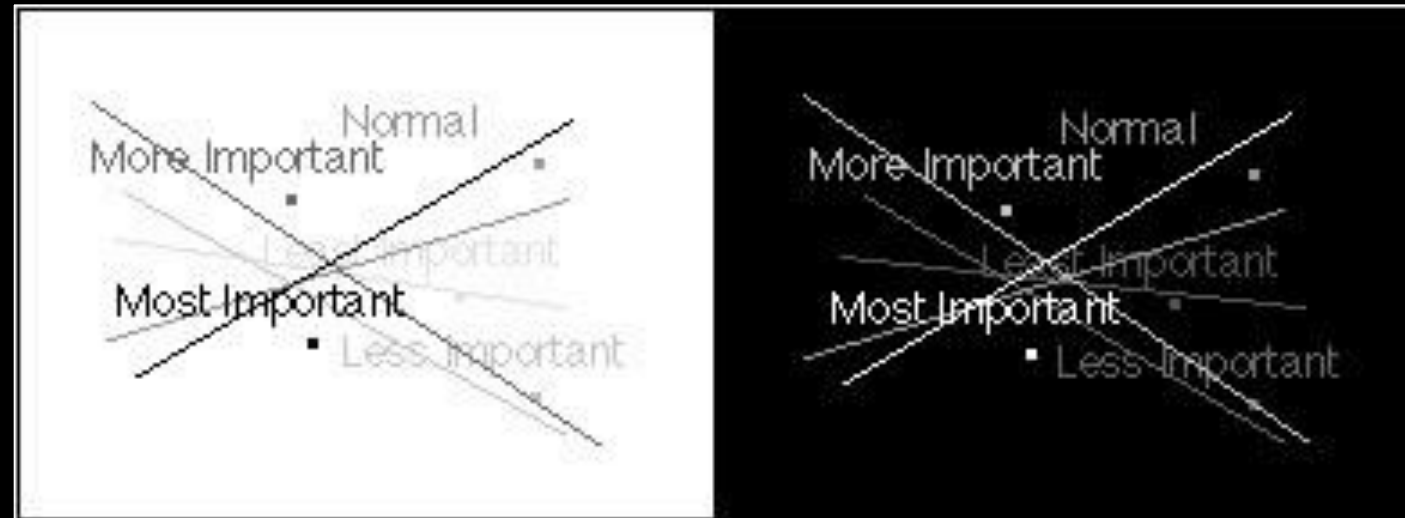
# Perceptual Layers

- There are several graphic manipulations that can be used to establish perceptual layers. The most common are brightness contrast, line weight, symbol size, and blinking and flashing. Of these only brightness contrast is directly affected by color assignments, but color design issues such as legibility and discrimination interact with the others.



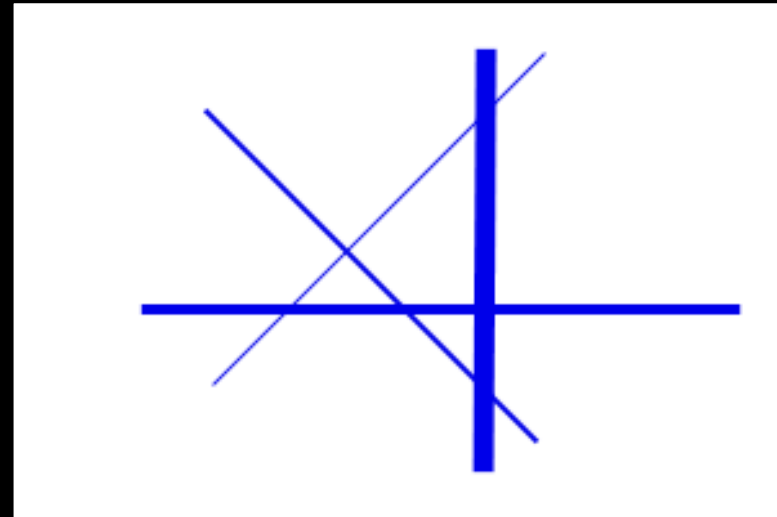
# Brightness Contrast

- Objects with higher brightness contrasts are more salient than those with lower contrasts. In this figure "Most Important" has the highest brightness contrast and "Least Important" the least brightness contrast.

