Human System Interface Description and Human Factors Engineering Process

Non-Proprietary Version

July 14-15, 2009

Mitsubishi Meeting Attendants

- Mitsubishi Heavy Industries (MHI)
  - ✓ Kenji Mashio (HFE Design Team manager)
  - ✓ Koji Ito (HFE V&V Team manager)
  - ✓ Emilie Ross (HFE V&V Team support)
  - ✓ James Easter (HFE V&V Team support)
  - ✓ Chris Paulsen (HFE V&V Team support)
- Mitsubishi Nuclear Energy System (MNES)
  - ✓ Satoshi Hanada (HFE Licensing representative)
  - ✓ Ken Scarola (I&C/HSI Design technical adviser)
  - ✓ Leonard Kabana (HFE V&V Team support)
- Mitsubishi Electric Corporation (MELCO)
  - ✓ Koichi Takahashi (Responsible for HSI Implementation Design)
- Mitsubishi Electric Power Products, Inc (MEPPI)
  - ✓ Gil Remley (HSI Facility manager)
  - ✓ Jim Dolfi (HSI Facility support, HED database manager)

Meeting Objective

- Clarify the scope of the Basic HSI System and the activities conducted to demonstrate its strong foundation for US nuclear plant HSI applications.
- Clarify the complete HFE design process for applying the Basic HSI System to plant specific applications.
- Establish a clear path forward for resolution of HSI/HFE Topical Report and US-APWR DCD Chapter 18 RAIs.

Meeting Topics

- US-APWR HFE Program Overview
- Phase 1a and 1b V&V program
- Basic HSI System
- US-APWR HFE Program Elements
- HSI Topical Report and DCD RAI Responses

US-APWR HFE Program Overview

HSI System Reference Design

- US-APWR HSI System is being developed from MHI's Japanese Standard HSI System
  - ✓ Development process included all NUREG 0711 elements
    - Including validation by approximately 200 Japanese nuclear power plant operators using a full scale MCR simulator
  - ✓ Will be operational in several Japanese nuclear power plants
    - NTC-4 (Japanese PWR training center - 2008)
    - Ikata Unit 1&2 (MCR & I&C replacement – 7/2009
    - Tomari Unit 3 (New Plant – CO 12/2009)
    - Likely to be in operational in 7 more Japanese plants prior to the first US-APWR
      - The Operating Experience Review program element for each application of MHI's HSI System considers prior plant experience

US-APWR HFE Program

Summary

Phase 3 → 9/2012 → **Site Specific HSI System**

Phase 2 → 6/2012 → **US-APWR HSI System**

Phase 1 → 6/2009 → **US Basic HSI System***

*for US-APWR and US plant modernization

Japanese Basic HSI System

What is an HSI System?

Basic HSI System

Design basis, processing methods, style guide for HSI **features**:

- Large Display Panel
- Alarms
- Displays
- Soft controls
- Conventional controls
- Procedures
- Navigation
- Tag-out
- Backup HSI - Safety & Diverse

HSI System

e.g.:
Japanese Plant X HSI System
US Operating Plant X HSI System
US-APWR Plant X HSI System

HSI Inventory

Plant specific alarms, displays, controls, procedures:

- For all plant systems and tasks, and for all HSI media
  - e.g. specific instruments, components and alarms shown on the LDP
- Generated during plant specific HFE program

US-APWR HFE Program

- Phase 1 - US Basic HSI System development
  - ✓ Objective
    - Confirm the reference is suitable for US operating methods
      - – Or adjust design as necessary
    - Compensate for lack of formal documentation in the Japanese HFE development program
  - ✓ Process
    - US Operating Experience Review
    - Static Verification by US HFE experts
    - Dynamic Validation by US HFE experts, using
      - – US operators
      - – Full scale simulator (with conventional PWR plant model)
  - ✓ Completion 6/2009
    - The HSI/HFE topical report will be updated to reflect this Basic HSI System

US-APWR HFE Program

- Phase 2 – US-APWR HSI System development
  - – Based on site specific assumptions
- ✓ Phase 2a – US-APWR HFE Analysis
  - Functional Requirements Analysis and Function Allocation, Human Reliability Analysis, Task Analysis
  - Completion 6/2009 (current ITAACs will be deleted)
- ✓ Phase 2b – US-APWR HSI System Design
  - Design the HSI inventory for the US-APWR
    - – Specific alarms, displays, controls, operating procedures, training
      - » Based on detailed task analysis
  - Plant-wide staffing analysis for safety significant tasks
  - V&V by US HFE experts
    - – Using US operators and US-APWR full scope simulator
    - – Includes operating procedures
  - Completion 6/2012 (Generic ITAAC)

US-APWR HFE Program

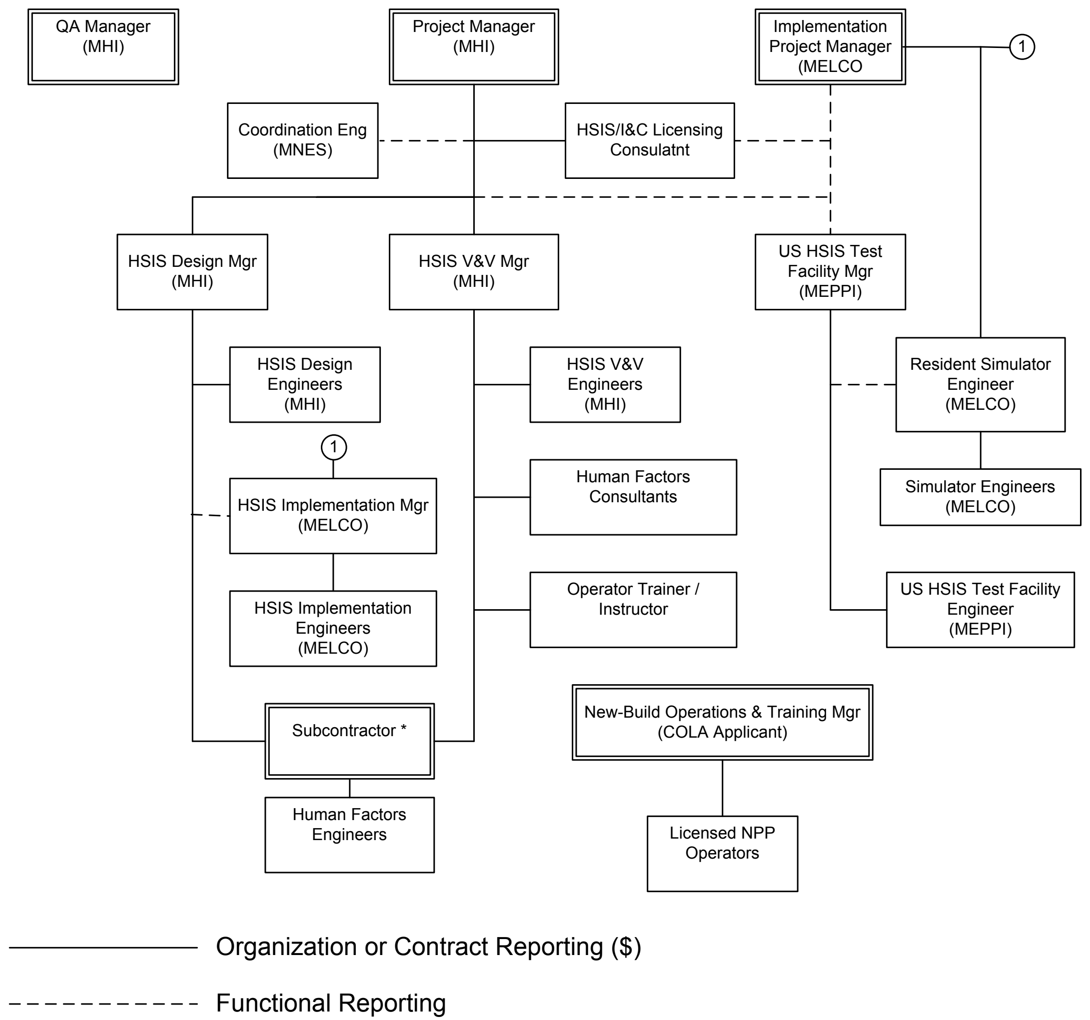
- Phase 3 – Site Specific US-APWR HSI System
    - CPNPP 3&4
  - ✓ Phase 3a – Site Specific HSI System development
    - Confirm site specific assumptions used for Phase 2
      - If needed, conduct design change process
        - » Extent of rework and additional V&V based on regression analysis
    - Completion 9/2012 (COLA ITAAC)
  - ✓ Phase 3b – Site Specific Operator Training
    - Using site specific plant reference simulator
      - Available 9/2012
    - Completion 2016 (to support pre-op test and fuel load)

HSI System Facilities

- The Basic HSI System design features described in the Topical Report are applicable to
  - ✓ Main Control Room
  - ✓ Remote Shutdown Room
  - ✓ Technical Support Center
- The HFE program described in the Topical Report is applicable to MCR, RSR, TSC and
  - ✓ Local control areas
    - For operations, testing and maintenance activities significant to plant safety
  - ✓ Emergency Operation Facility
    - For US-APWR, EOF is scope of site specific HFE team

HFE Program Organization

- Multiple
  - ✓ disciplines
  - ✓ organizations



* Responsibilities are delegated to subcontractors at the discretion of MHI's HSIS Design and V&V Managers and by contractual agreement.

HFE Program Responsibilities

- US-APWR HFE Design Team
  - ✓ HSI design implementation
  - ✓ Operating procedure writer's guide
  - ✓ Training developer's guide
  - ✓ OER, FRA/FA, TA, HRA, SA
    - Analysis integration across all HFE activities
- US-APWR HFE V&V Team
  - ✓ Formal design testing of HFE products
  - ✓ Verification & Validation of the complete US-APWR HSIS including operating procedures
  - ✓ Collection and analysis of HEDs
- Site specific HFE Team
  - ✓ EOF analysis and design
  - ✓ Human Performance Monitoring program
  - ✓ Generic US-APWR deviations
- Team members are documented in specific program element reports

HFE Program Responsibilities

- HFE Program Interface with Plant Systems Design
  - ✓ Documents that describe or impact human actions of safety significance
    - – Requirements or descriptions of safety significant human-machine interfaces
    - – Operations, maintenance or test activities
  - • Are reviewed by the HFE Team
    - – In most cases comments are resolved prior to issuance of the document
    - – Otherwise comments are tracked for resolution in the HFE Issues Tracking System
      - » Comments that cannot be resolved are elevated through the management chain for resolution

HFE Issues Tracking

- Human Engineering Discrepancies (HED)
  - ✓ May be identified by anyone during any phase of the HFE program
  - ✓ Formal design and validation testing is structured to elicit HEDs from operators
- Tracking and Resolution
  - ✓ HED is entered into a web accessible database
    - Problem statement
    - Originator's recommended solution (optional)
  - ✓ Potential solution determined by HFE Design Team
  - ✓ Evaluated by a multidiscipline Expert Panel
    - – HFE, operations, digital design
    - Significance categorization
    - Potential for solution success
    - Closure requirements, e.g.
      - – Test plan for design change
        - » Inadequate solutions will result in additional HEDs
  - ✓ Completion of closure requirements determined by HFE V&V team

HFE Program Documentation

- Basic HSI System
  - ✓ Topical Report
    - Description of Basic HSI System features
    - Key scope and methods for each HFE program element
  - ✓ HSI Style Guide
  - ✓ HSI Nomenclature
  - ✓ Component Control Design Guide
  - ✓ Procedure Writer's Guide
  - ✓ Training Developer's Guide

HFE Program Documentation

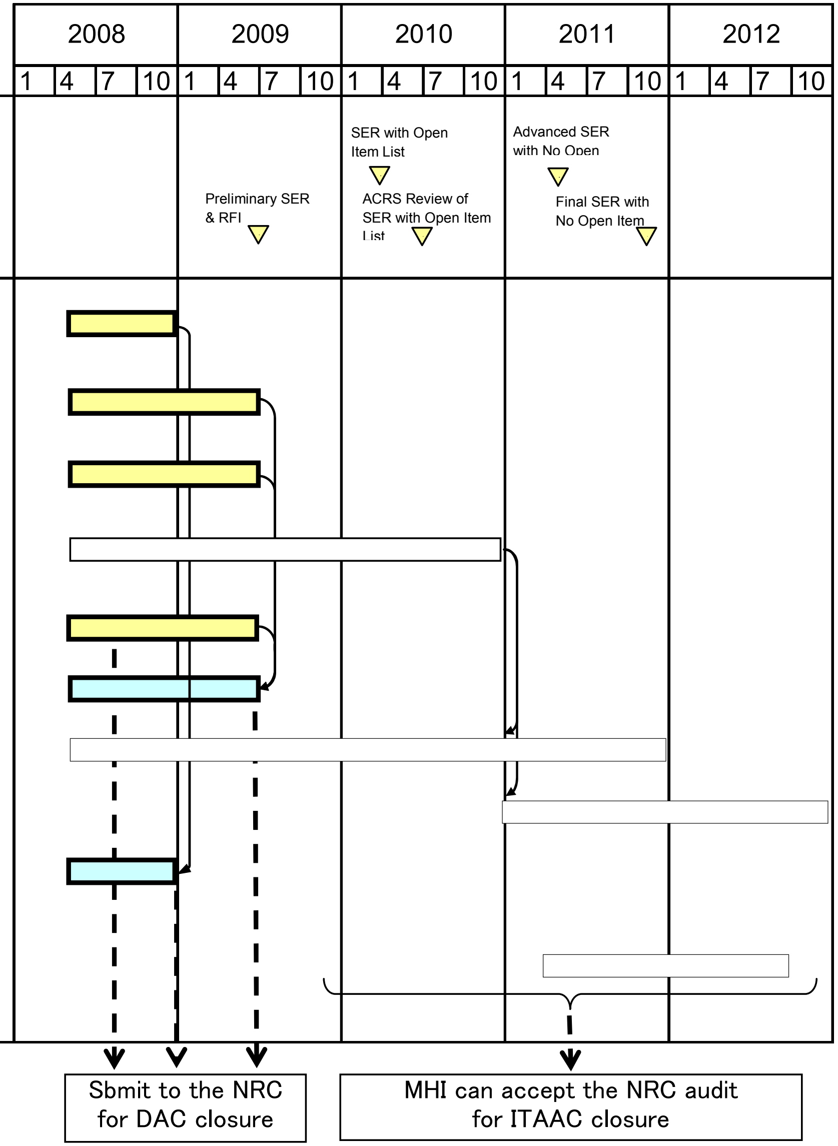
- Plant Specific Licensing Documentation
  - ✓ Implementation Plans for each program element
    - e.g. US-APWR DCD Chapter 18
- Plant Specific Implementation Documentation
  - ✓ Implementation Procedures and Reports for each program element
    - – e.g. US-APWR HSI Design Report MUAP-09019
    - – Similar reports for Phase 2b and 3
    - – Site specific HFE team is responsible for Phase 3 and Human Performance Monitoring
  - ✓ HSI detailed design
    - Drawings for VDU graphics, panel layout, room configurations
    - Database (e.g. icon pointers, instrument ranges, navigation)
    - Logic diagrams (e.g. alarm prioritization, BISI, OK status)
    - Operating procedures, training material

