



# **HSI Technology Evolution and Effects on Operators**

**August 26, 2008**



**MITSUBISHI HEAVY INDUSTRIES, LTD.**



# Overview

- HSI technology evolution in new control rooms will change some operator tasks
- This presentation highlights a few key areas for the US-APWR



# Information & Controls Accessibility



➤ All information and controls are easily accessible to each operator

- ✓ Video Display Units with hundreds of display pages
  - Menu selectable
- ✓ Multi-division VDUs
  - Control all safety divisions and non-safety from same VDU

➤ Very different than the geographic distribution of instrumentation and controls on conventional panels

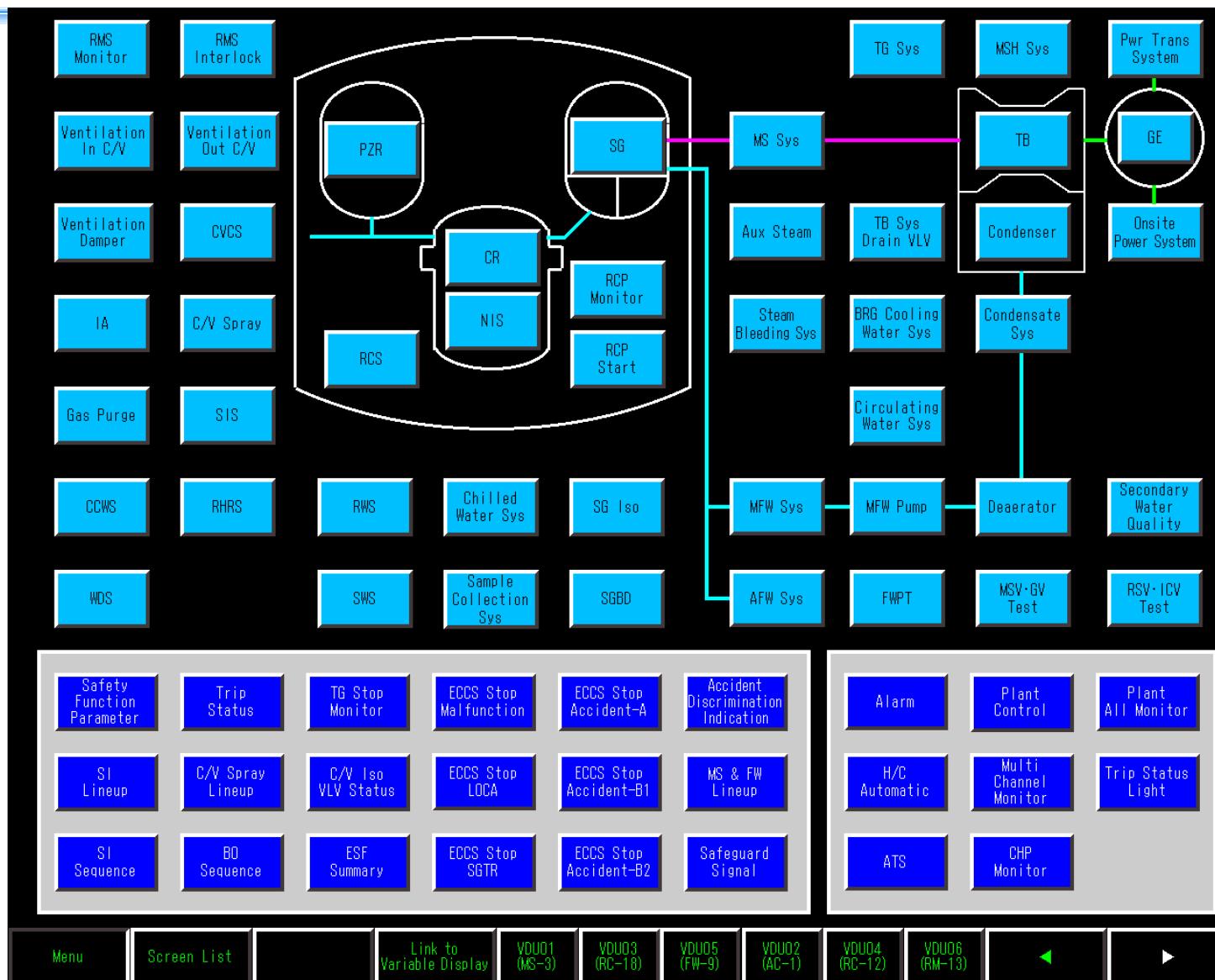
- ✓ One RO can monitor and control all plant functions
- ✓ With two ROs, the division of responsibility between ROs can be function based rather than system based
  - For example, one RO can be responsible for all systems (safety and non-safety) for controlling the same function (eg. RCS inventory).