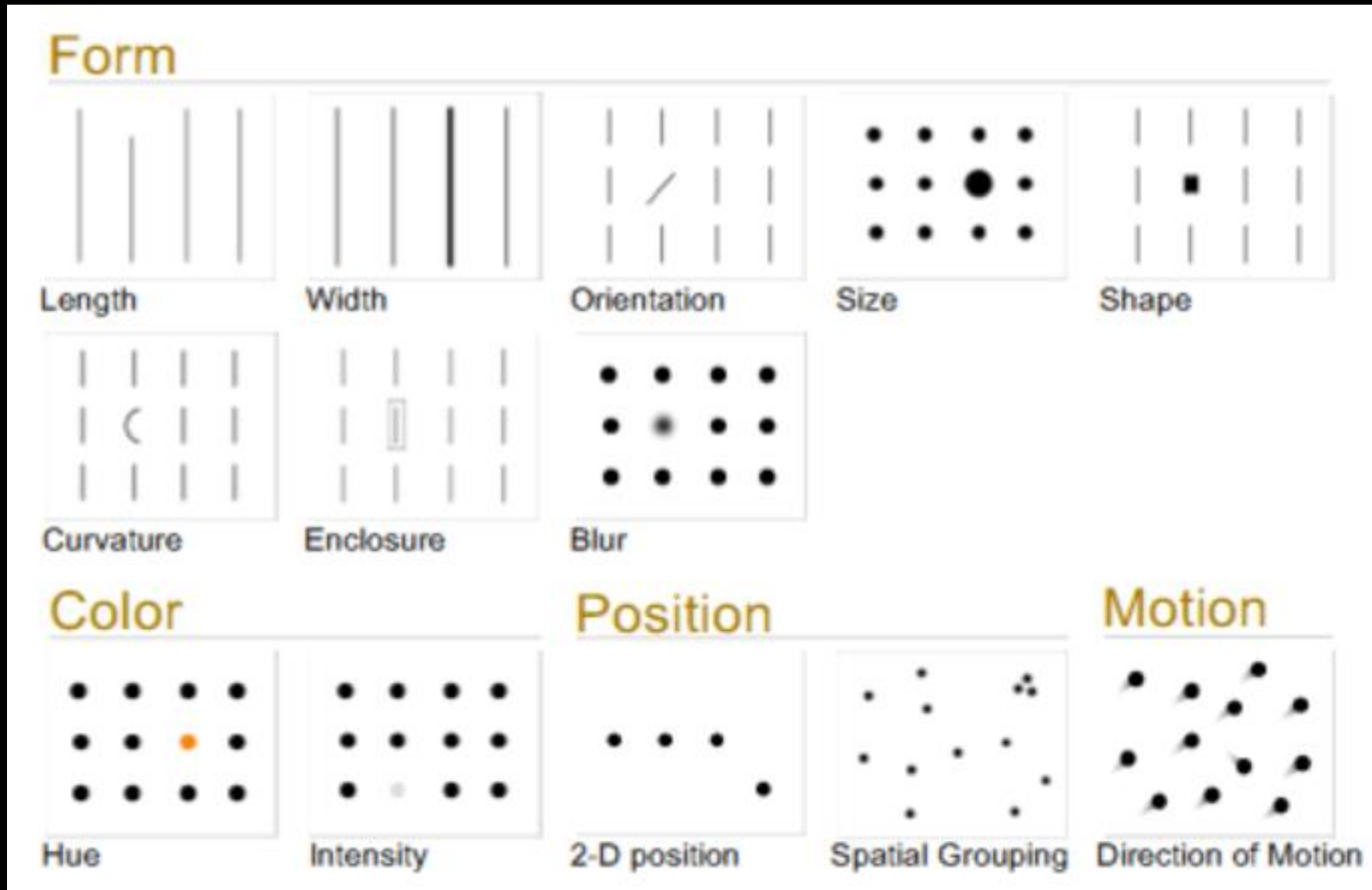


# Line Weight

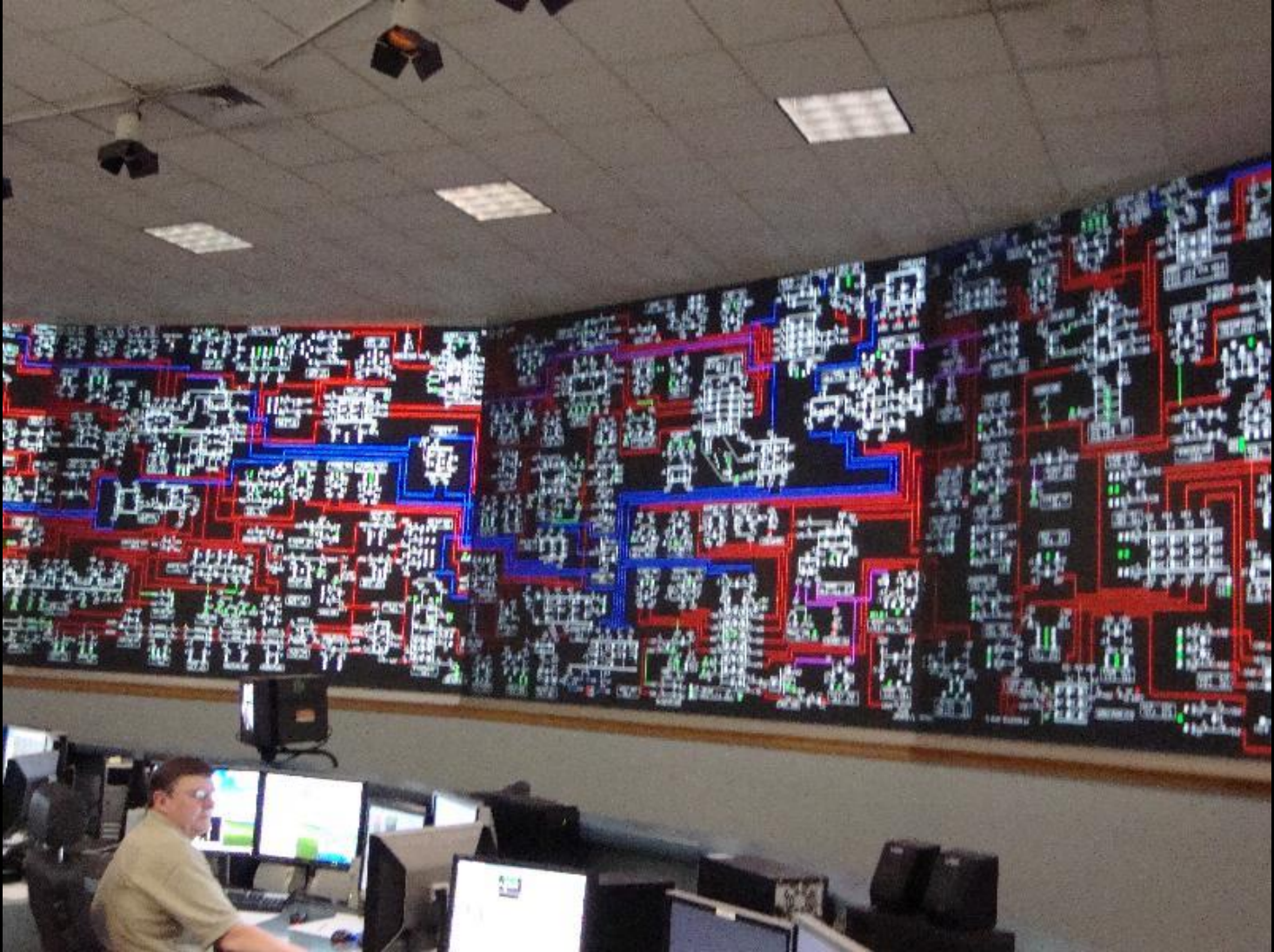
- Wider lines are more salient than narrower. For narrow lines this is partly due to the effect of line width on brightness contrast. For the same luminance contrast, wider lines have higher brightness contrast than narrower lines. Line width also affects color discrimination and legibility.