HFE Program Documentation

- Prior Reference Design
  - ✓ All HSI System applications build upon prior references
  - ✓ Implementation reports identify
    - How prior references are considered in the current design
    - The basis for deviations from the prior reference

US-APWR DC submittals, ITAACs

DCD Section	NEREG 0711	HFE Analysis, HFE Design and HFE V&V reports
		Key DCD and NEREG 0711Issues
18.2	E02	Operating Experience Rreview (OER)
18.3	E03	Functional Requirements Analysis/Function Allocation (FRA/FA)
18.4	E04	Task Analysis (for HSI/HFE design)
18.5	E05	Staffing and Qualifications Analysis (including job task analysis)
18.6	E06	Human Reliability Analysis (for HSI/HFE design) This report will submit to answer the RAIs for the PRA.
18.7	E07	**HSI Design Technical Report**
18.8	E08	Operating Procedures Development
18.9	E09	Operator Training Program Development
18.10	E10	**U.S. Operator V&V Technical Report (Phase 1 V&V)** US Assessment of Mitsubishi Standard HSI System
18.10	E10	US APWR HSI Desing Final V&V (Phase 2 V&V) Design, verify and validate final HSI design for the US-APWR



Phase 1a and b V&V Program

Phase 1a and b Program's Objectives

Demonstrate that the Basic HSI System conforms to HFE design principles and will enable personnel to successfully and safely achieve operational goals

- Identify the Japanese digital I&C's and HSI's compatibility with regulatory requirements and US operating practices
- Modify the design, as required, to meet US applications

Phase 1a & b focused on the Main Control Room

Overview of Phase 1a and b Tests

- Verification: Static examination of compliance with NUREG 0700 criteria
  display design- sample of 25%
  layout ergonomics – sample of over 75%

- Validation: Examination of ability of personnel to successfully and safely achieve operational goals under dynamic conditions.
  scenarios run including multiple independent failures
  CPNPP crews of 2 & 3 operators
  4 day sessions per crew with 8 hours of training
  Full scale dynamic simulator

1a: 8 crews/ 7 scenarios
1b: 5 crews/ 8 to 9 scenarios

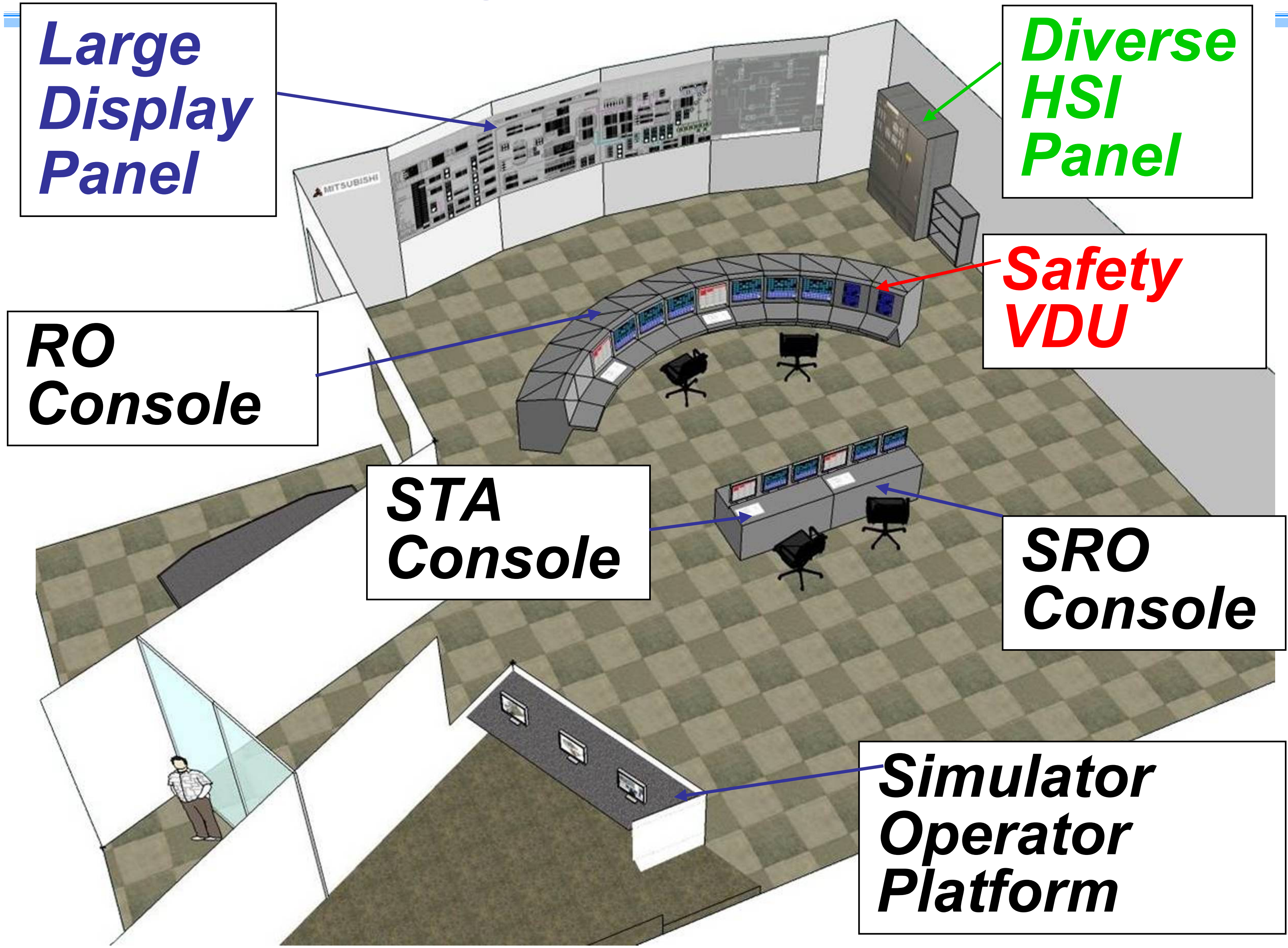
Part of a Comprehensive Multi-Phase V&V Testing Program

- Phase 1a – US Assessment of Japanese Basic HSI System
  - Purpose is to identify any changes needed in the Japanese Basic HSI System for US applications
- Phase 1b – US Basic HSI System
  - Design and evaluate changes needed from Phase 1a
- Phase 2 – V&V of US-APWR HSI System
  - V&V procedure to meet NUREG 0711 V&V requirements
  - Full scope US-APWR simulation
  - US-APWR operating and emergency procedures
  - Completion 6/20012
- Phase 3 – US-APWR Plant Specific HSI System
  - End-product is a full scope plant reference simulator for operator training
  - Completion 9/2012

General Testing Approach:

- Utilize current U. S. Power Plant operating crews as test participants (provided by Luminant / Comanche Peak)
- Test Non-safety HSI, safety HSI and Diverse HSI
- Include 2 and 3 person crews (min & max operating staffing)
- Utilize full-scope simulation representative of conventional 4 loop PWRs, including operating US PWRs and the US APWR.

V&V Facility Overview



Broad Range of Scenarios – Phase 1

- Normal, abnormal, and accident scenarios
- Multiple independent failure conditions that are cognitively complex (e.g., sensor failures, automated action failures)
- Dynamically paced scenarios that stress workload (in particular a SGTR)
- Scenarios that require risk important human actions
- Scenarios that include failures in non-safety HSI (and safety HSI)

Multiple Converging Measures

- Collection: Subjective; crew questionnaires;
  - » **5 Point Likert rating questions**
  - » **Open-ended comment and HED feedback requests**

  crew Verbal debriefs

  observer questionnaires

  Objective; **video & audio 5 station plus; LDP & displays**

  simulator digital buffer data;

  simulator/ plant parameters over time

  crew control actions/ timing

↓

Converging Measures Analysis Process:

- If multiple measures point to the same problem, it reinforces the need to address it
- If none of the measures reveal a problem, it increases confidence that there is nor a problem.

Examine Impact of HSI on Human Performance Issues

- Ability to perform actions in pace with plant dynamics
- Situation awareness
- Mental and physical workload
- Teamwork
- Sufficiency of a two-person crew

Identify and Document Human Engineering Discrepancies (HEDs)

- Input from study participants (experienced NPP operators)
  - Post-scenario questionnaires
  - Brief debriefs immediately after each scenario
  - Final questionnaire that addresses the major Basic HSI elements (LDP, displays, alarms, controls, computerized procedures…)
  - Final comprehensive verbal debrief (1.5 to 2 hours in length)
  - HED forms

- Input from interdisciplinary team of expert observers -- who are encouraged to document HEDs that they identify:
  - HFE/HRA experts
  - Operations/training experts
  - Utility representatives
  - I&C and HSI digital design experts
  - MHI, MELCO and MEPPI HFE design team members

These expert observers also participate in the HED Expert Review Panel giving them 'first-hand' insight into the HED issues.

Human Engineering Discrepancy Process

- Problem Statement:
  - Formulated by person raising the HED
  - May include recommended solution
- Proposed Resolution
  - ✓ Formulated by HFE Design Team
- Expert Evaluation:
  - By an “Expert Panel” comprised of HSI Design and V&V Team members, I&C experts, and nuclear plant process, systems, and operations experts
  - Evaluation groups related HEDs, assesses problem significance and proposed resolution (iteration may be necessary), and **establishes closure requirements** (e.g. additional training, testing, etc).
- Closure
  - Occurs when the closure requirements are satisfied by a document reviewed by the HFE V&V Team (e.g. training material, test plan, etc.)
  - Closure does not always imply problem is resolved, since inadequate solutions will be revealed by new HEDs in subsequent testing.

PHASE 1A

Phase 1a Test

- Objectives:
  - Identify any changes needed in the Japanese Basic HSI System for US applications
  - Identify HEDs
- Test conducted using the MEPPI full scope dynamic simulator
  - Represents Japanese Standard HSI System with obvious changes required for the US
    - Converted to English and US engineering units
    - Physically adjusted for US population ergonomics
    - Operating procedures are CPNPP 1&2 modified for conventional Japanese 4-loop PWR simulation model.
- Eight operating crews from CPNPP 1&2 participated
  - Six 2 man crews - one SRO and one RO
    - Minimum US-APWR crew size
  - Two 3 man crews - one SRO and two RO
    - Maximum crew size (excluding STA)

Phase 1a –Test Procedure

- Each crew participated for four days
  - Classroom training followed by 'hands-on' plant and HSI familiarization (8 hours over two days)
  - Days 2 – 4: Participation in 8 dynamic test scenarios.

- Multiple ways are used to examine human performance issues:
  - Scenarios are observed by human factors and operations experts
  - Operator feedback is solicited:
    - After each scenario via:
      - A short questionnaire (10 minutes)
      - A verbal group debrief (20 minutes)
    - On the last day after all scenarios are completed via:
      - A comprehensive questionnaire (one hour)
      - A final group discussion session (two hours)

Phase 1a: Multiple Ways to Identify HEDs

- Multiple opportunities for expert human factors and operations observers to identify HEDs
  - Observer notes
  - Formal questionnaires
  - HED forms

- Multiple opportunities for operators to identify HEDs
  - HED forms provided to be filled out at any time
  - Space provided on questionnaires

Phase 1a: Dynamic Testing

- Full scope simulator including non-safety & safety HSI
- Paper procedures (computer-based procedures were under development for US)
- Scenarios with multiple complicating faults (e.g., sensor failures, VDU failures):

Phase 1a General Results

- Phase 1a tests demonstrate that U.S. crews are able to handle a wide range of scenarios with the U.S. Basic HSI System, after only minimal training.
- There was no significant difference in performance between 2 and 3-person crews.
- A reasonable degree of operational crew awareness of plant conditions is exhibited.
- Mental and Physical Workloads appear to be consistent with that of current U.S. operating plants.

Phase 1a: General Results (Cont'd)

- Difference in style, scope, and level of detail of the procedures is probably the most significant cultural difference between Japan HSI design and the U.S.
- This difference leads to the desire by U.S. operators for more task displays tailored to procedures.
- Seems to need more display drill down navigation.
- Critical Safety Function monitoring appears not to be such an essential part of operations in Japan.

