Implementing a 4K Glass Panel Simulator (GPS)

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Salem Unit 1 (Westinghouse 4 Loop PWR, 1220 MW)
Salem Unit 2 (Westinghouse 4 Loop PWR, 1220 MW)
Hope Creek (GE BWR-4, 1270 MW)
Background

Glass Panels History at PSEG

- Hope Creek procured a GPS circa 2012
- At that time Salem Instructors expressed little interest in getting a GPS
- I was content to wait and see as new technology became available
- In 2017 Salem was “directed” by the Site VP to get a GPS using end of year capital
- Choice of Vendor limited to that used for Hope Creek GPS
- Salem GPS delivered on site Aug 2018, in process on getting staged in a new room

What we hope to use the Glass Panel for

- At minimum use for offline Testing and Scenario/Exam Development
- Upper Management push for ILOT Training
- Possible installation of a second GPS in the Plant (outside control room)
- Future addition of in-plant panel displays (for NEO training)
- Hope some of the enthusiasm and success Hope Creek has had with Glass Panels will spill over to Salem
Common GPS concerns (resistance to use)

- Where to put it?
- "Soda Straw" view of panels, hard to get the big picture. Too much Navigation.
- Large Capital Investment locks you into the Technology of the moment.
- Switch operation by Touch is non-intuitive. Mis-placed touches.
- Small panel detail may be fuzzy or hard to read, size might need to be exaggerated
- Insufficient Testing, Latent errors.
- Panel drawings targeted for GPS may not be ideal for Instructor Station/Desktop
- Nobody uses it……

“We can rebuild it, we have the technology…”
GPS Concerns

Glass Panel Modifications

- Regardless of vendor all GPS’s perform the same basic functions.
- GPS’s are somewhat standard products, features and basic operation are already set.
- Based on evaluation of the Hope Creek GSP some modifications were desired.
- Numerous modifications to tailor to Client requests can delay delivery and increase cost.
- So as to not impact delivery Salem planned to make some modifications in-house after market

Modifications desired for Salem

- Streamlined one-button Startup and Shutdown with error check (after market).
- Selection feed-back on Top Level Navigation Map (after market).
- Increased Glass Panel Screen Count (at delivery)
- Use of 4K Screens (at delivery)
Why 4K? Take advantage of the latest Technology

**RESOLUTION REVOLUTION**

- 720p (HD) 1280 x 720
- WXGA+ 1440 x 900
- 1080p (Full HD) 1920 x 1080
- 1440p (QHD) 2560 x 1440
- QHD+ 3200 x 1800
- 4K (UHD, 2010p) 3840 x 2160
- DCI 4K 4096 x 2160
- 5K (UHD+) 5120 x 2880
- 8K (UHD) 7680 x 4320
Why 4K? Visual Fidelity

Why 4K?

- For production Simulator possible 4K use limited to the Instructor Station (IS) where it is not practical for fixed form size fixed font size IS applications (too small to read), unless IS applications automatically scale the forms and fonts to a readable sized based on current Screen resolution (Salem Custom Instructor Station does)
- For Glass Panels goal is depiction of (close to) full size REALITY (Fool the eye…)
- What is the Resolution of the Human Eye? 525 Megapixels!
- “RETINA” display. Resolution where the Human Eye can not detect individual pixels (results in ability to see fine readable detail)
- Screen Size, Screen Resolution and Viewing distance all come into play. At a sufficient Viewing distance ANY Screen Resolution is RETINA

![Diagram showing Viewing Distance where Resolution Becomes Noticeable vs. Screen Size](chart.png)
Why 4K? Glass Panel interaction is up close

At what Viewing distance is a 46 inch 1080P Monitor considered RETINA?

> 72 Inches

How close is a Panel Operated From?

30 Inches

At what Viewing distance is a 46 inch 4K Monitor considered RETINA?

> 36 Inches

84 in 4K Monitor is RETINA at > 66 inches
Why 4K? Lower Resolution may require some size fudging

For Hope Creek panels (created at the lower resolution) certain liberties had to be taken to allow for readable fonts on 1080P and lower resolution screens:

- Control size made relatively larger than real life to allow for bigger fonts
- Thus Relative spacing of the controls has to be reduced

Actual panel bezel station have metal pull tab at bottom and there is space between rows.

In Glass Panel drawings the tabs are omitted and rows stacked to fit on 1080P Screen and still be visible.
GPS 4K not for everybody

- 1080P displays may be good enough
- For “typical” simulator Panel with large controls and labels 4K provides little benefit
- For Salem Panel Pushbutton inscription are very small and to be readable WITHOUT exaggerated size

4K MUST be used

Why 4K? Maybe Not…………

Salem simulator panels WOULD BENEFIT
in the readability of the small RZ Bezel
buttons text without the need to exaggerate
size
Why 4K: It’s all about the Fonts....

4K Render of Small Font

1080P Render Same Drawing
Deciding Scope: How Many Display Panels?