# HP HMI Revisited



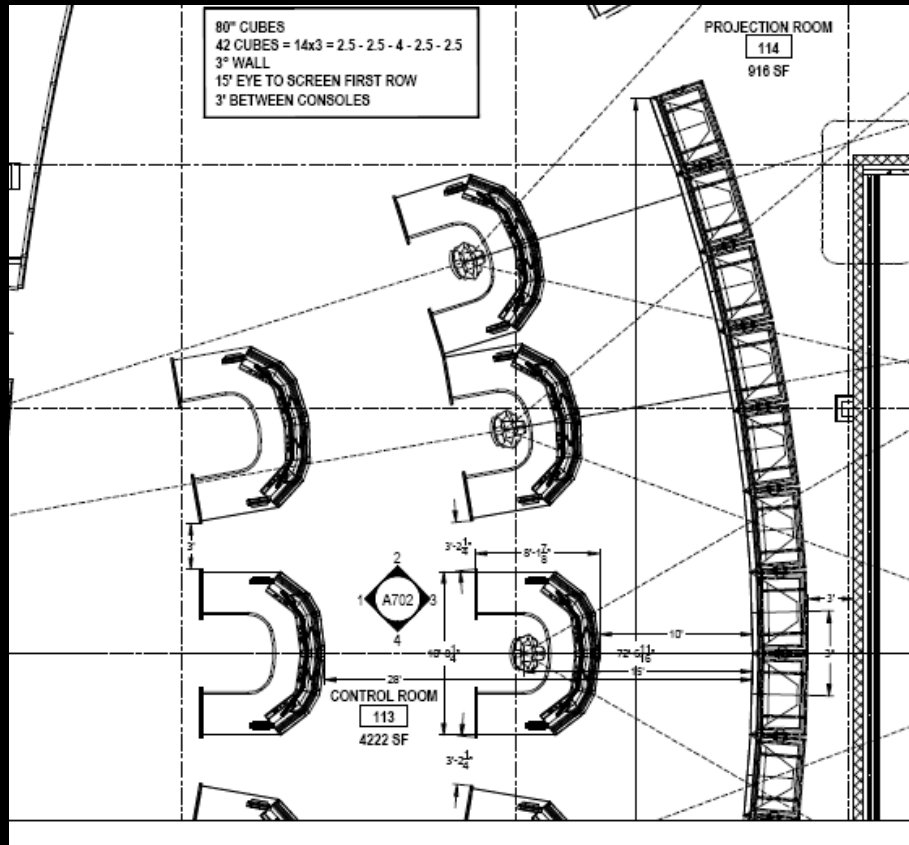
# Video Wall



# New Center

- 361 Days – Ground Breaking to Occupancy
  - No Safety Incidents
- Budgeted \$29 Million
  - Cost \$23 Million
  - 20% Under Budget
- New Situational Awareness Tools Added
  - E-Terra Vision
  - Historical PI Displays

# Good Situation Awareness

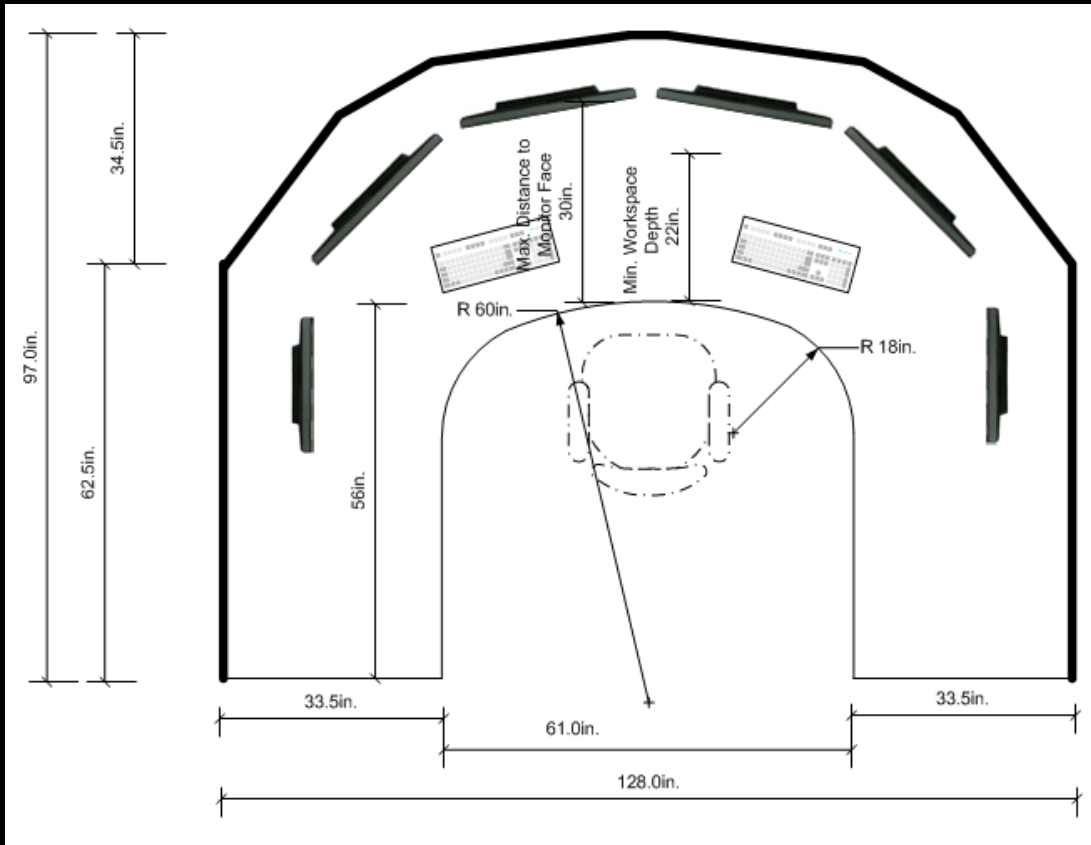


- All angles checked against ISO 11064 specification & specifically for Barco Displays.