Phase 1a Results: Key HEDs and Human Performance Issues – Normal HSI

- Key Human Performance Issues

- Key HEDs

Proprietary

Phase 1a Results: Key HEDs and Human Performance Issues – Safety HSI

- Key Human Performance Issues
  - Operators had difficulty maintaining situation awareness.
    - Contributors included display structure and menus that made it difficult to monitor and control at the same time
  - SGTR scenario was challenging
    - Contributors included difficulty controlling aux. feedwater and difficulty performing cooldown .
    - Cooling down using the MSRV required the operator to continuously hold their finger on the soft control for the MSRV in order to hold it open
- Key HEDs
  - More support required for monitoring key parameters and control at the same time.
  - More display space required
  - Improved controllers required to eliminate the need to continuously hold down soft controls
  - More information for continued stable operation

Phase 1a Resulted In:

PHASE 1B

Objectives of Phase 1b

- Test Phase 1a HED resolutions implemented on the MEPPI simulator
- Test new components of HSI not tested in Phase 1a
- Continue to test the full HSI
  - Expand scope and complexity of test scenarios

Major HED-Driven Design Modifications Implemented and Tested in Phase 1b

- Non-safety HSI:

Safety-HSI:

Additional Automation

Additional Basic HSI Components Tested in 1B

Phase 1b Test Methodology

- Similar dynamic test methodology as used in Phase 1a testing
- Test conducted using the MEPPI full scope dynamic simulator modified to reflect design changes based on Phase 1a
- Five 2-person operating crews from CPNPP 1&2 participated
  - Phase 1a demonstrated same results for two or three person crews. HFE experts consider 2-person crew most limiting condition
  - 8 of the operators in Phase 1b also participated in Phase 1a

Expanded Scope and Complexity of Phase 1b Test Scenarios

- Scenarios that sampled risk significant human actions (scenario 2a)
- Scenarios where more than one critical safety function was challenged requiring the crews to utilize function restoration EOPs (scenarios 3, 8)
- Scenarios where automated systems failed requiring crews to detect automation failures and manually take-over automated functions. (scenarios 1, 2c, 3, 7)
- Scenarios that required shifting to the DHP panel; common cause failure. (scenario 6)

8 Test Scenarios

Primary Changes in Test Procedure from Phase 1a

Focused Demonstrations

Overview of Phase 1b Results

- Positive operator feedback for HED-driven changes:
  - Improved controls
  - Improved ability of SRO to supervise RO
  - Improved ability to monitor CSF
  - Improved trend information for look ahead

- Operators were able to handle all scenarios
  - ✓ Some difficulty with SGTR using Normal HSI as well as Safety VDUs
    - Reason to believe this is mitigated through additional experience with HSI (see next slide)
- Fewer HEDs obtained

Phase 1b Results: Key HEDs and Human Performance Issues – Normal HSI

- Key Human Performance Issues

[ ]

- Key HEDs

[ ]

Phase 1b Results: Key HEDs and Human Performance Issues – Safety HSI

- Key Human Performance Issues

[ ]

- Key HEDs

[ ]

Phase 1b Results: Key HEDs and Human Performance Issues – Automation

- Key Human Performance Issues

- Key HEDs

Phase 1b Results: Key HEDs and Human Performance Issues – DHP

- Key Human Performance Issues

- Key HEDs

Effects of hands on experience added to limited training

S/GTR after ~20hrs of 'hands-on'

S/GTR after ~32hrs of 'hands-on'

S/GTR after ~32hrs of 'hands-on'

S/GTR after ~32hrs of 'hands-on'

Current Phase 1b Status

- Summary report has been submitted – 6/09
- Expert Panel to review HEDs – 8/09
- Detailed report will be completed Fall 09.
  - Includes HED closure requirements

Relation of Phase 1a and b to V&V Requirements in NUREG 0711 Rev 2

- Phase 1a and b are part of a comprehensive V&V program
- Phase 1a and b were not intended to meet all the requirements of a final, plant specific, integrated V&V
- Never-the-less they do follow the general methodology outlined in NUREG-0711, Rev. 2:
  - Representative crews as test participants
  - Range of normal, abnormal and accident scenarios
  - Inclusion of risk-significant human actions
  - Examination of failure of HSI components and need to transition to backup systems – safety HSI, DHP, paper-based procedures.
  - Consideration of operator situation awareness, workload and teamwork as well as technical performance.
- A final, comprehensive, US-APWR specific V&V that meets NUREG-0711, Rev 2 requirements will be performed in Phase 2

US-APWR Integrated System Validation Will Meet NUREG-0711, Rev 2 requirements

- Full scope dynamic simulation with US-APWR plant specific HSI and US-APWR plant model
- Licensed operators trained on the US-APWR plant and US-APWR HSI
- Comprehensive set of test scenarios that include:
  - Normal, abnormal and accident conditions
  - All risk-significant human actions
  - A range of procedure guided tasks (e.g., startup, shutdown, alarm response, surveillance, maintenance, all EOPs)
  - A range of human cognitive activities, workload conditions, and situational factors known to challenge human performance.
- Similar test and feedback methods as used in Phase 1a and b:
  - Objective measures of plant performance and critical operator actions -- with performance acceptance criteria
  - Measurement of operator situation awareness, workload, and teamwork via questionnaires, expert observer assessment, and objective operator performance.
  - Identification of HEDs by operators and expert observers
  - Evaluation, tracking and resolution of HEDs via Multi-disciplinary Expert Review Panel

Conclusions from Phase 1a and b

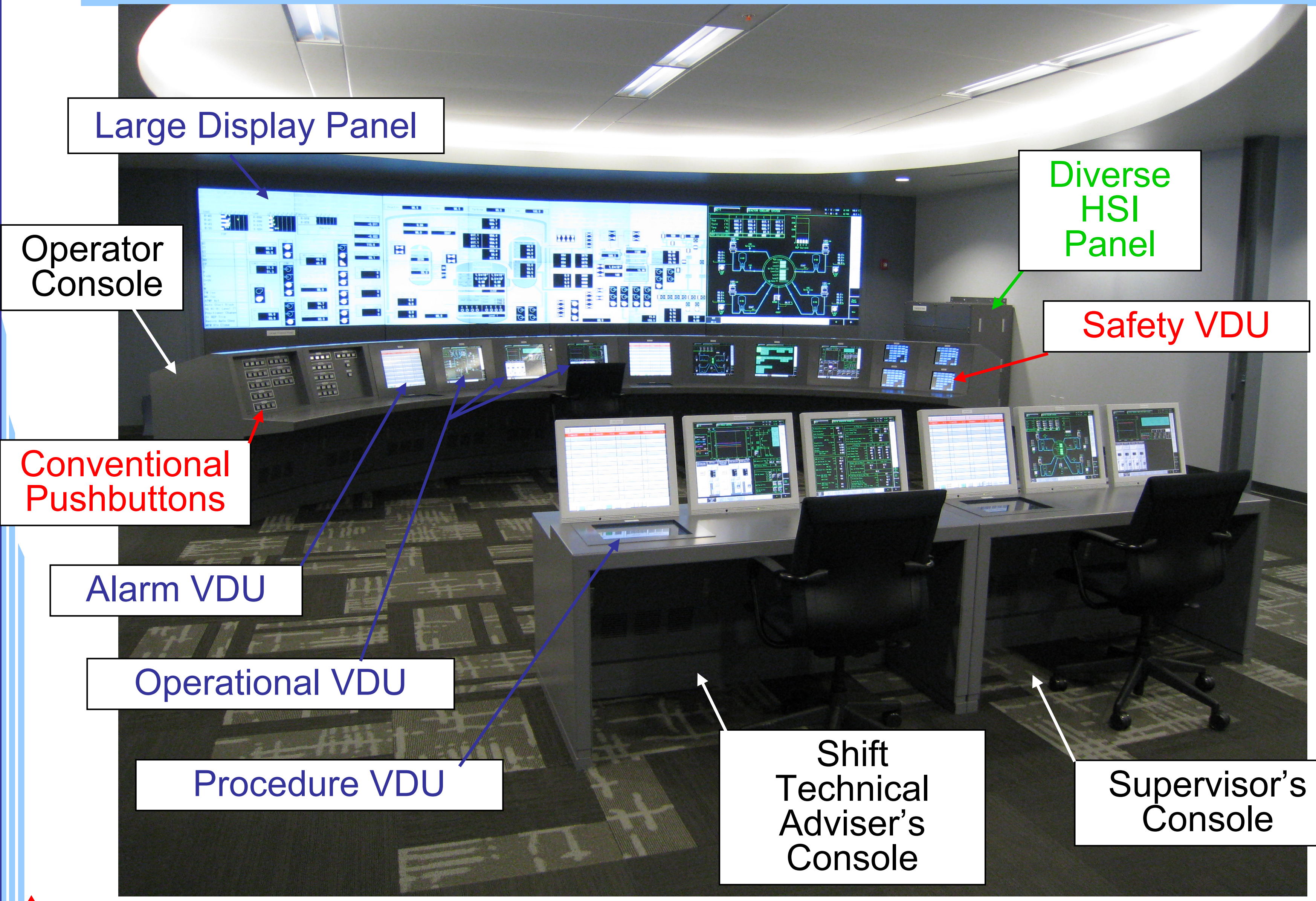
- Phase 1a and b tests demonstrate that U.S. crews are able to handle a wide range of scenarios with the U.S. Basic HSI System, after only minimal training.
- Personnel tasks can be accomplished within required time and performance constraints
- Operators believe situation awareness has improved compared to operating plants, although more improvement is still needed.
- Workloads appear to be consistent with that of current U.S. operating plants.

Basic HSI System

Basic HSI System

- The Basic HSI System is described in Section 4 of the Topical Report
  - ✓ Appendix D clarifies the "Scope of the Basic HSI System" and how it is applied to a "Plant Specific HSI System".
  - ✓ "Plant Specific HSI System"
    - Reflects the systems (mechanical, electrical and I&C), safety analysis, D3 coping analysis and HFE analysis, for each plant.
      - – Analyses are reassessed for each plant even though the analyses may be very similar among different plant types.
    - "Plant" refers to a specific nuclear unit or a family of units that share the same design
      - – e.g. US-APWR, System 80, SNUPPS
      - – Plants have site specific variations, such as interconnections to the grid and to the ultimate heat sink
    - HFE analysis is a Phase 2 activity for each plant.
      - – Site specific variations are accommodated in Phase 3

Basic HSI System Overview



PCMS
PSMS
DAS

Basic HSI System Overview

- PCMS
  - ✓ Plant Control and Monitoring System
    - Normal HSI for all plant conditions
      - » Normal and abnormal
    - Basic HSI features integrate safety and non-safety information and controls
    - PCMS has no single point vulnerabilities
- PSMS
  - ✓ Protection and Safety Monitoring System
    - HSI credited for compliance to Class 1E qualification and redundancy requirements for safe shutdown and accident mitigation
    - PSMS has 4 electrically and physically independent trains
    - PSMS HSI is credited for failure of PCMS HSI
      - – limited continued plant operation
- DAS
  - ✓ Diverse Actuation System
    - HSI credited for accident mitigation with concurrent digital common cause failure in PSMS, or PSMS and PCMS

Basic HSI System Features

- Large Display Panel
- Touch Pointing
- Alarm VDU
- Operational VDU
- Computerized Procedure VDU
- Conventional Controls
- Safety VDU
- Diverse HSI Panel
- Main Control Room
- Other HSI Facilities

Large Display Panel

- Design Basis - Functional
  - ✓ Situation Awareness
    - Critical functions
        - » Safety and power production
      - – Systems used to control critical functions
        - » Normal, preferred emergency
      - – Key parameter values, trends and alarms
      - – Key component status and alarms
      - – Displayed within a graphical representation that quickly correlates to a common mental plant model
    - All other plant alarms
    - Key plant interlock state changes
    - LDP is the apex of the HSI System information hierarchy
      - – with drill down on Operational and Alarm VDUs
  - ✓ Crew Coordination
    - Fixed display sections promote a common mental model of plant status – Normal Operation and Shutdown
    - Variable display allows focus on specific plant conditions

Large Display Panel

- Design Basis - Regulatory
  - ✓ LDP fulfills requirements for Minimum Inventory of SDCV information:
    - NUREG-0737 SPDS
    - RG 1.47 Bypassed and Inoperable Status
    - RG 1.97 Type A, B, C variables
    - SECY 93-087 Prompting alarms and indications for credited manual operator actions
  - SDCV information is readable from Operator Console and Supervisor Console.
- LDP design basis is a Basic HSI Feature
  - Specific graphic layout and information content is plant specific

Large Display Panel

- Design Basis – Presentation
  - ✓ Grey board
    - – Normal indications are black and white, with shape coding
    - – Color is used only to distinguish sections of graphic display
      - » water, steam, electricity
  - Component status
    - – Hollow
      - » valve open, breaker open, pump running
    - – Filled
      - » valve closed, breaker closed, pump off
    - – Half filled
      - » valve intermediate
  - Numerical values
  - Trend arrows and setpoint deviations

Large Display Panel

- Design Basis – Presentation
  - ✓ Color is used to accentuate abnormal conditions
    - – Component icons
      - » Abnormal state
    - – Component labels
      - » Auxiliary functions
    - – Parameter labels
      - » Abnormal conditions (eg. High, Low)
  - • Red
    - – Alarm
      - » action needed
  - • Yellow
    - – Caution
      - » acknowledgement needed, but no action
  - • Green
    - – Status
      - » no action, no acknowledgment

Large Display Panel

- Information Processing
  - ✓ Numeric value for process parameters is from automatic selection of second highest of four redundant process measurements
    - Eliminates erroneous indication/control from a sensor that deviates high or low
    - Selection of second highest is a simple, effective method easily understood by operators
    - Same selected value is consistently used for automated control, trend arrows, alarm processing
    - Deviating sensors are alarmed as I&C equipment failures, not process transients
      - Operational VDU provides drill down to specific sensor deviations
      - Automation eliminates manual tech spec Channel Checks
      - Distinct out-of-range indication
  - ✓ Actual plant parameters are plant specific, based on critical functions
    - Most PWRs are very similar

Large Display Panel

- Partial Trip Monitor
  - ✓ Red alarm for one-of-N channel
    - – trip, actuation or interlock function
      - » Functions are plant specific
  - Trip, actuation or interlock occurs on 2-of-N channels
  - Single channel actuation typically indicates equipment failure
    - – Operational VDU provides drill down to specific failure conditions
    - – Operators can initiate channel bypass to prevent plant upsets

Large Display Panel

- Trend Arrows
  - ✓ For critical power production parameters
    - Parameter selection is plant specific
  - ✓ Distinguish direction (up/down) and rate of change (fast/slow)
  - ✓ Enhance situation awareness by allowing operators to quickly detect changing process conditions without needing to read changing numerical values

Large Display Panel

- Critical Safety Function Status Monitoring
  - ✓ Automated processing of CSF status tree logic in functional recovery EOP (F0)
    - CSF are plant specific
      - – Typically similar to US Westinghouse PWRs
        - » Subcriticality (S)
        - » Core Cooling (C)
        - » Heat Sink (H)
        - » RCS Integrity (P)
        - » Containment (Z)
        - » Inventory (I)
      - – Display for yellow, orange, red conditions
  - ✓ Indication of “not in auto mode” for each critical function
  - ✓ Operational VDU provides drill down to specific conditions

Large Display Panel

- Bypassed or Inoperable Status Monitor
  - ✓ For ESF functions
    - Specific functions are plant specific
  - ✓ Automated monitoring of component availability prior to automated control demands
    - Confirms component operability
    - Identifies inoperable or misaligned components
      - – Yellow
        - » Inoperable trains, but minimum acceptable remain operable
      - – Red
        - » LCO action entry condition
    - Operational VDU provides drill down to specific components

Large Display Panel

- Grouped Alarms
  - ✓ Alarm tiles and icons typically represent multiple individual alarm conditions, e.g.
    - – Parameter windows indicate
      - » Process/setpoint deviations
      - » Absolute low, low-low
      - » Absolute high, high-high
    - – System windows indicate numerous distinct trouble conditions
    - Alarm windows display highest priority alarm
    - Reflash occurs for new conditions after acknowledgement
  - ✓ Alarm grouping allows SDCV indications to enhance situation awareness
  - ✓ Alarm VDU and Operational VDU provides drill down to specific alarms
  - ✓ Specific alarms in each group is plant specific