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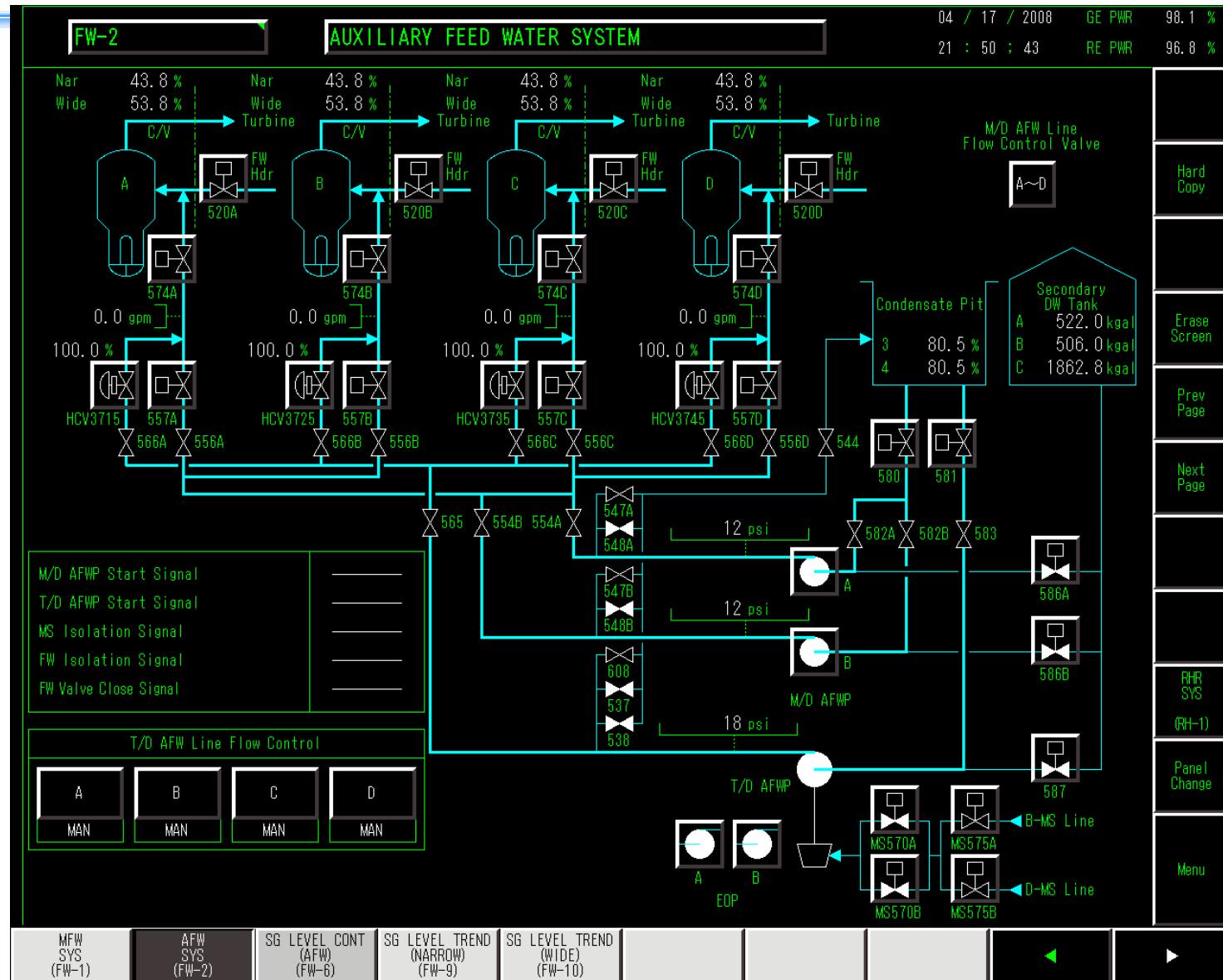
# Operational VDU – Screen Menu