# Console Designed for SA

- Consoles approved by operator's designed by UCDS Inc.



# Console Design



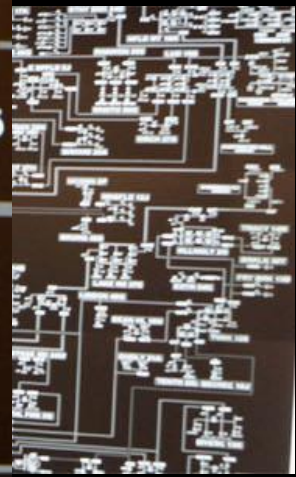
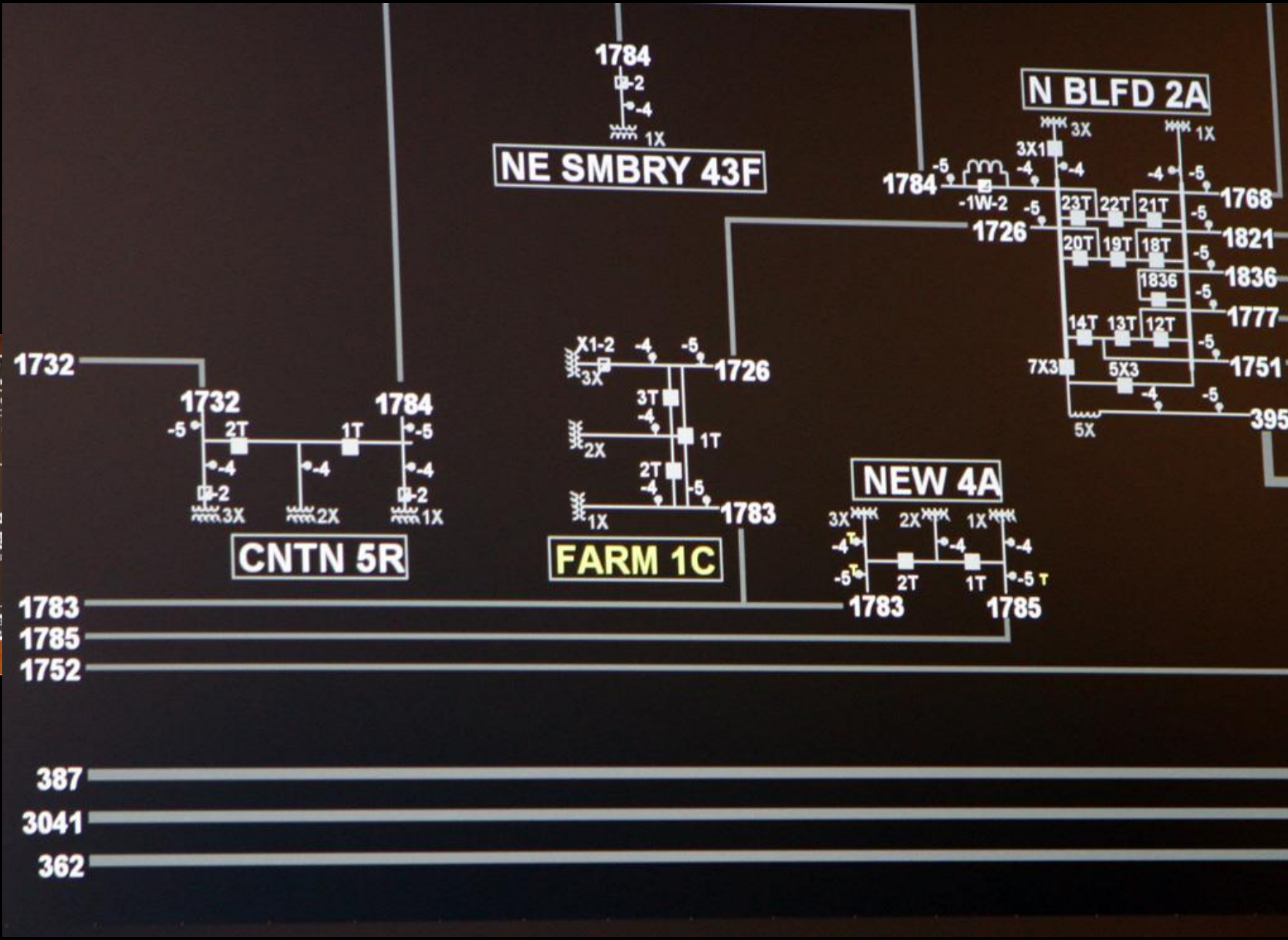
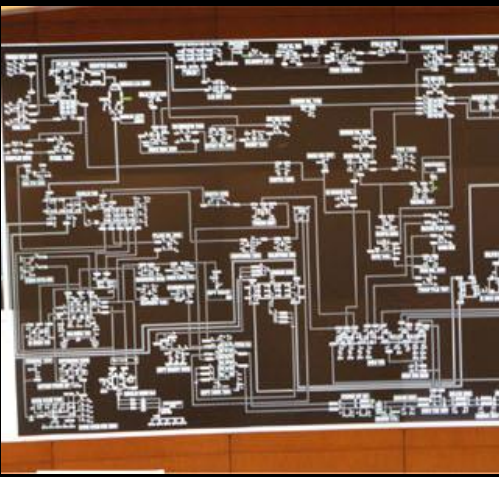
- Just because it is ergonomic does not mean it does not look good!