Large Display Panel

- Grouped Component Icons
  - ✓ Some component icons represent multiple individual plant components, e.g.
    - – Each Turbine Bypass icon represents a group of valves
      - » Hollow: all open
      - » Filled: all closed
      - » Half filled: some open
  - • Allows the status of multiple components to be displayed with focus on significant information
  - • Operational VDU provides drill down to specific components
  - ✓ Specific components in each group is plant specific

Large Display Panel

- Alarm States
  - ✓ There are four alarm states
    - – New*, acknowledged, cleared, reset (normal)

      *flashing for priority 1 and 2
    - – Distinct audible tones for each priority level and first-out alarms
    - – Audible tones can be silenced separately from alarm acknowledgement
  - Audible tones and flashing promote rapid awareness of new alarm conditions
  - Distinct tones help operators prioritize alarm response

Large Display Panel

- First Out Alarms
  - ✓ For ECCS, Reactor Trip, Turbine Trip, Generator Trip
    - Separate first-out buffer for each condition
  - ✓ Helps operators begin diagnosis of upset conditions
  - ✓ Alarm VDU shows all initiating conditions
  - ✓ Specific trip alarms are plant specific

Large Display Panel

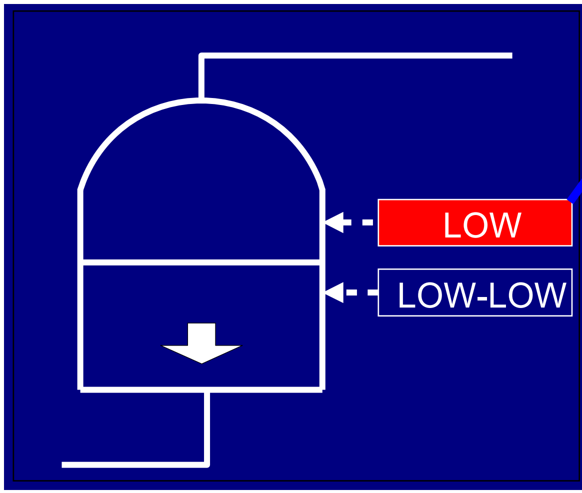
- OK Status Monitor
  - ✓ For Reactor Trip and ESF Actuation functions
    - Specific functions are plant specific
  - ✓ Automated monitoring of component status after automated control demands
    - To reduce significant operator task burden during high stress situations
    - Confirms correct response, identifies incorrect response
      - Yellow
        - » Failed train(s), but minimum acceptable
        - » Can be diagnosed later by other operators
      - Red
        - » Minimum actuation not achieved
        - » Requires immediate action to avoid threats to critical functions
    - Operational VDU provides drill down to specific components

Large Display Panel

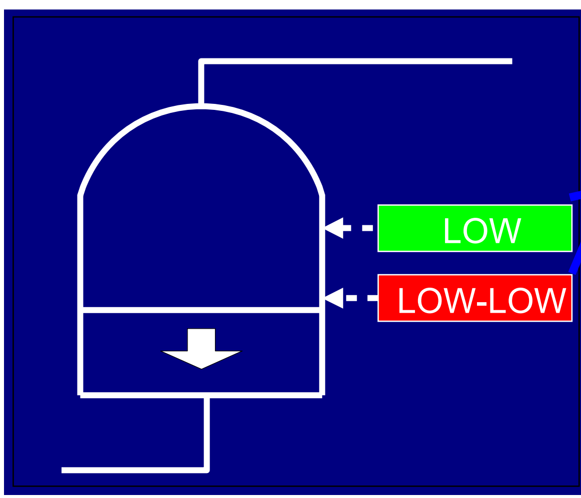
- Dynamic Alarm Prioritization
  - ✓ Alarm color display (red, yellow, green) is dynamic, based on related plant conditions
    - Prioritization is within a small set of inter-dependent alarms
    - Prioritization rules are
      - simple, easily understood by operators
      - effective in reducing important alarms to help operators prioritize their alarm response
  - ✓ Alarms and prioritization logic are plant specific

Dynamic Alarm Priorities(1/3)

1. Higher prioritization rule



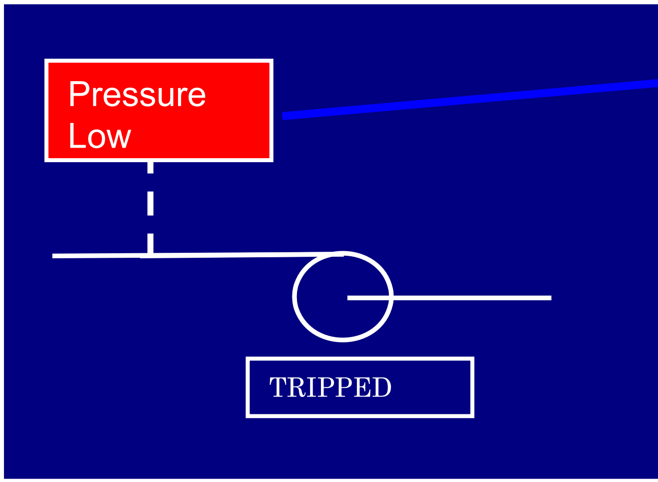
Low alarm is displayed as Priority 1 (alarm information) until the tank level achieves to the Low-Low alarm setpoint.



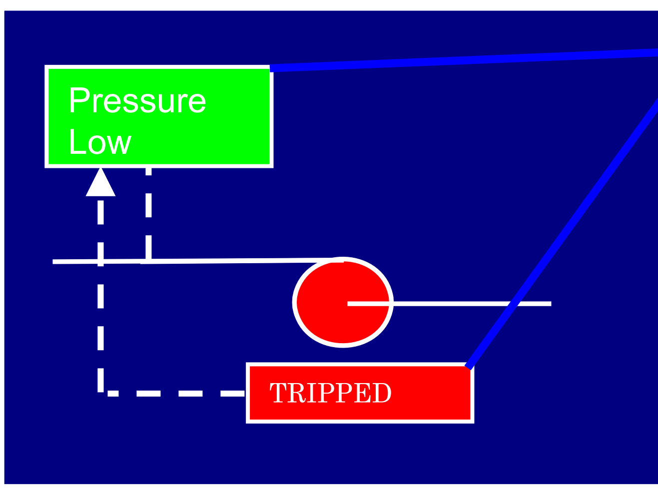
When the level achieves the Low-Low alarm setpoint, the Low-Low alarm is displayed as Priority 1 and the Low alarm is changed to Priority 3 (status information).

Dynamic Alarm Priorities(2/3)

2. Cause-consequence rule



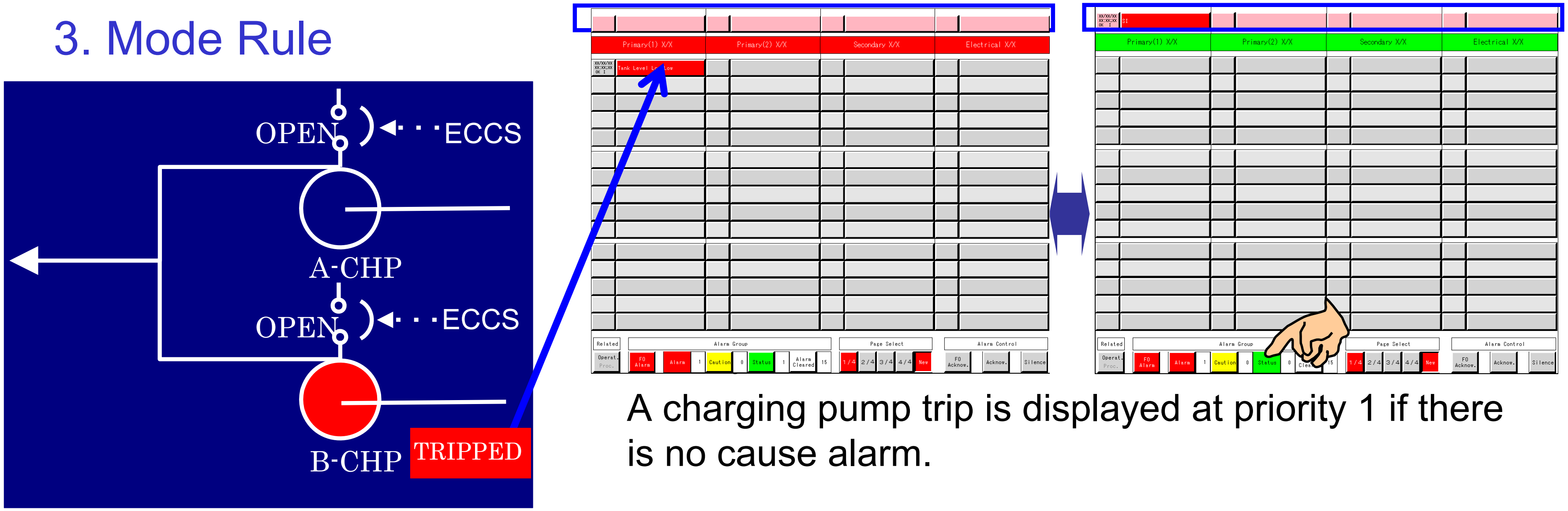
A low discharge pressure alarm is displayed at priority 1 if there is no cause alarm.



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.

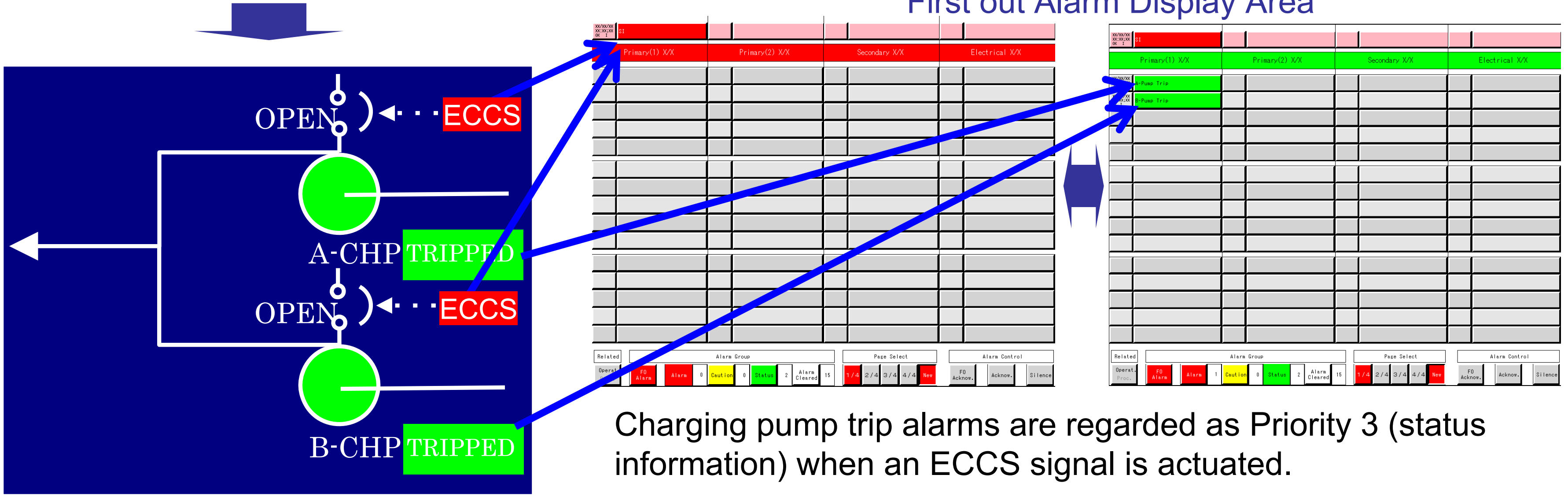
Dynamic Alarm Priorities(3/3)

3. Mode Rule



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

First out Alarm Display Area



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

Basic HSI Features

- Large Display Panel
- Touch Pointing
- Alarm VDU
- Operational VDU
- Computerized Procedure VDU
- Conventional Controls
- Safety VDU
- Diverse HSI Panel
- Main Control Room
- Other HSI Facilities

Touch Pointing

- Used consistently on all HSI devices
  - ✓ Alarm VDU
  - ✓ Operational VDU
  - ✓ Computerized Procedure VDU
  - ✓ Conventional Controls
  - ✓ Safety VDU
  - ✓ Diverse HSI Panel
- Selected based on Japanese evaluation including operators
- Preferred by Luminant operators
  - ✓ Over mouse used with recent digital upgrade
- Screen blank feature
  - ✓ Allows screen cleaning