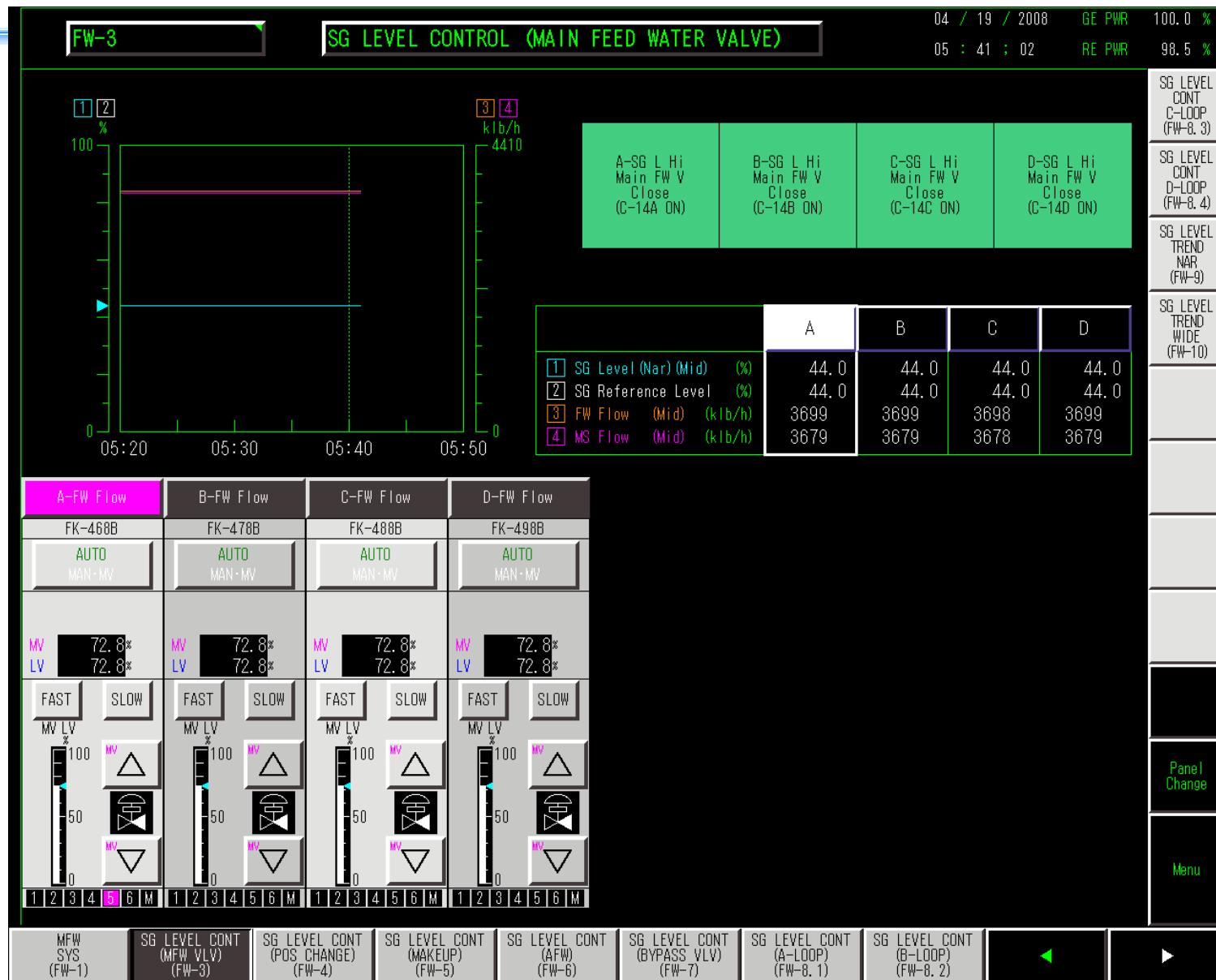
System display request area

Emer display request area

# Operational VDU - Monitoring



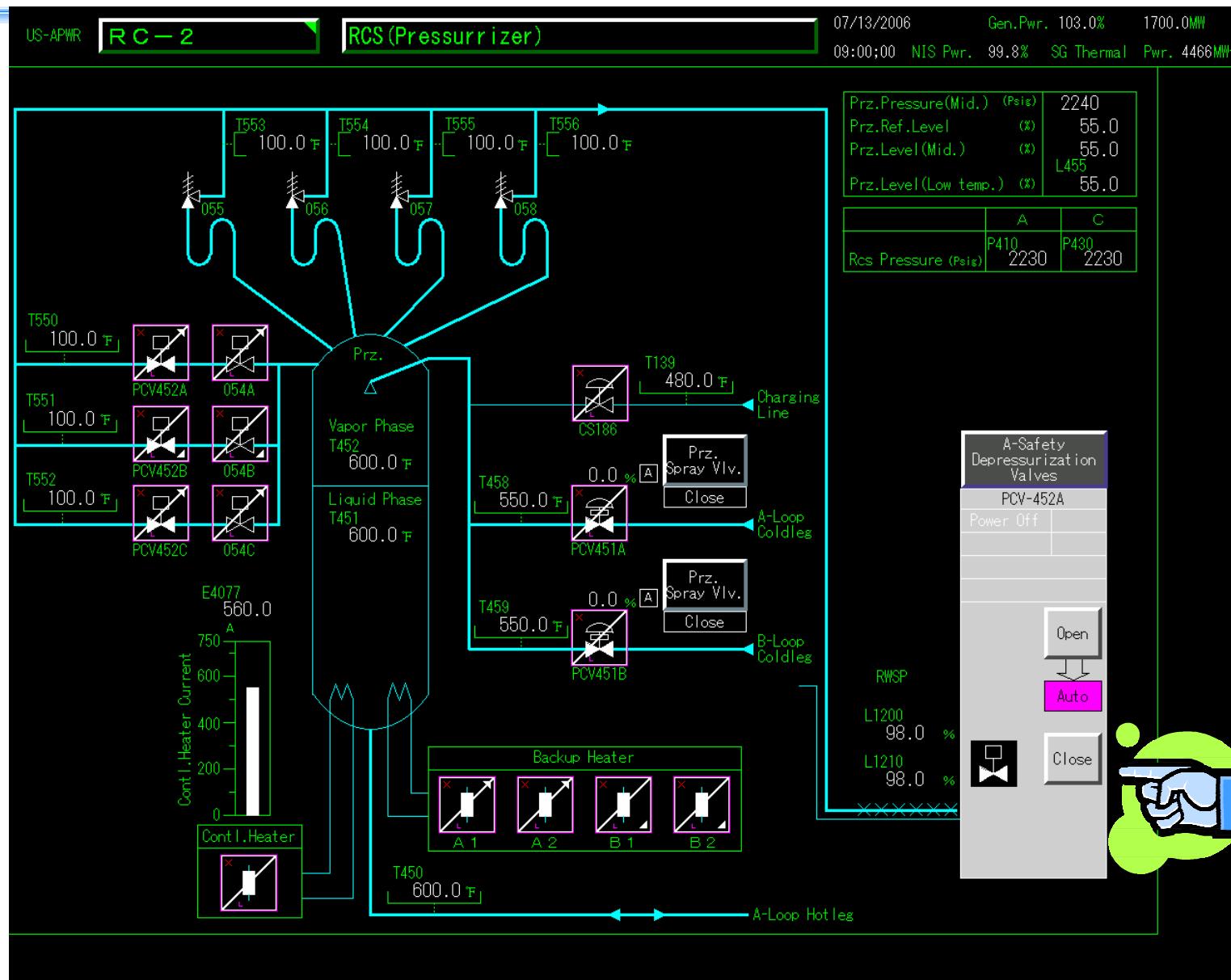
# Operational VDU - Control



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# Operational VDU - Multi-Division



# Automated Cross Channel Checks



- **Computers continuously perform cross channel checks**
  - ✓ Operators don't need to do this anymore
- **Monitoring and control displays show one parameter, not four**
  - ✓ Four are available on diagnostic level displays
- **Control systems use all channels**
  - ✓ No effect from single channel failures
- **Operators respond to channel deviation alarms**