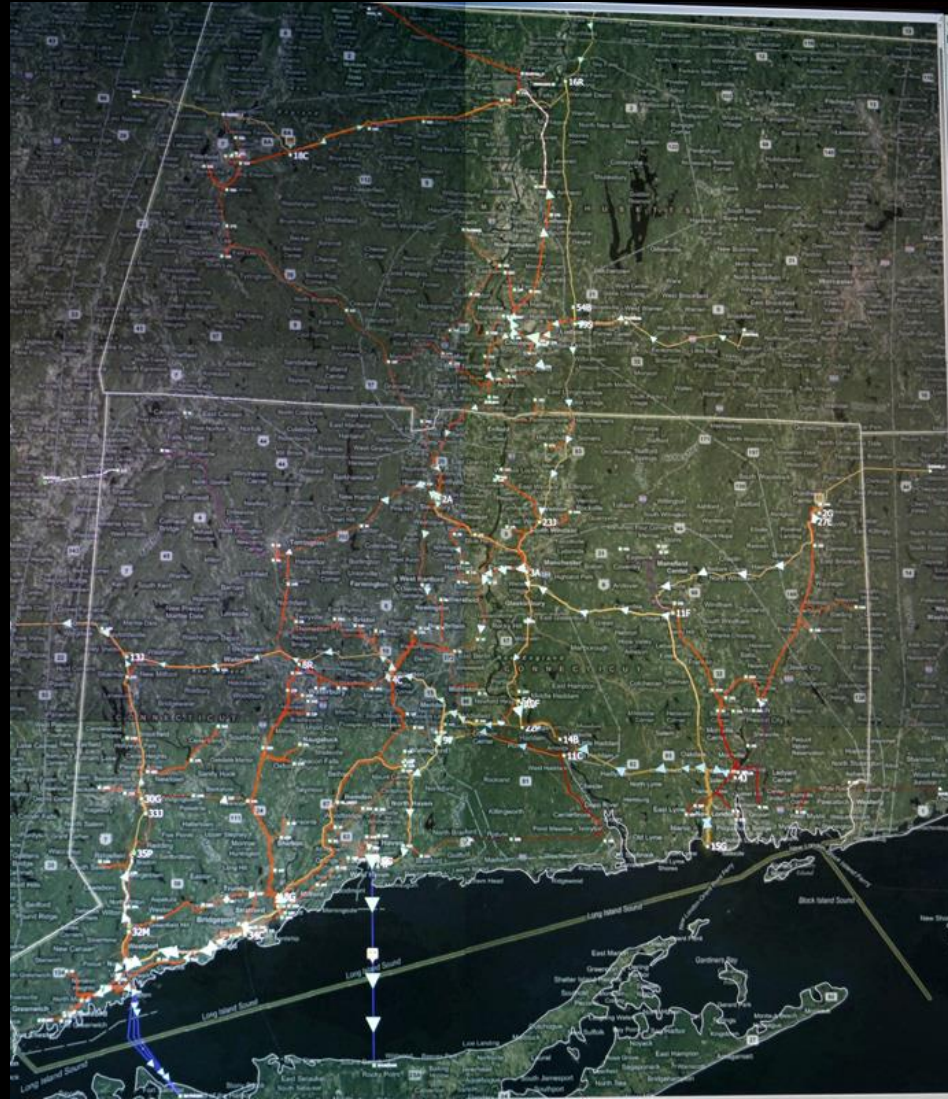






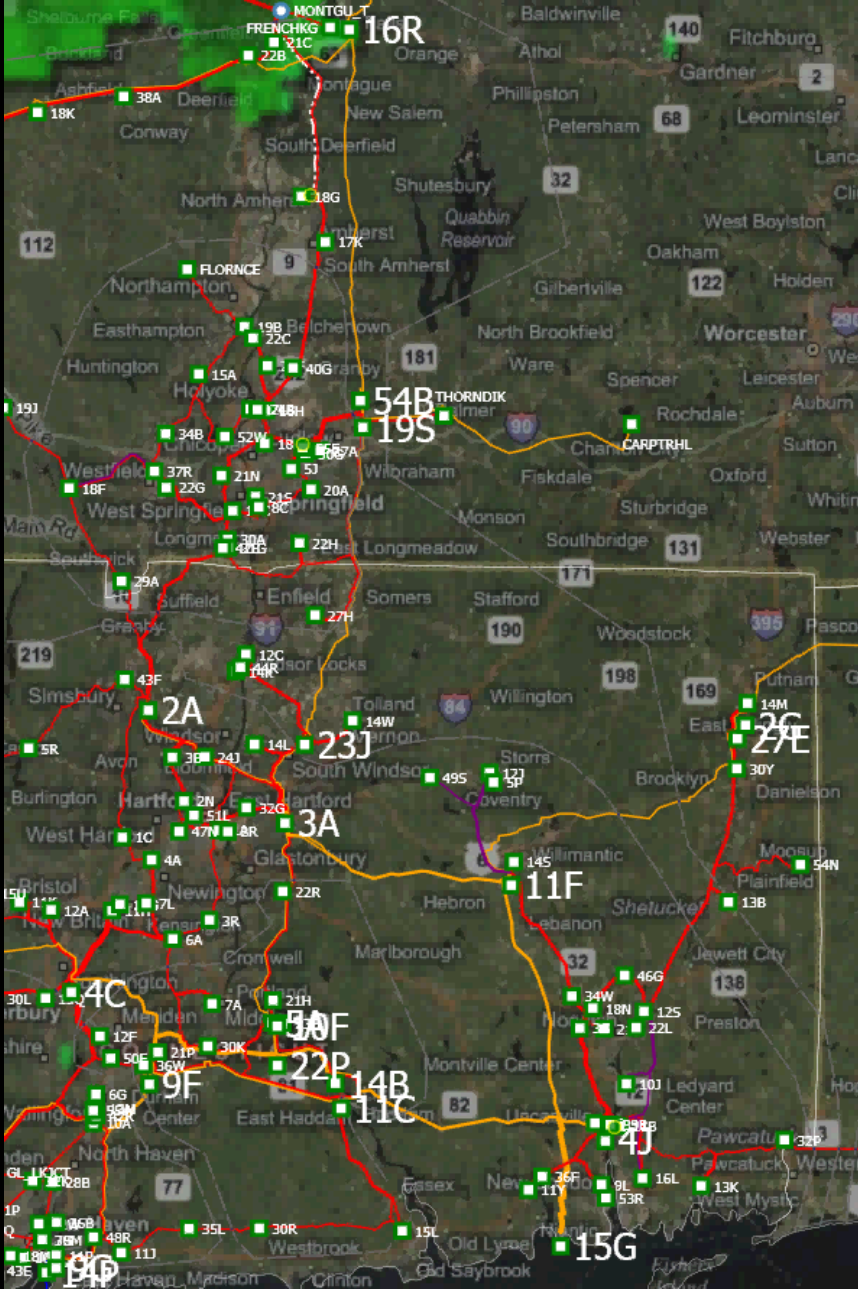


# Alstom's ETerra Vision





# Weather Overlay



**Substations**

Group by

- None
- Division
- KV

Filter:

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**Lines**

- Both ends open (12)
- Closed lines (399)
- One end open (5)

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**Interfaces**

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**Monitored**

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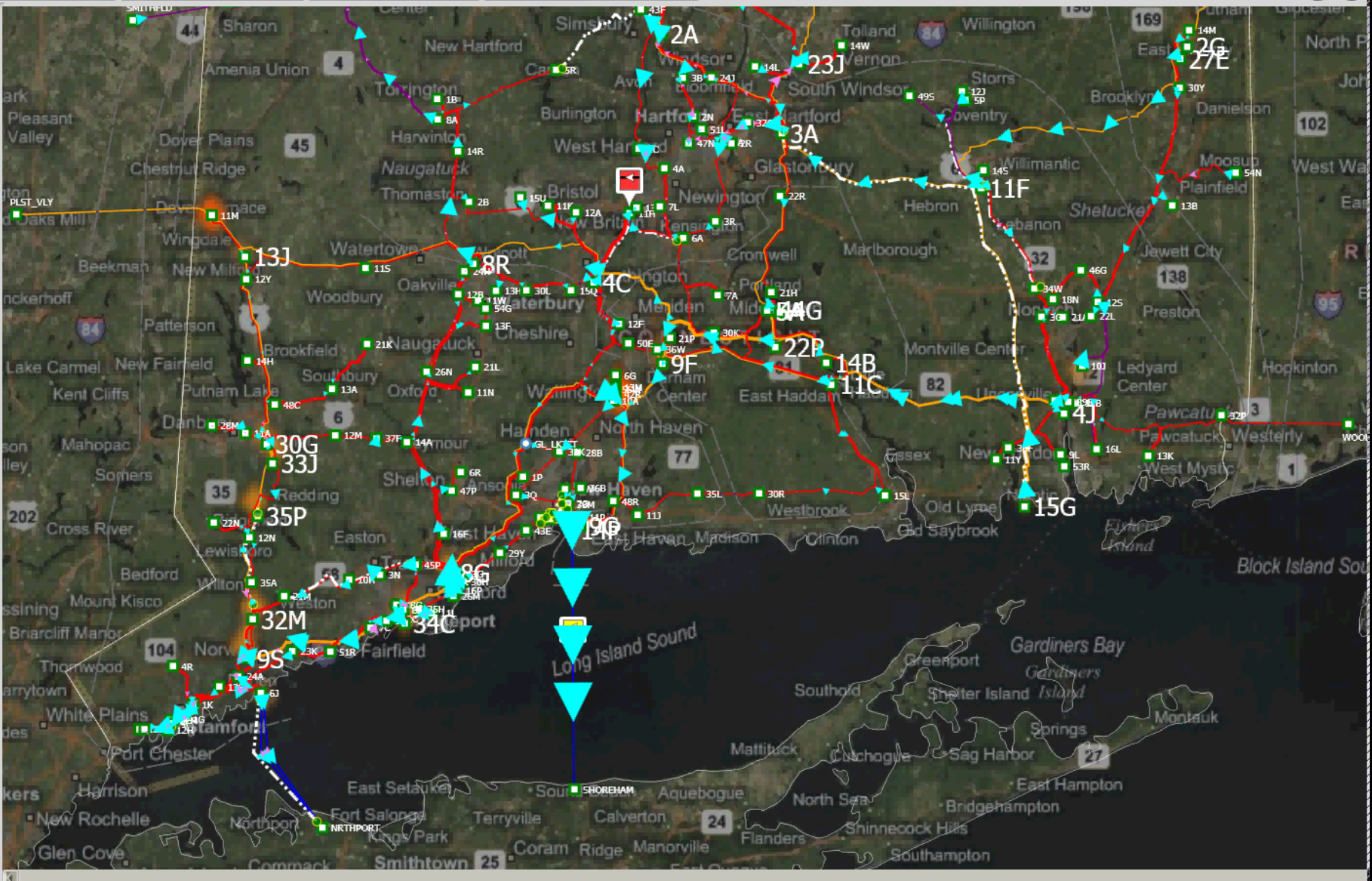
**Areas**

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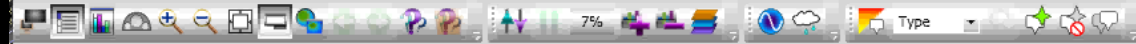
**Displays Directory**

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**Lists**







**Substations**

Group by

- None
- Division
- KV
- Category

Filter:

**Lines**

- 10A
- 10G
- 10H
- 10J
- 10W
- 11A
- 11B
- 11C
- 11F
- 11H
- 11J
- 11K
- 11L
- 11M
- 11N
- 11P
- 11R
- 11S
- 11W
- 11Y
- 12A
- 12B
- 12C
- 12F
- 12H
- 12J
- 12M
- 12N
- 12S