Basic HSI Features

- Large Display Panel
- Touch Pointing
- Alarm VDU
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- Conventional Controls
- Safety VDU
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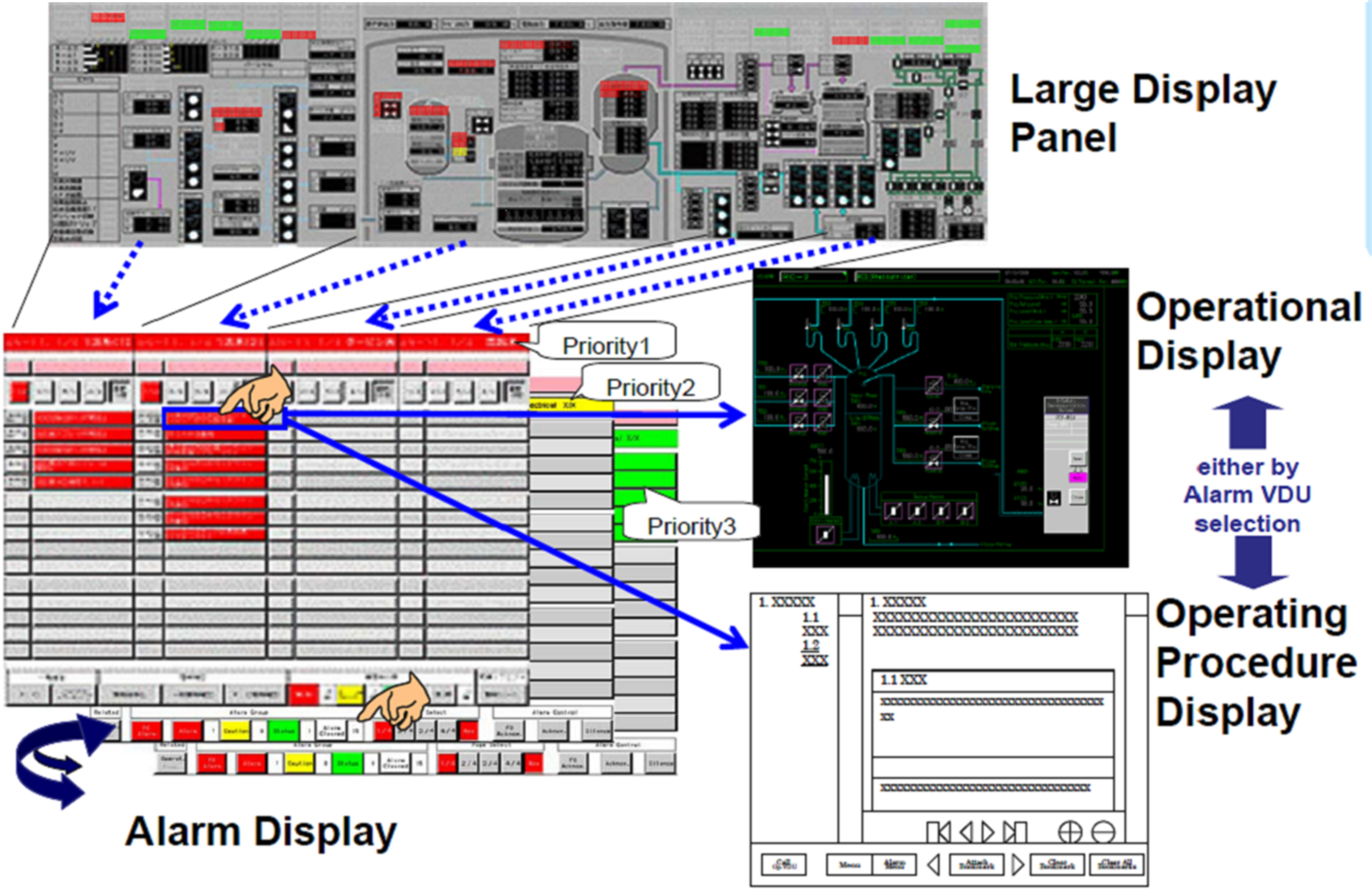
- Other HSI Facilities

Alarm VDU


Large Display Panel
Priority1
Priority2
Priority3
Operational Display
either by Alarm VDU selection
Operating Procedure Display
Alarm Display

Alarm VDU

- ➢ Accelerates alarm response
  - ✓ OK monitor for expected automation
  - ✓ Navigational links to graphic displays and/or procedures
- ➢ Separate displays are provided for each alarm priority and first-out alarms.
  - • Alarms shift to the appropriate priority display automatically.
  - ✓ Allows operators to focus attention on highest priority alarms
- ➢ Each alarm display area is divided into four plant areas
  - • Primary system-1, 2, turbine system, generator/electrical system
  - ✓ Groups alarms by related functions
- ➢ Alarms belonging to the same group are displayed in chronological order.
  - • Page controls for overflow
  - ✓ Chronological listing facilitates diagnosis and alarm response

Alarm VDU

- Alarms are configured on a plant specific basis
  - ✓ Primarily by system designers
  - ✓ HSI designers establish priority and dynamic prioritization logic
  - ✓ HFE V&V team confirms alarms provide appropriate tasks support
- Operators can add alarms
  - ✓ Typically for specific unanticipated tasks
  - ✓ Operators cannot change preconfigured alarms

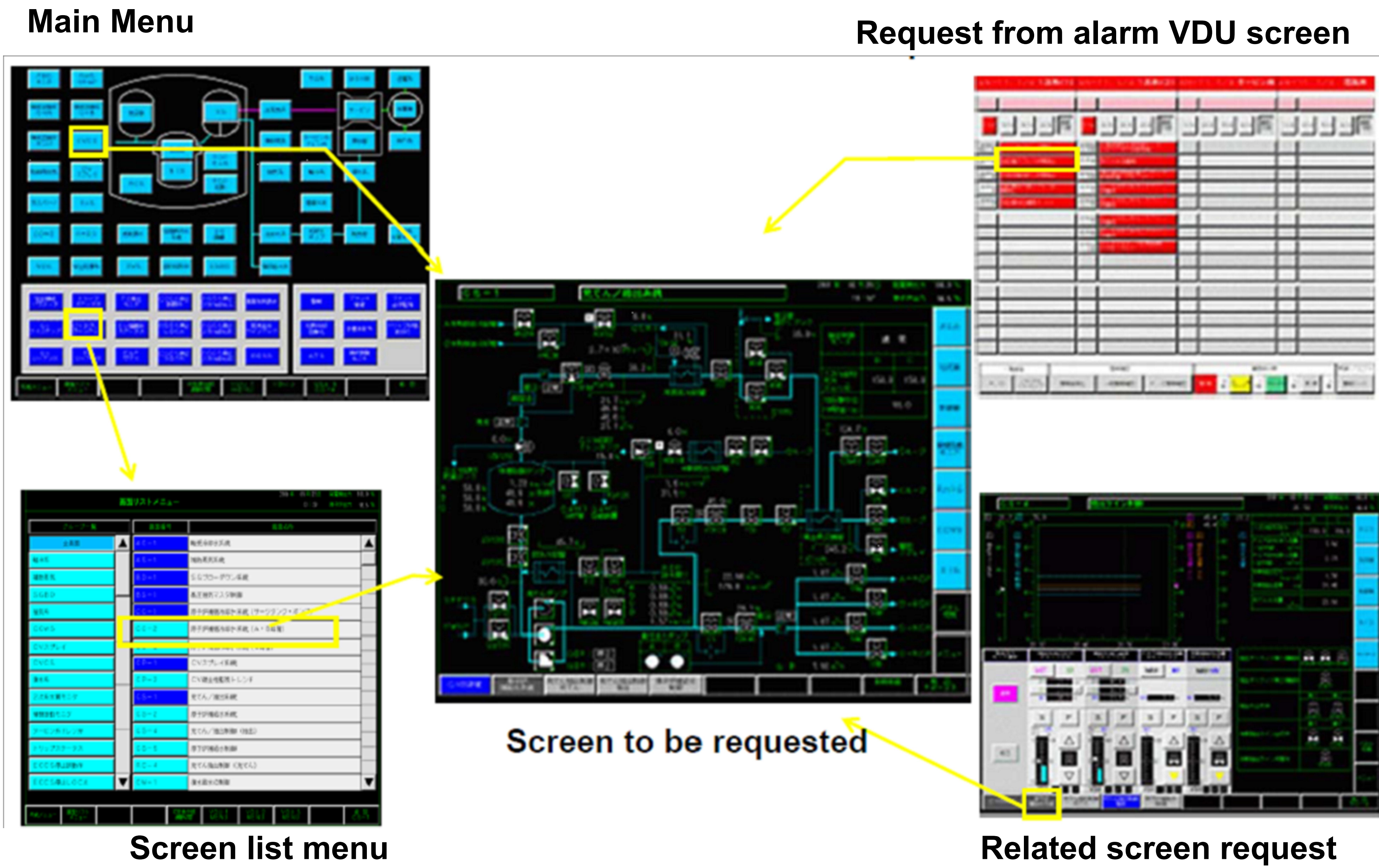
Basic HSI Features

- Large Display Panel
- Touch Pointing
- Alarm VDU
- Operational VDU
- Computerized Procedure VDU
- Conventional Controls
- Safety VDU
- Diverse HSI Panel
- Main Control Room
- Other HSI Facilities

Operational VDU

- Display navigation
- Component control popup
- Process control popup
- Trends
- Tagging

Operational VDU

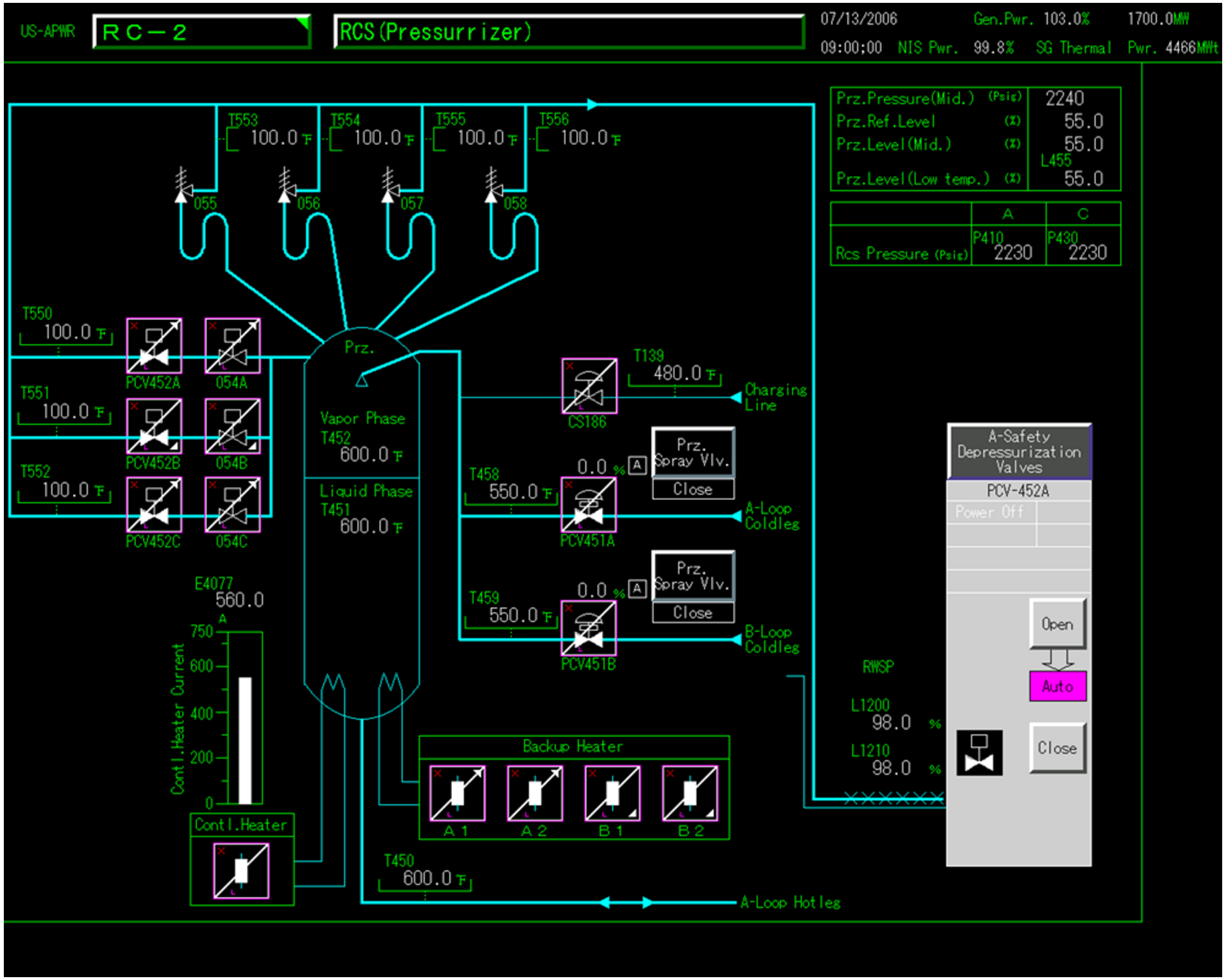


Operational VDU

- Display navigation
  - ✓ Main menu is divided into System and Emergency displays
    - Displays provide navigation to subsystem, task, and related displays
      - Facilitates three click access for most display needs
  - ✓ Contents of menus and display graphics are plant specific
    - Content of System displays is dominated by system design
    - Content of emergency, tasks displays and related display menus are dominated by task analysis
      - Task displays are employed when task requires more than 3 concurrent System displays
    - Graphics are configured using generic HSI System Style Guide

Operational VDU

- Component Controls
  - ✓ Safety and Non-safety components can be operated from Same Screen

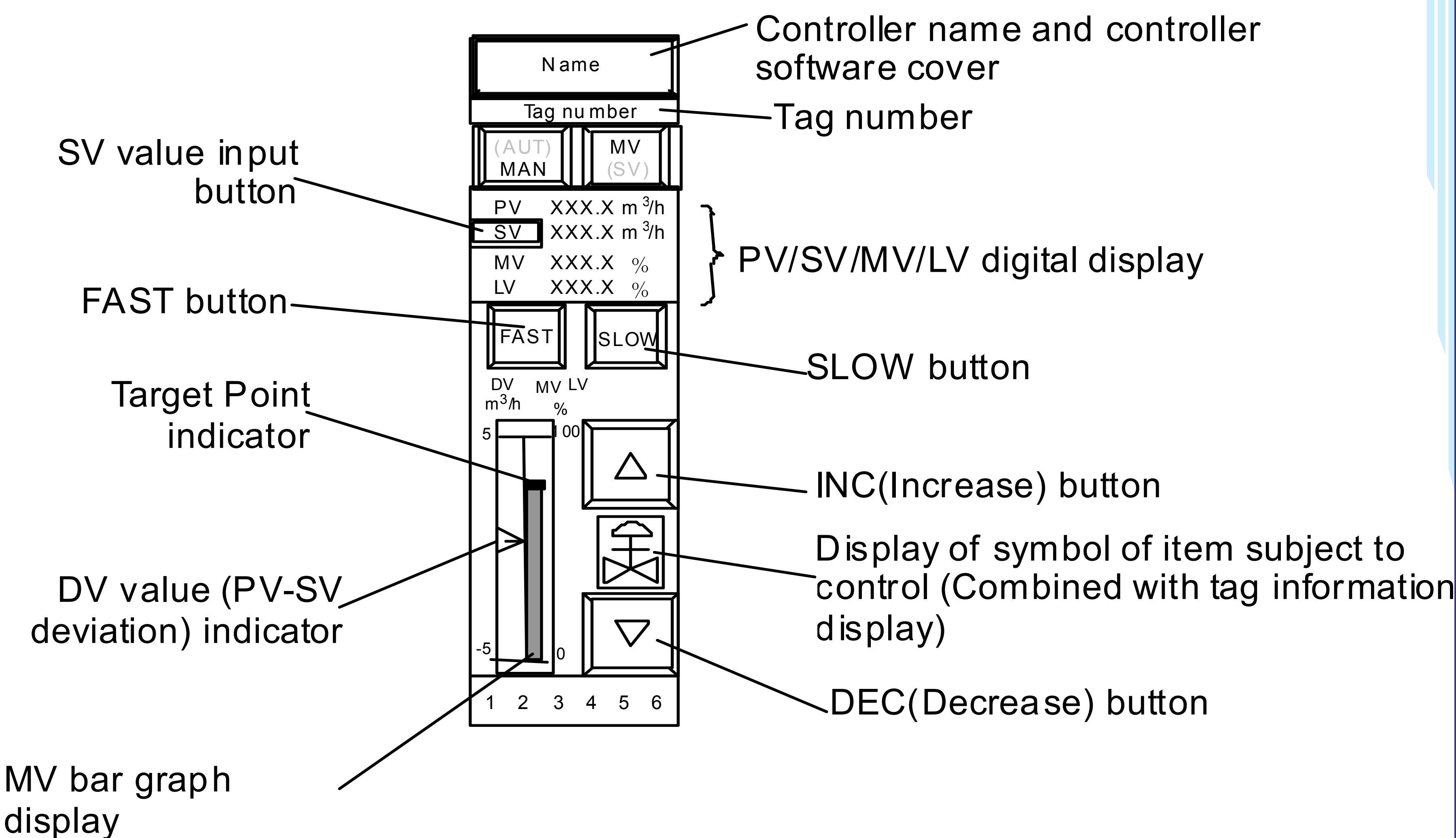


Operational VDU

- Component Controls
  - ✓ Standard control templates for
    - – MOVs, solenoid valves, pumps, etc.
  - ✓ Standard functions (controls, indications, alarms)
    - – Jogging, mode selection, override, bypass
    - • Correlated to component control detailed logic
      - – Documented in generic Component Control Design Guide
  - ✓ Three click design minimizes control errors
    - • Select component
    - • Enable control window
    - • Control action
  - ✓ Controls for safety components are enabled/disabled from Safety VDU
    - • To prevent adverse failure interaction
  - ✓ Specific components selectable on each display are plant specific