  - ✓ Check system level effect (usually none, Partial Trip)
  - ✓ Confirm deviation
  - ✓ Check Tech Spec LCOs
  - ✓ Longer term action
    - Maintenance work order



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# Automated Actuation Checks



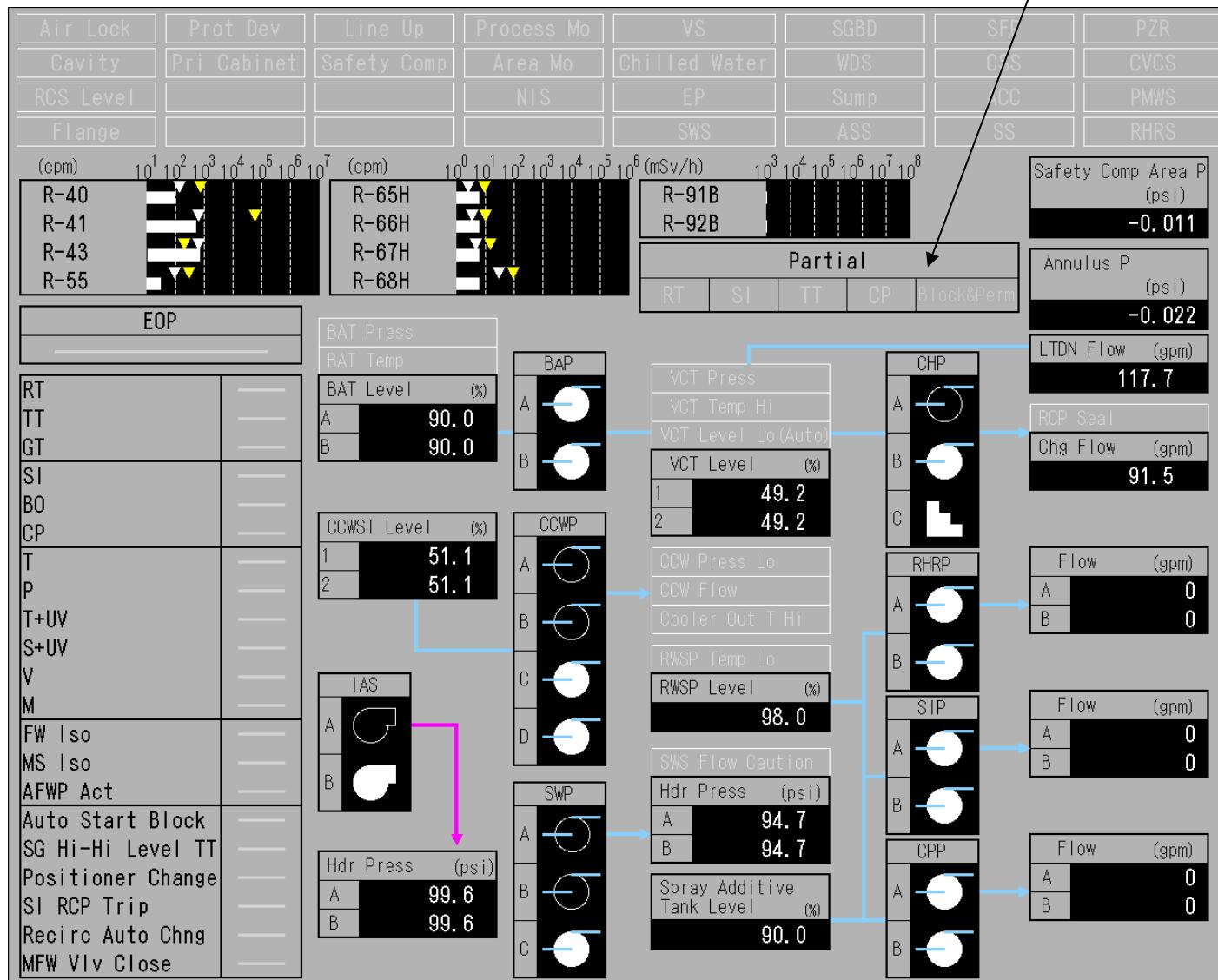
- Computers check correct actuation of all ESF system components
  - Pump start, valve line-up
  - ✓ Operators don't need to do this anymore
- Operators respond to “Not OK” alarms
  - ✓ Confirm alternate train is “OK”, including performance
  - ✓ Longer term action
    - Confirm “Not OK” status
    - Restore to “OK” status
    - Maintenance work order