Option 1: Complete Control Room (All Panels) ----
- **PRO:** Can see everything at once
- **PRO:** Handle large Crew
- **PRO:** Navigate by walking to panel where it is located
- **CON:** Cost $$$$
- **CON:** Extensive Facility Staging

Option 2: 6 Screen (2 x 3) similar to Hope Creek--
- **PRO:** Lower Cost, can be portable
- **PRO:** Standard Design
- **CON:** Limited View, does not fill field of vision
- **CON:** Slice Navigation can be confusing

Option 3: Something in between Option 1 and 2
Salem Compact Control Room allows dense displays

**Salem Benchboard and Back Panels**
- Compact Control Room concept. Densely packed push-buttons (Bailey RZ)
- Most controls on inner Horseshoe bench, back panels mostly for status
- Want at least one complete bench wing and ALL Overhead Alarms viewable at one time
Option 3 (4 x 3) Compromise

GPS Scope Chosen
- 4 x 3 (two panels side by side) chosen for Bench board (plus 84 inch Vertical Screen for Back Panel Slices)
- Allows ALL Overhead Annunciators to be displayed at one time
- Allows display of an entire wing of the inner horseshoe at one time
- 1080P: 7680 X 4320 (33 million pixels) cumulative resolution
- 4K: 15360 X 8640 (132 million pixels) cumulative resolution
Hardware: 4K Screens more expensive and hard to find

Monitor Search

- Wanted a 46 inch 4K Monitor with Touch
- Wanted integrated (not Overlay) Capacitive (not Infrared) Touch
- No Monitors with the above specs could be found
- Deeper dive came up with IDEUM 49 inch Touch Screen
- Built like a brick house, designed for kids at museum wailing on them all day
- (found a cheaper alternative after the fact)

Presenter

Interactive multitouch walls with superior 3M touch technology. Available with LG Commercial 43”, 49”, 55”, or 65” 4K Ultra High Definition (UHD) displays with all-aluminum casework.
Hardware: Cabinet Design

Existing Design Glass Panel Enclosure
- Full Metal Jacket (looks more like a Control board Panel)
- Sized to fit Original Monitor, replacements may not be available
- High Fabrication cost
- Would not work for Salem 49 inch Monitors, redesign needed

New Design
- Open Design (looks a little less like a Control Panel)
- More Flexible, can handle different size monitors
- No Welds, bolts together (can be sold as kit)
- Lower Overall Cost
Hardware: Display Computers

Cabinet Design and Computers

- Small form factor INTEL NUC PC’s used to drive displays (LOW HEAT OUTPUT)
- Originally I5 processors were intended however needed I7 for speed
- Preferred Windows 7 but latest chipset did not support so used Windows 10
- Rear mounted computer not accessible if GPS placed against a wall.

Eight (8) Display Computers to Drive Bench board
One Display Computers to Drive Vertical Back Panel
One MST/Navigation Computer
Now we have it Where to Put it?

Temporary home in Hallway Outside the Simulator

Permanent home still under Construction
Challenges

- 4K use newness caused graphics file generation to take longer than usual to get started
- Graphics generation went well once started
- Panel enclosure re-design took some time
- Needed new DLL interface for Thunderview <-> OpenSim data transfer
- Initial panel response was way too slow. Auto/Manual swap lamp update was taking 3 to 8 seconds.
- Realized that drawings designed for 4K look good at 4K but not so good at lower resolutions such as 1080P
Response Time fix

- Hope Creek response time was also an issue. Quick fix was to split out some items into sub-drawings. For Salem hoped to have a more global fix.
- Vendor fix was to optimize the display program and redo the drawings to reduce object count.
- Busiest drawing had over 7000 objects. Combining multi-line text such as Bezel engravings and Meter Scales into single object reduced that count almost in half.
- After fix response time is good (almost instantaneous)
After Market Modification: One Button Startup

As Delivered Startup steps from powered down
- Step 1: One button Click to Start MST Load
- Step 2: Use Wake-On-Lan Utility to Power and Boot Display Computers
- Step 3: Wait and visually Confirm that all Displays have booted and started Nav Server Task
- Step 4: One button click to load INITIAL Panel Display
- Step 5: Good to go for IC Reset and Run and Navigation

Desired a Simplified One Button Startup (and Shut down)
- Hope Creek had combined steps into one Batch File launched from the Desktop
- For Salem Added Glass Panel Boot and Load to existing One button MST Start
- (next slide)
After Market Modification: One Button Startup

Displays Loaded with default Panels

POWER UP ALL Glass Panel Display PC’s

UNLOAD ALL Glass Panel Displays

POWER DOWN Glass Panel Display PC’s

Click to Power Down GPS Display PC’s

Click to Shutdown MST and Unload GPS Displays
Why 4K? Navigation

Navigation at Glass Panel level vs Instructor Station Level

- ThunderView cookie cutter design works well when a lot of screens are available.
- For Single Screens such as Instructor Station and Desktops, the Navigation from Panel to Map to Panel is cumbersome and panels displayed on a smaller screen may have readability issues.
- Salem had in-house developed drawings that used approach of each “drawing” represented an entire panel section that could be viewed at that zoomed out level or zoomed closer and panned.
- Instructor Station graphics uses bitmap photos so quality suffers at zoom extremes since bitmaps do not scale well, giving muddy appearance. ThunderView drawings are much cleaner.
- Still going to maintain the Instructor Station Graphics since they are better suited to control plant on a single screen since navigation is less cumbersome.
- Instructor Station will allow either Panel Graphics to be used at the users discretion.
Instructor Station Options (GPS Panels or existing IS Panels)

Can choose between running ThunderView or Custom Panel (PSPanels) Graphics
IS Graphics Floating Panel mini-map to Speed up Navigation

Entire panel is dynamic (can operate plant) at this level but bezel text will be barely visible even at 4K. Clicking on any Bezel Section White Top Label lamicoid will zoom to a readable view.
IS Graphics Panning and Zooming Tool

Swipe on Background pans view, single Click anywhere on background brings up Panning Tool

Floating Panning Tool
Conclusion

- 4K display improvement in image sharpness is subtle, not starting
- May not be worth the extra cost if Simulator Panels do not contain small fonts and details
- For small fonts and details 4K may be needed for readability unless size is exaggerated or zoomed
- Large Monitors (84 inch) should be 4K (1080P has too much pixel spread at that size)

- QUESTIONS?