Operational VDU

➢ Process Controls

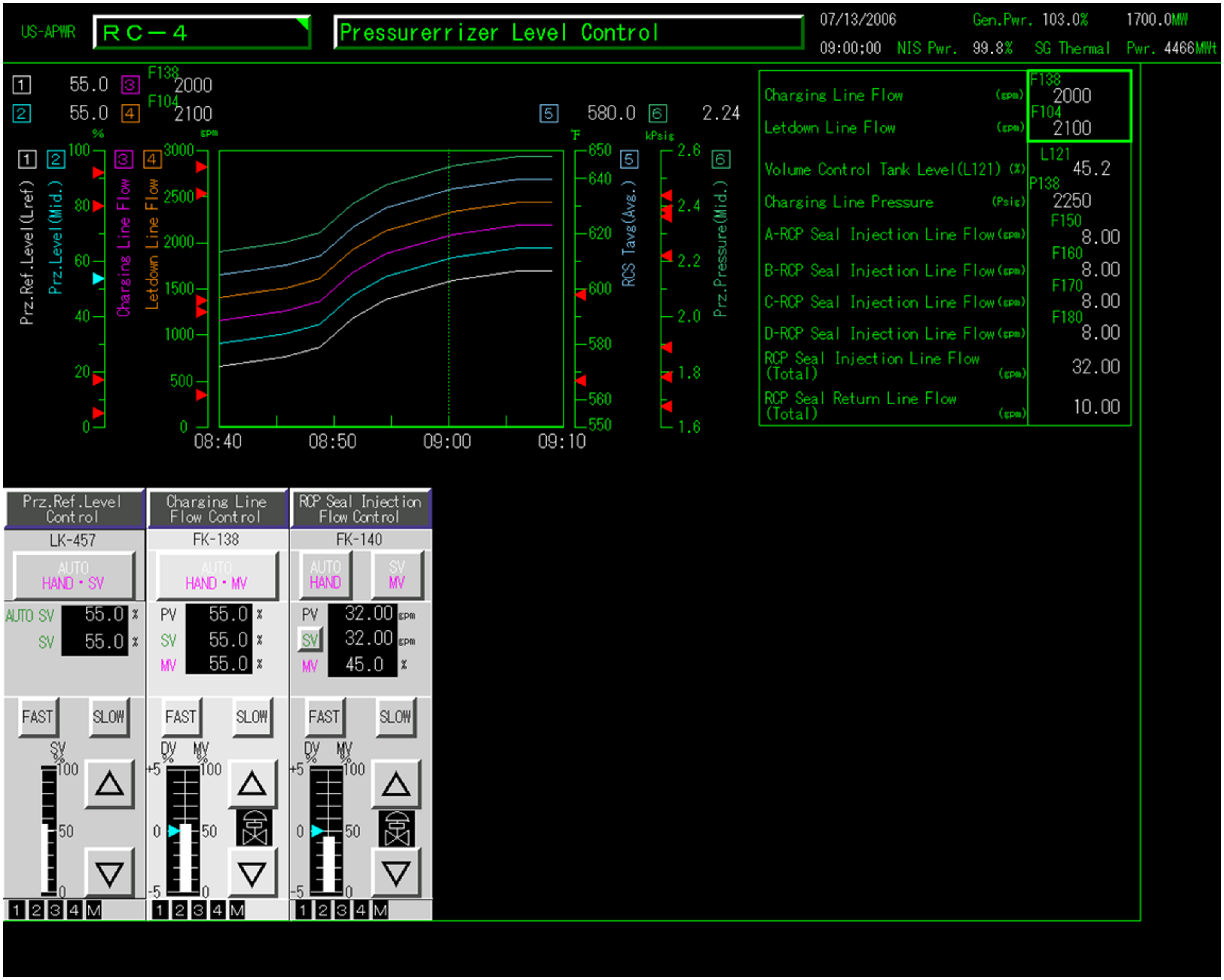


Operational VDU

- Process Controls
  - ✓ Standard control templates for closed loop modulating controls.
  - ✓ Standard functions (controls, indications, alarms)
    - – Setpoint manipulation, mode selection, manual control, process and component status
    - • Correlated to process control detailed logic
      - – Documented in generic Component Control Design Guide
  - ✓ Three click design minimizes control errors
    - • Select task display
    - • Enable control window
    - • Control action
  - ✓ Separate display of operator demand and control system response compensate for digital and process delays
  - ✓ Normal, Fast, Slow selections allow course and fine adjustments
  - ✓ Bumpless auto/manual transfer
  - ✓ Specific controls on each display are plant specific

Operational VDU

- Trends

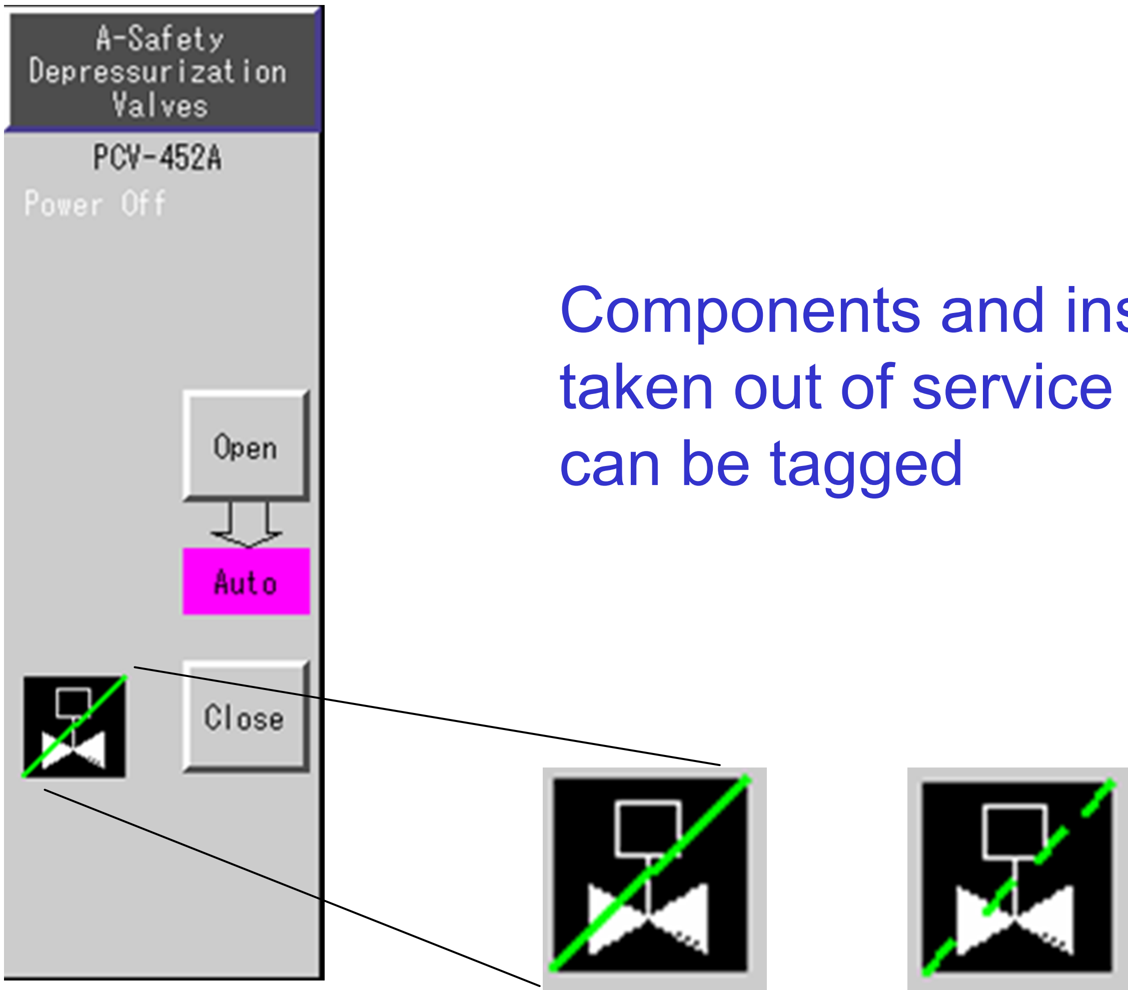


Operational VDU

- ➢ Trends
  - ✓ Preconfigured trends are plant specific
    - Typically integrated with process controls
  - ✓ Operators can easily configure trends
    - – Parameter selection
    - – Historical start point
    - – Time axis
    - Configured trends can be saved and reaccessed on the display menu

Operational VDU

- Tagging



Components and instruments
taken out of service
can be tagged

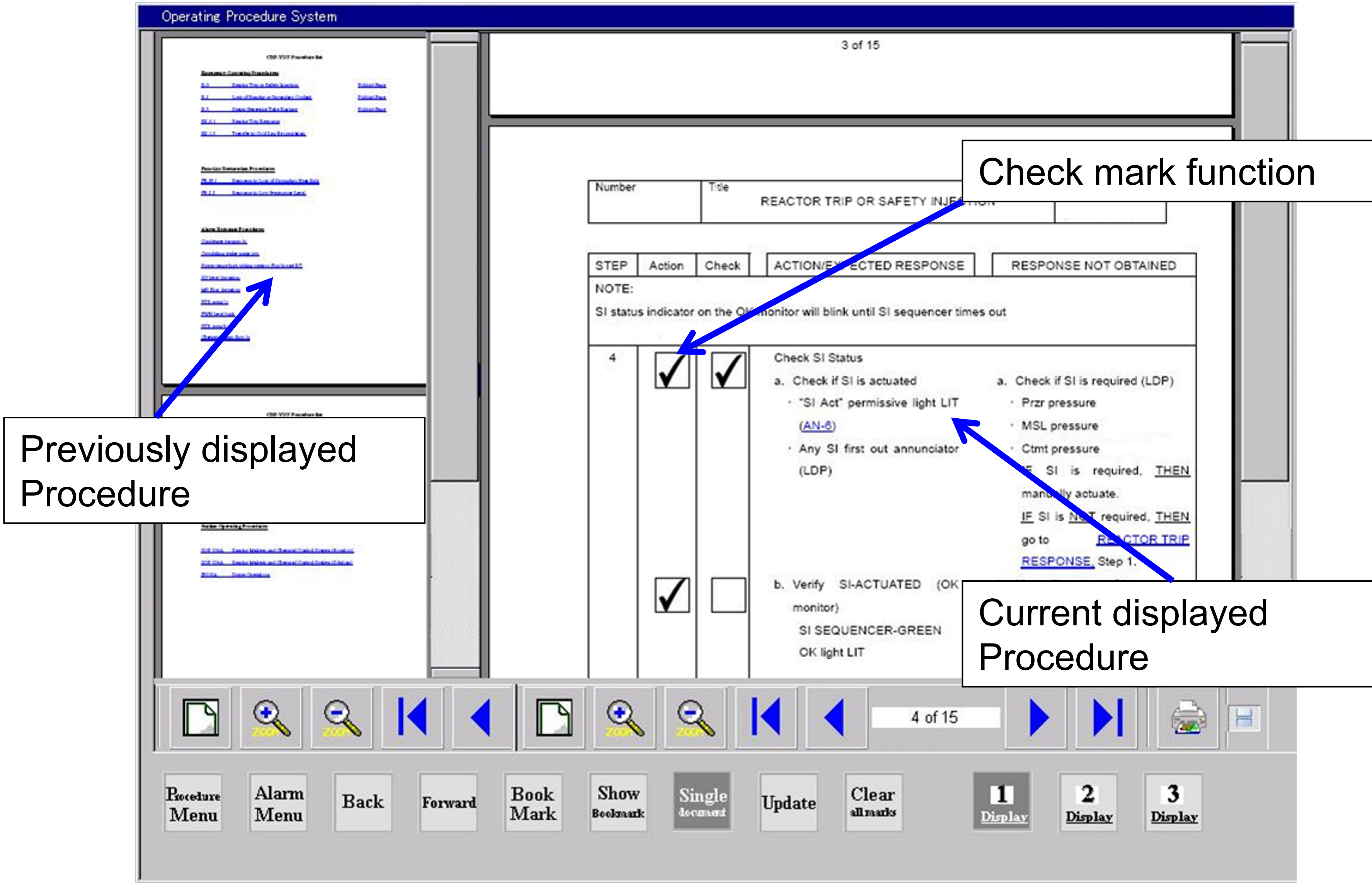
Operational VDU

- Tagging
  - ✓ Allows HSI system to mimic physical tags placed on plant equipment
  - ✓ HSI tagging is integrated into maintenance process for physical tagging
  - ✓ HSI tagging can accommodate unique tag icons to represent various phases of maintenance, e.g.
    - » Component isolated
    - » Component out of service
  - Actual tag phasing is plant specific