# Large Display Panel

Partial Trip Monitor



# Automated BISI



Bypassed or Inoperable Status Indication

- **Computers monitor components for inoperable or misalignment conditions**
  - ✓ While in standby mode
- **Computers determine and display effects at train level**
  - ✓ Operators don't need to do this anymore
- **Operators respond to “Not Ok” alarms**
  - ✓ Confirm “Not Ok”
  - ✓ Check Tech Spec LCOs
  - ✓ Longer term action
    - Restore to “OK” status
    - Maintenance order



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# Alarm Management



- Alarm avalanche conditions are common in current alarm systems
  - ✓ EOPs and training do not credit the alarm system
- Alarm avalanche conditions are significantly reduced by
  - ✓ Signal validation
    - based on automated cross channel checks
    - One process alarm, not one for each division
  - ✓ Cause-consequence dependency logic
    - Plant mode
    - Equipment mode
  - ✓ Prioritization logic
    - Highlights degrading conditions
- Allows the alarm system to be credited

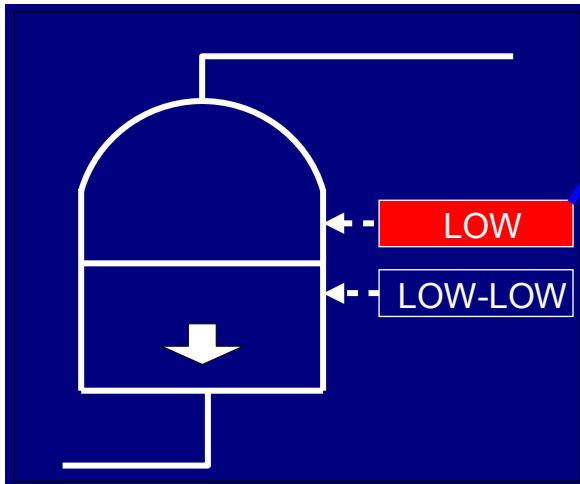


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# Dynamic Alarm Priority Rules (1/3)

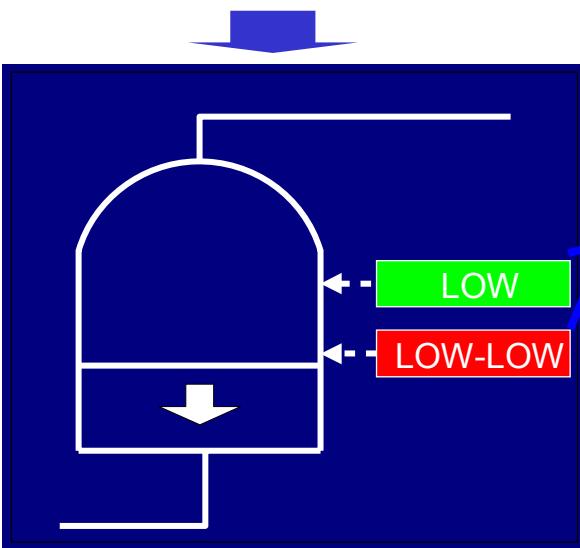


## **Higher prioritization rule**



The screenshot shows the Cisco Prime Network Monitor interface. At the top, there are four tabs: Primary (1) VM, Primary (2) VM, Secondary VM, and Hosted VM. The Primary (1) VM tab is selected. Below the tabs is a network topology diagram with several nodes and connections. At the bottom of the screen, there are several control buttons: Related, Refresh, Allure Group, Page Select, and Allure Control. A hand icon is pointing towards the Allure Group button.

Low alarm is displayed as Priority 1 (alarm information) until the tank level reduces to the Low-Low alarm setpoint.



The screenshot shows a software interface for monitoring powerplants. The main area is a large grid where each row represents a powerplant and each column represents a status indicator. The columns include:

- Related
- Operate
- F0
- Status**
- Alarming
- 1
- alarm
- 15
- 1/1
- 2/2
- 3/3
- 4/4
- 5/5
- 6/6
- 7/7
- 8/8
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Below the grid, there are several buttons and labels:

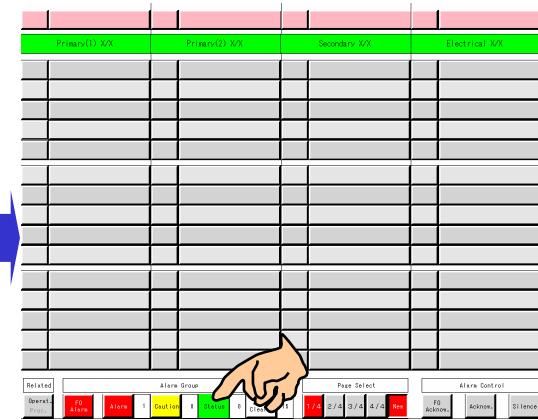
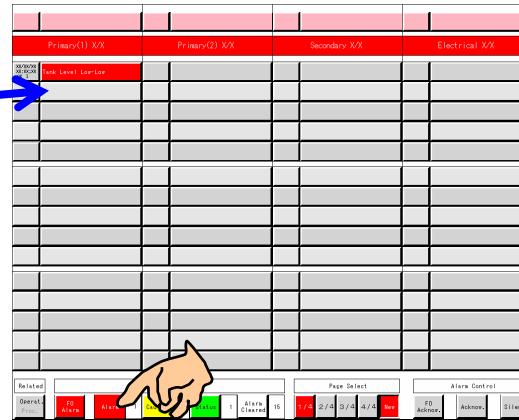
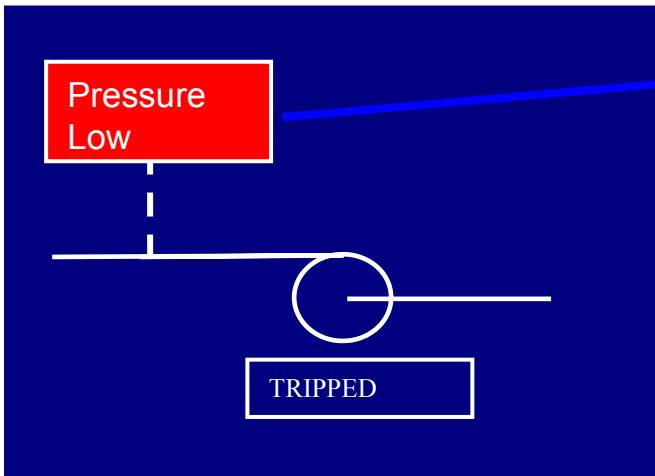
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When the level reaches the Low-Low alarm setpoint, the Low-Low alarm is displayed as Priority 1 and the Low alarm is changed to Priority 3 (status information).

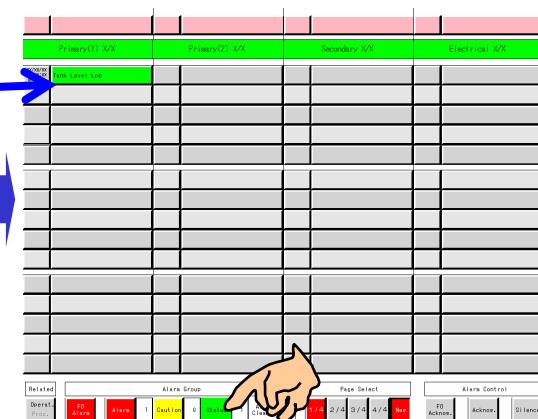
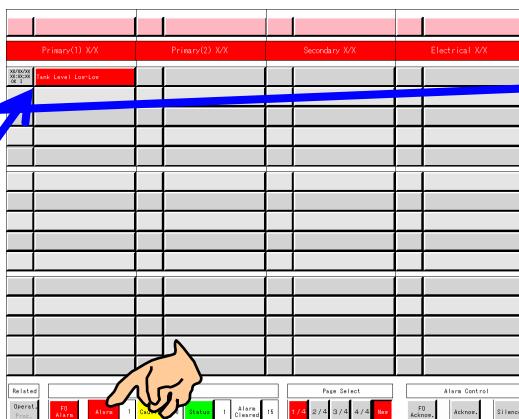
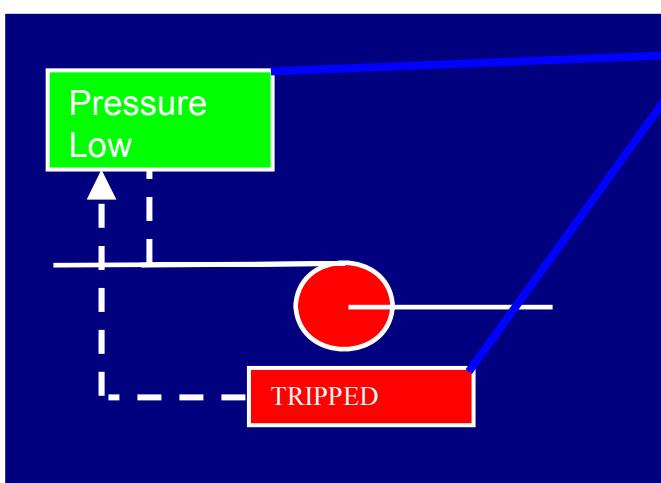
# Dynamic Alarm Priority Rules (2/3)