**Interfaces**

**Monitored**

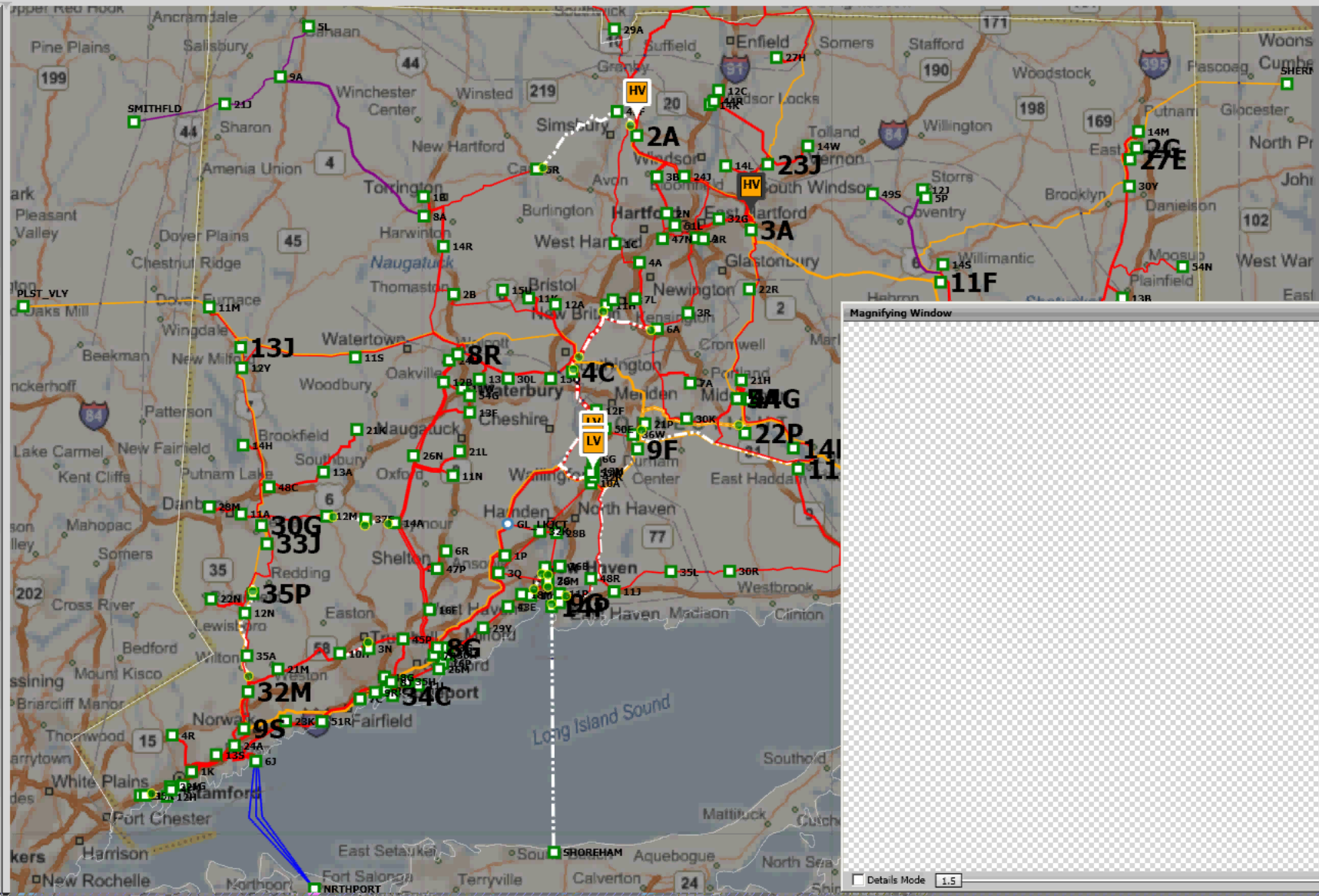
**Contingencies**

**Abnormal Ctg**

**Areas**

**Displays Directory**

Control Panel



Magnifying Window

Details Mode 1.5

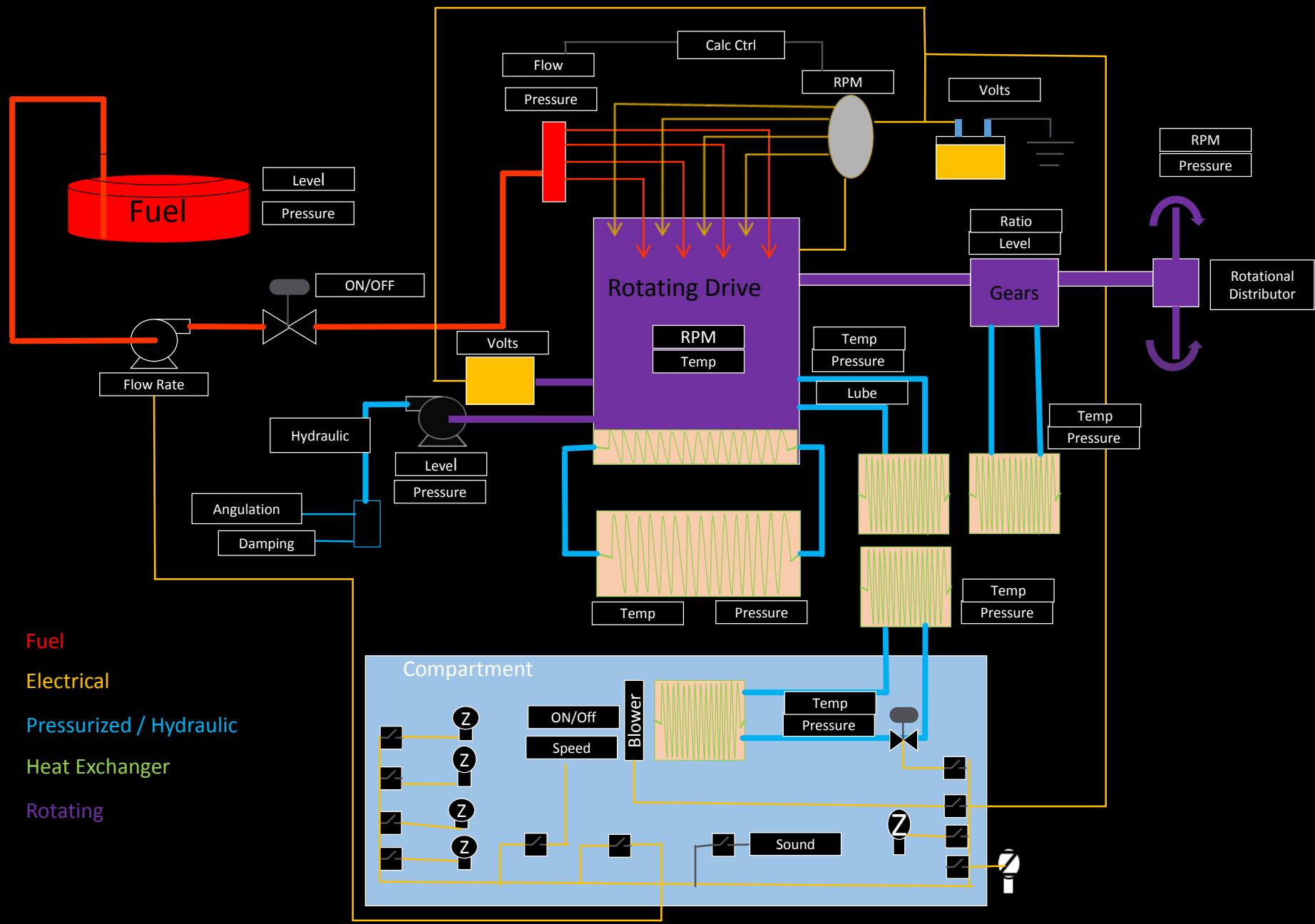


# Level 1 Displays

- What is happening across the whole of the operators EUC?
- How well is the process doing?
- What has happened so far?
- Provide warnings of impending problems or dangers that we may need to take action to avoid?

# A Level 1 Display

- Can you identify the process?









Here is what the operator actually uses.

And ALL he/she actually needs- simplicity.

The gas gauge, the temperature gauge and the oil indicator lamp all provide information that allow the driver to take action before the car stops through lack of fuel or engine seizure.

# Yachts Instrument Panel





# Leading Indicators

- The wind indicator provides information on wind speed and direction, thus adjustments can be made to sail at maximum speed.
- The radar highlights obstructions on route.
- The compass provides information on the course being steered thus enabling the course to be plotted.
- Predicts future actions, They provide information about current situations that may effect future performance.

# Lagging Indicators

- The log provides information on the boat speed and the distance covered.