Basic HSI Features

- Large Display Panel
- Touch Pointing
- Alarm VDU
- Operational VDU
- Computerized Procedure VDU
- Conventional Controls
- Safety VDU
- Diverse HSI Panel
- Main Control Room
- Other HSI Facilities

Computerized Procedure VDU



Computerized Procedure VDU

- Each Procedure VDU has
  - ✓ Procedure navigation function
    - Hierarchical links (Table of Contents)
    - Hyperlink to procedure page or alternate procedure, with back function
      - Allows execution of multiple procedures or procedure sections
  - ✓ Display navigation function
    - Hyperlink to related display on Operational VDU
  - ✓ Checkmark function
    - Which procedure step is complete
      - Checkmarks can be added or removed for each step
      - All checkmarks can be deleted with button at the bottom of the display window
- Procedure format and navigation is generic
  - ✓ Specific procedures and navigational links are plant specific

Basic HSI Features

- Large Display Panel
- Touch Pointing
- Alarm VDU
- Operational VDU
- Computerized Procedure VDU
- Conventional Controls
- Safety VDU
- Diverse HSI Panel
- Main Control Room
- Other HSI Facilities

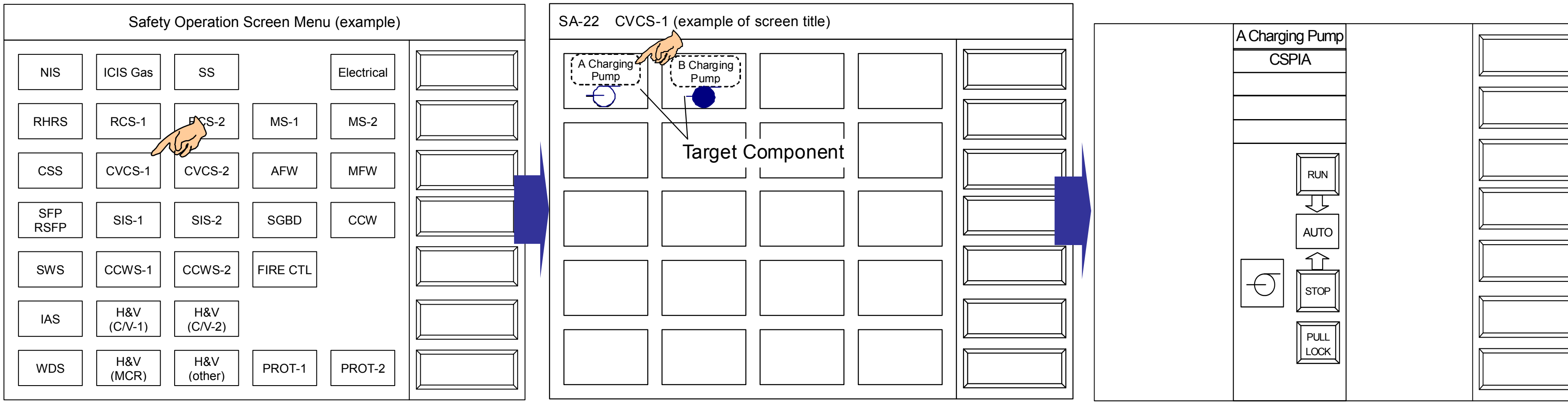
Conventional Controls

- Design Basis - Regulatory
  - ✓ RG 1.62 and IEEE 603
    - Division level actuation based on minimum
      - – Operator action
      - – Equipment
    - Conventional pushbuttons are provided for reactor trip and each ESFAS function
      - – Specific ESFAS functions are plant specific
- HSI
  - ✓ Pushbutton covers prevent inadvertent actuation
  - ✓ Critical controls require two concurrent control actions
    - Eg. Containment spray
  - ✓ Actuation functions are duplicated on Operational VDUs and Safety VDUs
    - For accessibility and reliability

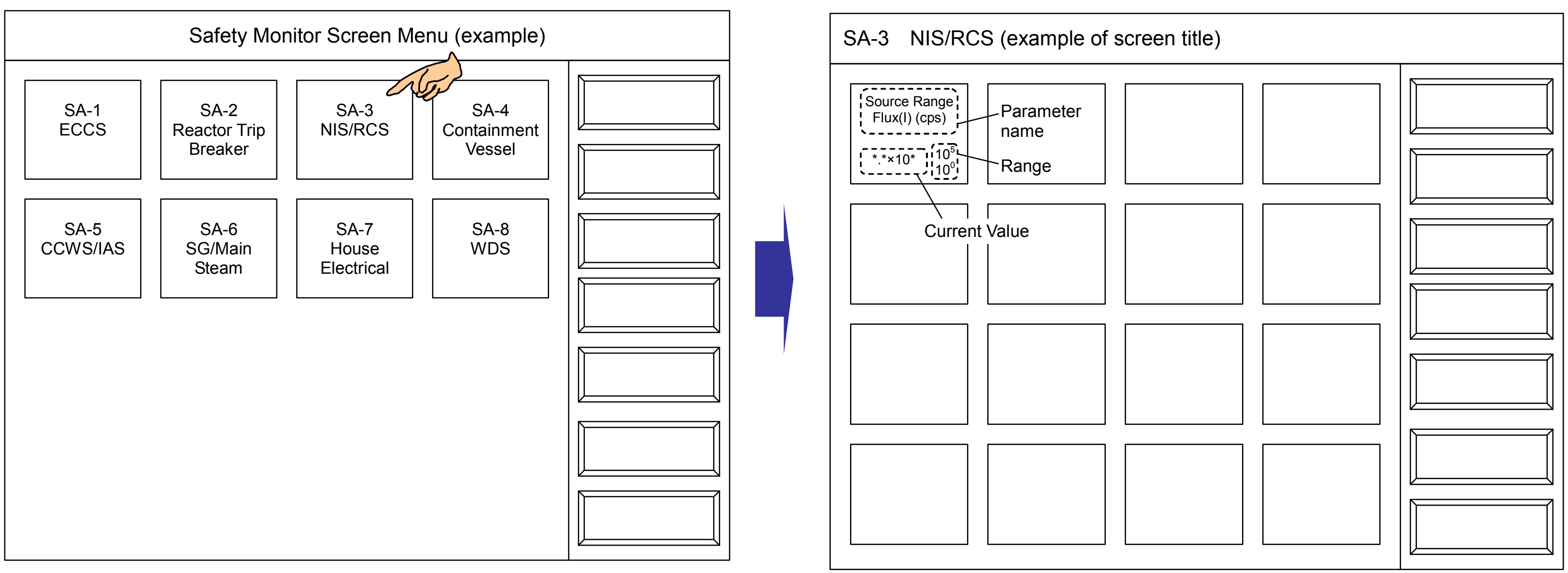
Basic HSI Features

- Large Display Panel
- Touch Pointing
- Alarm VDU
- Operational VDU
- Computerized Procedure VDU
- Conventional Controls
- Safety VDU
- Diverse HSI Panel
- Main Control Room
- Other HSI Facilities

Safety VDU



Backup HSI for all safety related instrumentation and plant components



Safety VDU

- Design Basis - Regulatory
  - ✓ RG 1.97
    - Class 1E SDCV HSI for Type A and B variables
      - Type A: Instrumentation to support manual operator actions credited in accident mitigation
      - Type B: Instrumentation to monitor critical safety functions
  - ✓ IEEE 603
    - Class 1E controls credited for accident mitigation and safe shutdown
  - ✓ SECY 93-087
    - Class 1E alarms to prompt manual actions credited in the accident analysis
  - ✓ Safety VDUs provide HSI for all safety related instrumentation and controls defined by system designers
      - HVAC, electrical, cooling water, alternate EOP success paths
    - Therefore exceeds regulatory basis
    - Inventory of SR instrumentation and controls is plant specific

Safety VDU

- Design Basis – Presentation
  - ✓ Control pop-ups mimic the pop-up functions of the Operational VDUs
    - Non-safety functions are not available
    - Consistent style guide
      - – Including three step control actions
        - » To prevent erroneous operations
- Design Basis – Degraded HSI
  - ✓ HSI for continued stable plant operation without PCMS HSI
    - Additional HSI inventory is plant specific
    - Safety VDUs are used with backup paper procedures
      - – Not electronic procedures

Basic HSI Features

- Large Display Panel
- Touch Pointing
- Alarm VDU
- Operational VDU
- Computerized Procedure VDU
- Conventional Controls
- Safety VDU
- Diverse HSI Panel
- Main Control Room
- Other HSI Facilities

Diverse Actuation System HSI Panel

- Backup HSI for coping with AOOs and Postulated Accidents with concurrent digital CCF

Diverse Actuation System HSI Panel

- Design Basis - Regulatory
  - ✓ SECY 93-087 and BTP 7-19
    - Diverse HSI for manual actions credited in D3 coping analysis
      - – AOOs and Postulated Accidents
    - Diverse HSI for monitoring and controlling critical safety functions
- HSI
  - ✓ Pushbutton covers prevent inadvertent control actuation
  - ✓ DHP is used with paper procedures
    - Not electronic procedures
- Inventory of Diverse HSI and resulting DHP layout is plant specific

Diverse Actuation System HSI Panel

- CCF Manual Action Strategy
  - ✓ The CCF coping strategy credits unique alarms to prompt entry into Special Event EOPs for coping with AOOs or PAs, with concurrent CCF
  - ✓ Operators will be trained to provide an immediate response to the unique prompting alarms
    - Without additional equipment failure diagnosis or plant event diagnosis
  - ✓ DAS design features ensure these alarms will not be spuriously generated
    - If there is no CCF in RPS/ESFAS
    - Due to single failures in DAS
  - ✓ DAS operability, including alarms, is ensured through
    - Periodic testing
    - Limiting conditions of operation

Diverse Actuation System HSI Panel

- CCF Scenario Example SGTR
  - ✓ No CCF
    - PCMS generates MS Radiation Alarm (N-16)
      - DHP alarm is blocked by signal from HSI computers
    - Operators initiate manual reactor trip
      - DAS automatic reactor trip is blocked by signal from RTBs
    - Operators use Operational VDUs to manage event

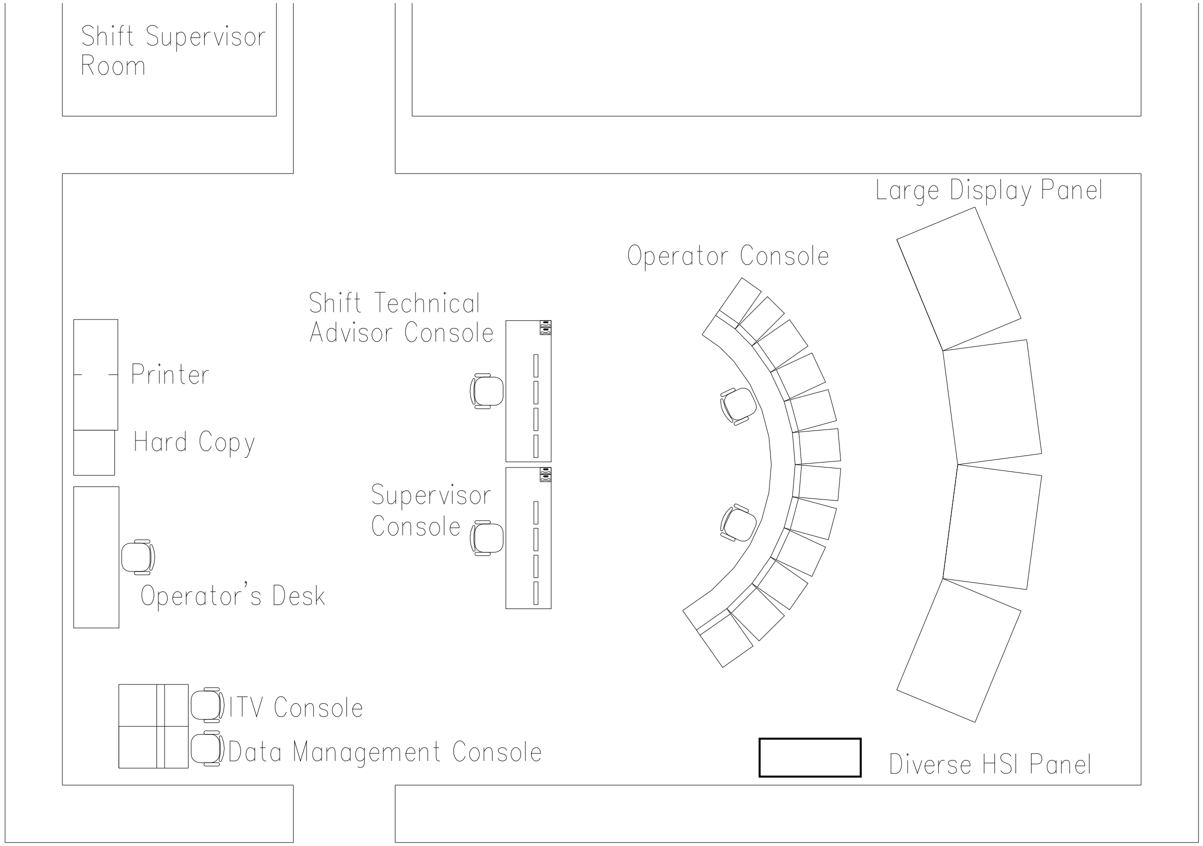
Diverse Actuation System HSI Panel

- CCF Scenario Example SGTR
  - ✓ CCF is in PSMS and PCMS
    - (eg. CCF is in MELTAC basic software, which is common to both systems)
  - N-16 alarm is generated on DHP
    - Because N-16 alarm is not generated by PCMS HSI computers
  - Alarm prompts operators to move to DHP
    - Operators use DHP to manage event

Basic HSI Features

- Large Display Panel
- Touch Pointing
- Alarm VDU
- Operational VDU
- Computerized Procedure VDU
- Conventional Controls
- Safety VDU
- Diverse HSI Panel
- Main Control Room
- Other HSI Facilities

Main Control Room



Main Control Room

- Design Basis - Regulatory
  - ✓ GDC-19 Functionality
    - Normal operation, accident mitigation and safe shutdown
  - ✓ 10CFR50.54 (m) Staffing
    - – Minimum in MCR at all times
      - One SRO, one RO
    - – Minimum in plant at all times
      - One additional SRO, one additional RO
    - Confirmed in Phase 1 testing
- Design Basis – Commercial
  - ✓ Separate workstations to continuously accommodate
    - MCR supervisor, STA, two ROs
  - ✓ Portable workstation for maintenance and testing
    - Used only during shutdown conditions
- General arrangement of MCR and consoles is a Basic HSI Feature
  - ✓ Plant specific variations are in licensing documentation