## Cause-consequence equipment rule



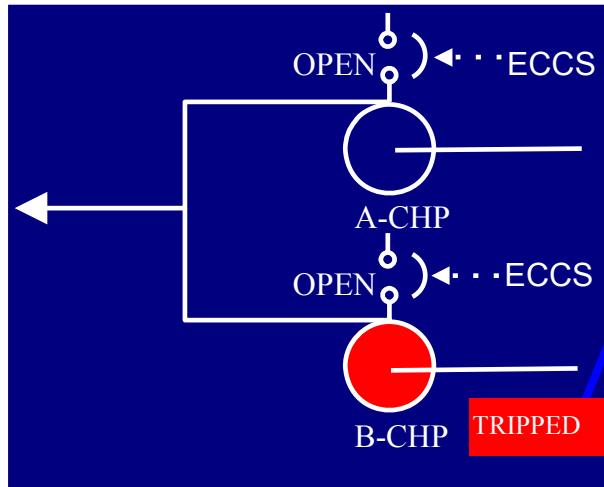
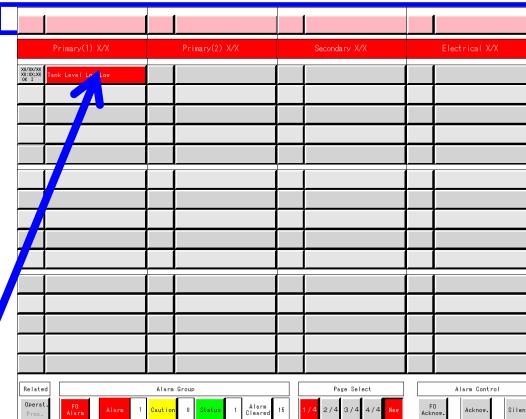
A low discharge pressure alarm is displayed at priority 1 if there is no cause for the alarm.



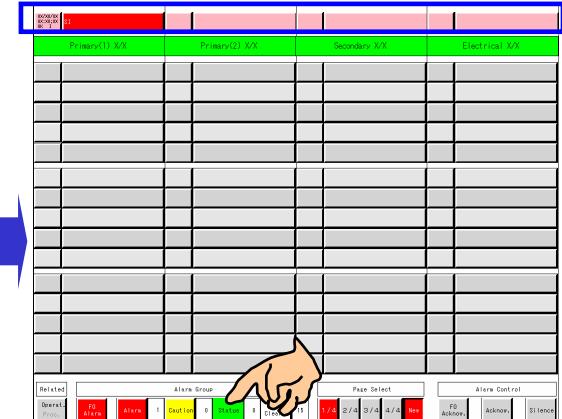
However, the low pressure alarm (“result” alarm) is regarded as Priority 3 when the pump is stopped by the interlock alarm (“cause” alarm) which is displayed as Priority 1.

# Dynamic Alarm Priority Rules (3/3)

## Cause-consequence mode rule

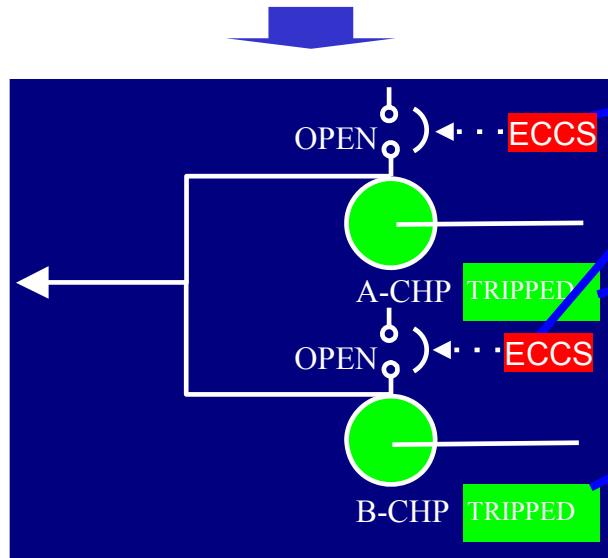
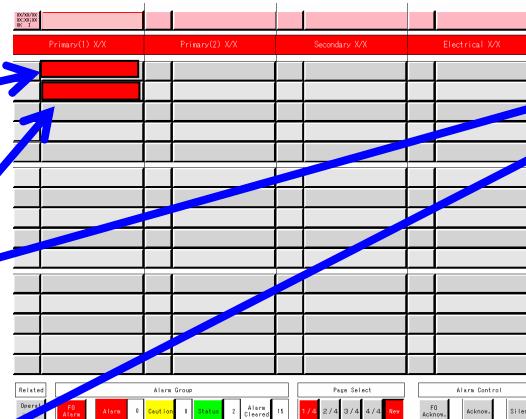



Alarm monitoring interface showing a primary alarm at priority 1. The alarm is labeled "No cause" and "Level 1". The interface includes tabs for Primary(1) X/X, Primary(2) X/X, Secondary X/X, and Electrical X/X. A blue arrow points from the schematic to this screen.



Alarm monitoring interface showing a primary alarm at priority 1. The alarm is labeled "No cause" and "Level 1". The interface includes tabs for Primary(1) X/X, Primary(2) X/X, Secondary X/X, and Electrical X/X. A hand icon points to the alarm row.

A charging pump trip is displayed at priority 1 if there is no cause for the alarm.

Alarm monitoring interface showing a primary alarm at priority 3. The alarm is labeled "No cause" and "Level 3". The interface includes tabs for Primary(1) X/X, Primary(2) X/X, Secondary X/X, and Electrical X/X. A blue arrow points from the schematic to this screen.