- (Note it is relative to the past! They measure the outcomes that have resulted in past actions).
- In our boat example, the log provides a measure of how far we have travelled.

# Leading Performance Indicators

- A 'leading performance indicator' is something that provides information that helps the operator respond to changing circumstances and take actions to achieve desired outcomes or avoid unwanted outcomes. This characteristic implies that the indicator should not be used simply as a metric of the current situation.

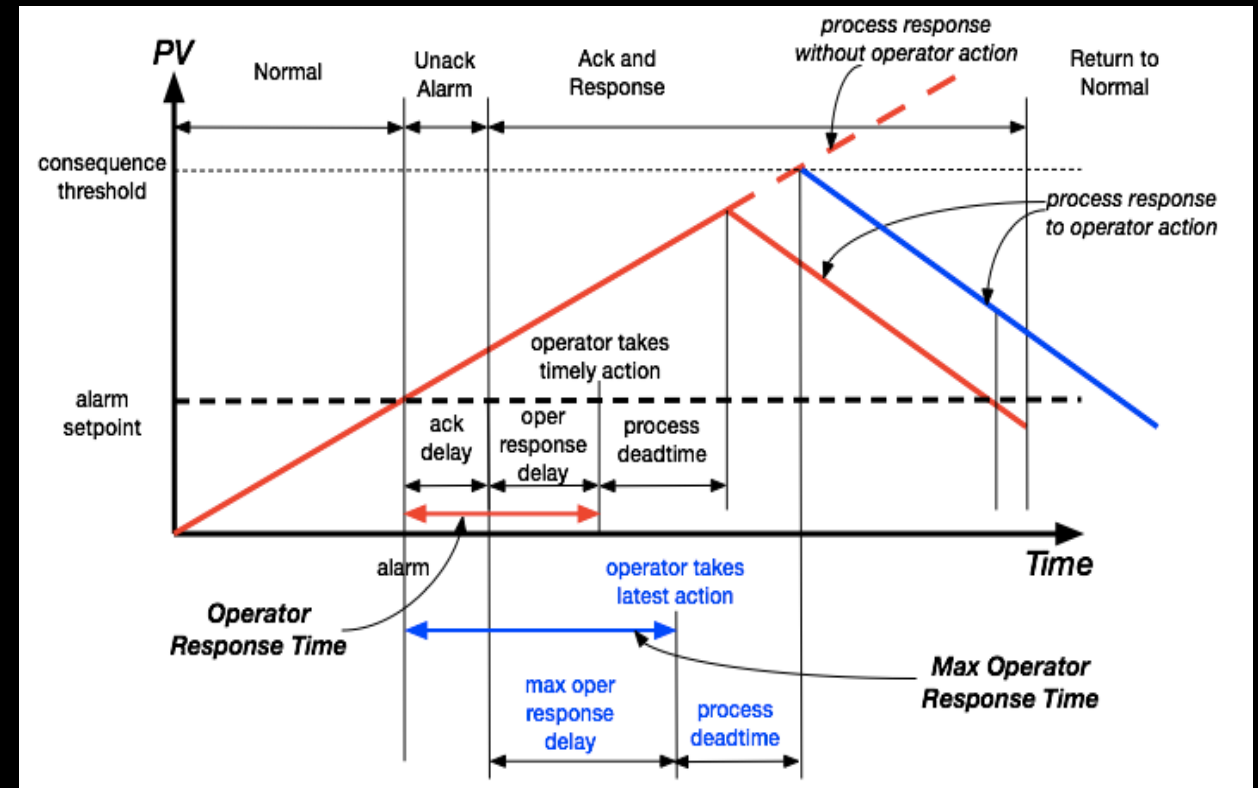
# Leading Performance Indicators

- For leading performance indicators to play an effective role in the improvement process, there must be an association between the inputs they are measuring and the desired lagging outputs.

# Leading Performance Indicators

- There needs to be reasonable belief that the actions taken to improve the leading performance indicator will be followed by an improvement in the associated lagging output indicators.

- One of the least understood elements of alarm management is the time to respond to the alarm, what is included in that and what do the numbers mean.



# Time is not on our side!

- We need to prioritize.
- We need to predict.
- We need sufficient time to respond.
- We need to identify 'leading and lagging performance indicators.
- They need to be sufficiently demanding
- They need to link actions with results.