Alarm monitoring interface showing a primary alarm at priority 3. The alarm is labeled "No cause" and "Level 3". The interface includes tabs for Primary(1) X/X, Primary(2) X/X, Secondary X/X, and Electrical X/X. A blue arrow points from the schematic to this screen.

Charging pump trip alarms are regarded as Priority 3 (status information) when an ECCS signal is actuated.





# Degraded HSI Conditions

## ➤ Current control rooms

- ✓ HSI is an integral part of the plant systems and components (eg. pumps, valves, instruments)
- ✓ Operators train to cope with plant component failures, not HSI failures

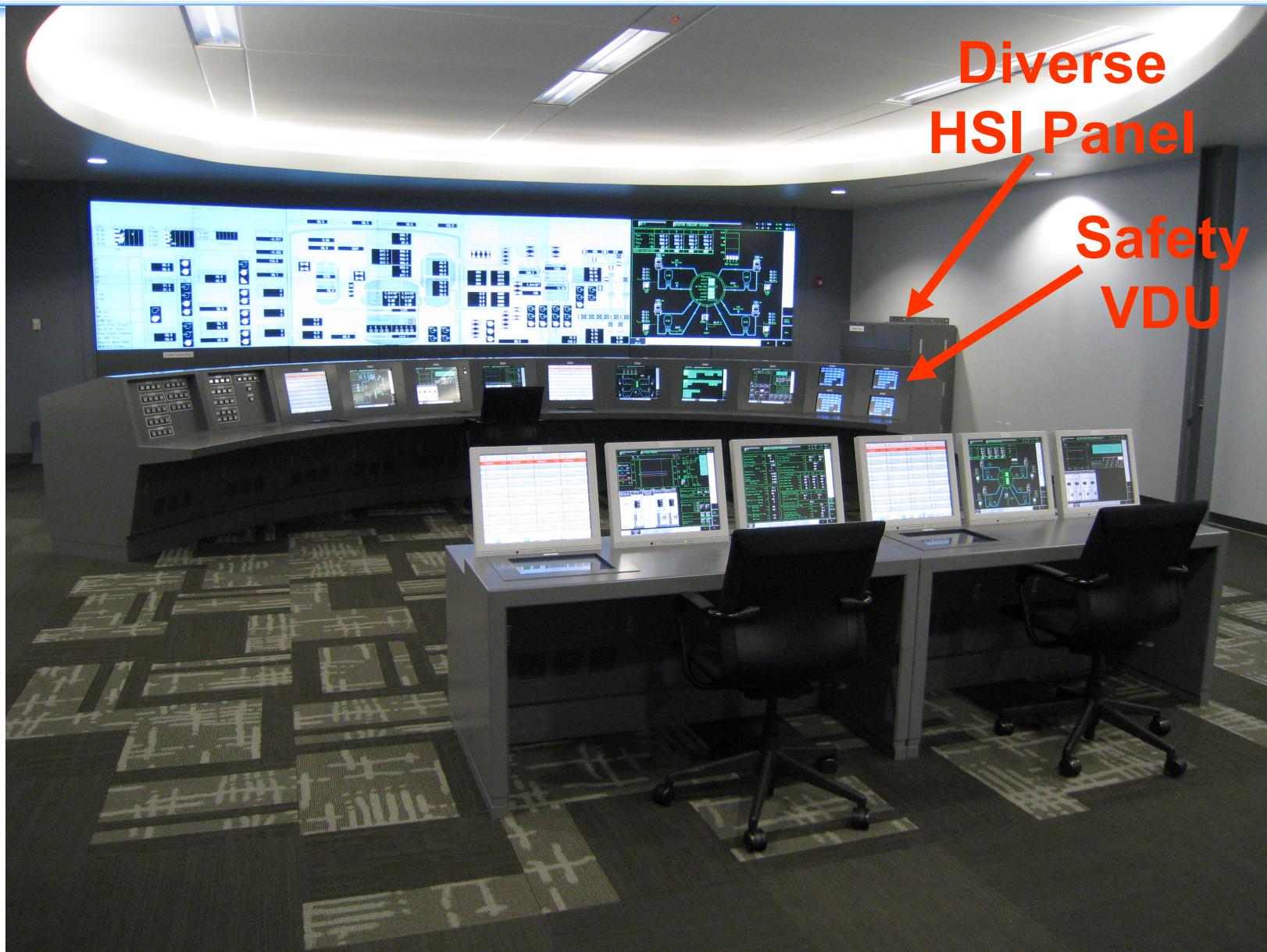
## ➤ New control room

- ✓ HSI redundancy to minimize the potential for failures
- ✓ If an unusual failure occurs, the effect can be much more global (eg. complete VDU freeze)
  - In addition to training operators for plant component/system failures, we must also train them for HSI failures
  - This is further complicated by NRC criteria for consideration of common cause failure
    - Adds even more training for beyond design basis events
- ✓ Degraded HSI may be the most significant operator training challenge





# Degraded HSI Conditions



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# Summary

- HSI technology evolution in new control rooms will reduce routine operator task burden
- Digital technology has proven highly reliable
- Regardless, operators must be well trained for degraded HSI conditions