Basic HSI Features

- Large Display Panel
- Touch Pointing
- Alarm VDU
- Operational VDU
- Computerized Procedure VDU
- Conventional Controls
- Safety VDU
- Diverse HSI Panel
- Main Control Room
- Other HSI Facilities

Other HSI Facilities

- Remote Shutdown Room
  - ✓ Design Basis – Regulatory
    - Appendix R
      - Achieve safe shutdown with complete MCR damage and evacuation
  - ✓ Remote Shutdown Console (RSC) contains
    - Three operational VDUs and 4 safety VDUs
      - Same functionality as MCR
  - ✓ RSC is used with paper procedures
      - Not electronic procedures
  - ✓ RSC controls are activated by Master Transfer from MCR
    - VDUs are typically blank to enhance screen life

Other HSI Facilities

- Technical Support Center
  - ✓ Same LDP and Operational VDUs as in MCR
    - No alarm acknowledgement, no control
  - ✓ For the US-APWR the TSC is included within Phase 2 of the HFE program
- Emergency Operations Facility
  - ✓ HSI inventory for the SPDS is received from PCMS
    - For the US-APWR the SPDS is included within Phase 2 of the HFE program
  - ✓ For the US-APWR the HFE program for the EOF is the scope of the COL applicant
    - Following US-APWR HFE program plan
- Local Controls
  - ✓ Included in generic Component Control Design Guide
    - – To clarify interaction with controls in MCR, RSC
    - However, not encompassed within Basic HSI System Style Guide
  - ✓ For the US-APWR local controls are included within Phase 2 of the HFE program

Basic HSI System Summary

- The Basic HSI System establishes a solid foundation for a plant specific HSI System that achieves the following:
  - ✓ Personal tasks can be accomplished within the required time and in accordance with specified performance criteria
  - ✓ A high degree of operating crew awareness of plant conditions
  - ✓ Operational vigilance is maintained with acceptable workload levels to minimize periods of operator underload and overload
  - ✓ Operator error is minimized, and provisions for error detection and recovery are effective
- The Basic HSI System conforms to HFE design principles and will enable personnel to successfully and safely achieve operational goals
  - ✓ When coupled with the plant specific HSI inventory developed, verified and validated through the plant specific HFE program

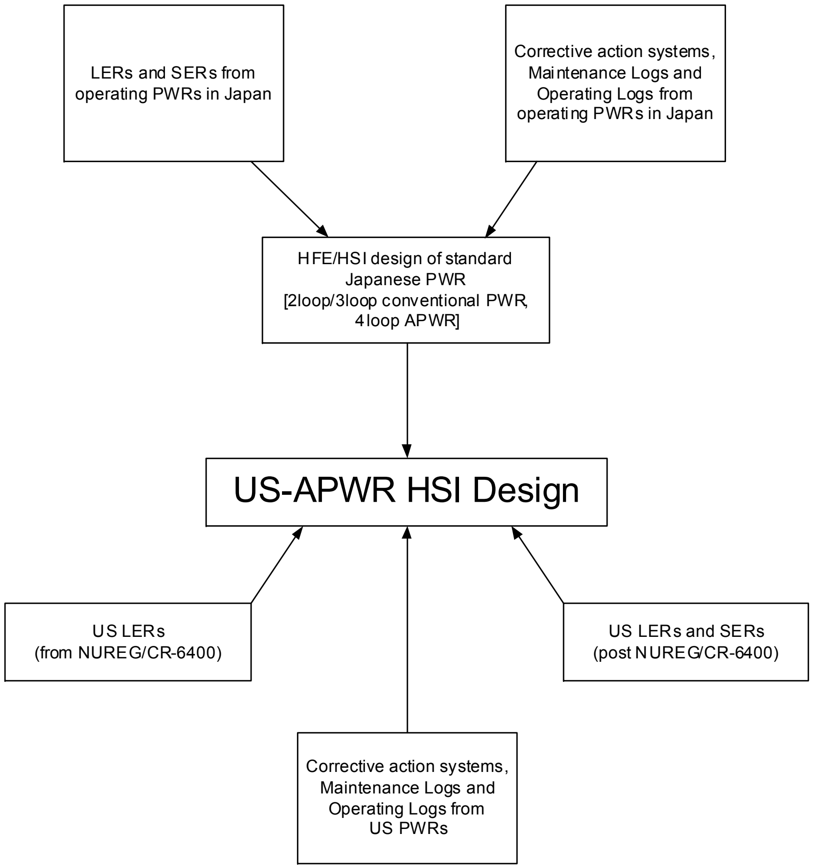
US-APWR HFE Program Elements

HFE Program Elements

- The US-APWR HFE Design Process is a systematic program encompassing all elements of NUREG-0711
  - ✓ Operating experience review (OER)
  - ✓ Functional requirements analysis and function allocation (FA/FRA)
  - ✓ Task analysis (TA)
  - ✓ Staffing and qualifications
  - ✓ Human reliability analysis (HRA)
  - ✓ HSI design
  - ✓ Procedure design
  - ✓ Training design
  - ✓ Human factors verification and validation
  - ✓ Design implementation
  - ✓ Human performance monitoring

OER

- Information Sources
  - ✓ NUREG/CR-6400, Generic Letter, Information Notices
  - ✓ INPO Database
  - ✓ Japanese PWR
  - ✓ Non nuclear facilities in U.S. and Japan
- Issues identified during the review are classified for their applicability
  - ✓ Addressed in the current Basic or US-APWR design (no HED)
  - ✓ Not adequately addressed, HED identified
  - ✓ Applicable to the US Basic HSI System
  - ✓ Applicable on a plant specific basis



OER for the US-APWR is documented in Phase 1a Report MUAP-08014".
This initial OER is generically applicable to all US applications of the Basic HSI System.
OER will be conducted for each new project using the methodology defined in the Topical Report.

OER

- Results
  - ✓ All human aspect issues are identified and addressed.
  - ✓ Future unsolved issues are extracted as HEDs which include HSI design, Operating Procedures, Training program and other plant designs.
- Examples Basic HSI System:

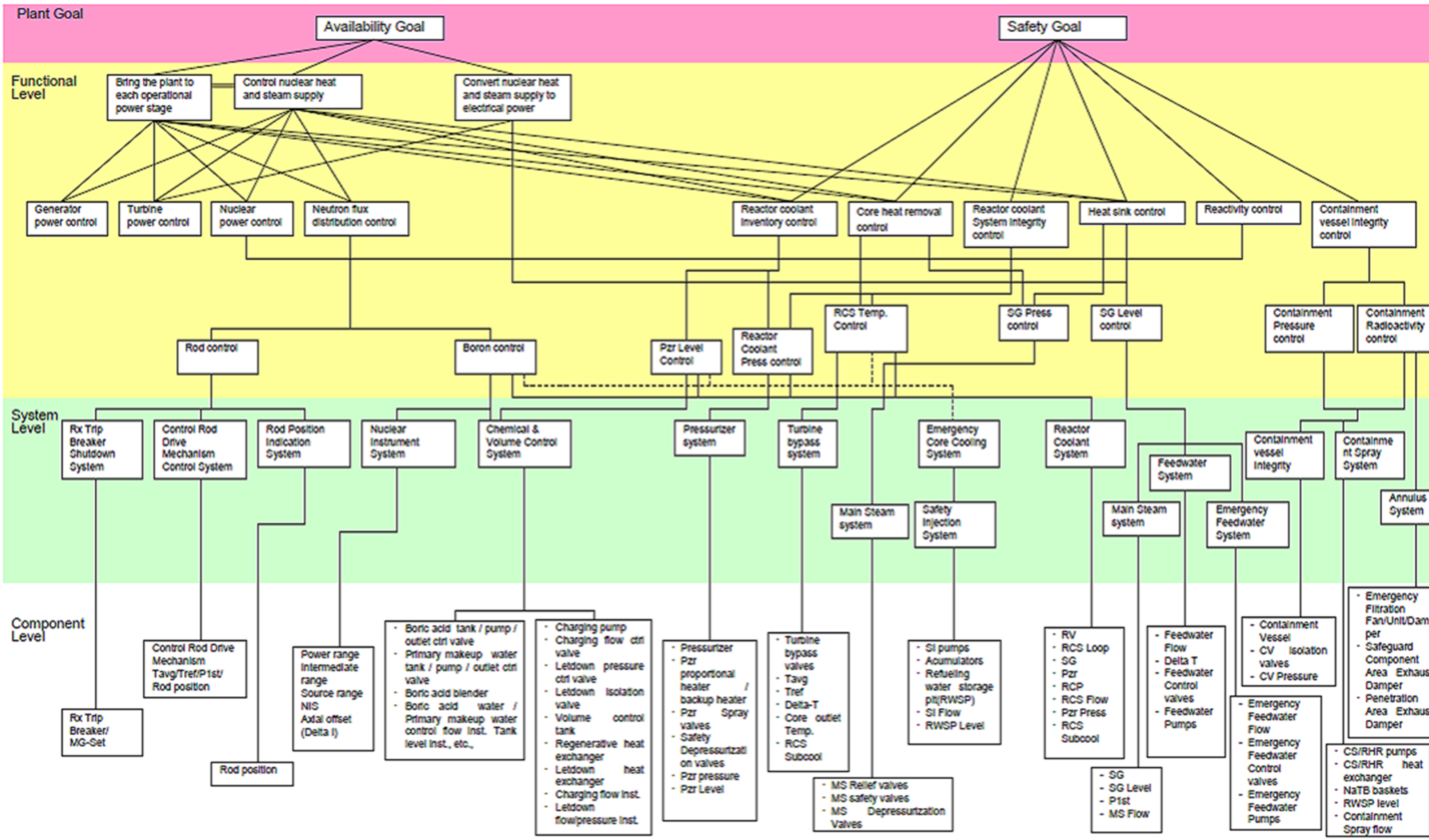
  HED1 Computer Based Procedure;

  The computer based procedure system, shall include …

  HED2 Component Controls;

  The Component Control Design Guide shall include …

FRA (Functional Requirements Hierarchical Structure)



FA

- The functional allocation has been performed considering NUREG-0711 criteria 8.4.5 (4), which includes workload, time margin (Feedback), frequency, complexity and decision making.

FA

➢ Example: Function Assignment to Man or Machine Based on Time

Man/Machine/Location Determination		
If Action Time Available is:	≤ 10 minutes	> 10 minutes
Then Function Assignment is:	Automation	Human
If Human Action Time is:	≤ 30 minutes	> 30 minutes
Then Action Location should be:	MCR	Outside MCR

➢ Example: Function Assignment to Man based on Scenario Complexity with consideration of Time Margin

Isolation of Small Coolant Leak Outside Containment	
Operator Actions to Perform Isolation	≥ 45 minutes
Moderator Dilution Operator Response	
During Refueling Operation	≥ 30 minutes
During Startup, Shutdown, Hot Standby and Power Operation	≥ 15 minutes

FRA/FA

- FRA/FA Results
  FRA/FA was conducted and assigned specific parameters and controls supporting critical safety functions and availability functions for manual and automatic control.
- There is no difference in the functions which support safety goal and plant availability goal from conventional PWR.
- The are no differences in US-APWR that would cause the allocation of those functions to change. Allocations have been confirmed considering NUREG 0711 criteria, which include workload and time/complexity allocation criteria.
- These parameters and control allocation is used for input of HSI display design and operator's role in MCR and local station.
- The FRA/FA for the US-APWR is documented in Part 2 of the technical report "HSI Design" (MUAP-09019).
- FRA/FA will be conducted for each new project using the methodology defined in the Topical Report.

HRA

- The methodology is described to identify risk important HAs based on the Level 1 and Level 2 PRA (probabilistic risk assessment) for the US-APWR DCD

  i.e. Risk importance measures such as the Risk achievement worth (RAW) and Fussell-Vesely (FV) importance measures, which can be derived from the PRA, were used to measure risk importance of HAs.
- The HFE/HSI assumptions that led to HA error probabilities in the PRA, are confirmed by the HFE team and also documented
- The HRA for the US-APWR does not rely on data from previous plants.

HRA

- Result

  -With these operation step assumption (i.e. Basic HSI assessment (Indications/Controls allocation, etc.), operating procedure step reflection on corresponding operation procedures and staffing estimation), any risk significant human action steps can be demonstrably executed from Human Factor Engineering aspect.

  -US-APWR HSI design, operating procedure, operator training program, staffing analysis and V&V program shall use those risk significant HAs as their input information.

- The HRA for the US-APWR is documented in Part 2 of the technical report "HSI Design" (MUAP-09019).
- HRA will be conducted for each new project using the methodology defined in the Topical Report.

HRA

- Risk significant HAs are generically supported by the Basic HSI System, as follows:
  - ✓ Situation awareness through LDP
  - ✓ Priority 1 prompting alarms - Action
  - ✓ Three step control actions to minimize component selection errors
  - ✓ SRO VDU to monitor RO actions
  - ✓ Emphasis in Procedure Writer's Guide
  - ✓ Emphasis in Training Developer's Guide
- Test scenarios to address all risk significant HAs will be included in the Phase 2 V&V program
- SGTR test scenarios in the Phase 1 V&V program addressed a few risk significant HAs

Task Analysis

- A table-top technical review of the Phase 1 Task Analysis for risk important human actions for the US-APWR was performed with the objective of ensuring the following for each task:
  - Accuracy of the English translation
  - Accuracy of the task substeps
  - Time required to complete each task
- Partial task analysis for risk important human actions was conducted and identified detailed level of information and control requirement as well as task support requirements using the table top analysis and cognitive workload assessment.

Task Analysis

- GOMS and OSD methodology was used for time required task in order to evaluate cognitive workload.
- The Task Analysis for US-APWR is documented in Part 2 of the technical report “HSI Design” (MUAP-09019).
- TA for risk significant human actions has been completed.

  Remaining TA will be implemented in conjunction with Operating Procedure development as ITAAC.
- TA will be conducted for each new project using the methodology defined in the Topical Report.

Staffing Analysis

- Minimum operator staffing levels have been established based on experience with previous plants, government regulations, and staffing reduction goals as described in HSI system description and HFE process topical report Section 5.5.
- SA shall determine the number and background of personnel for the full range of plant conditions and safety related tasks in conjunction with the other HFE analysis.

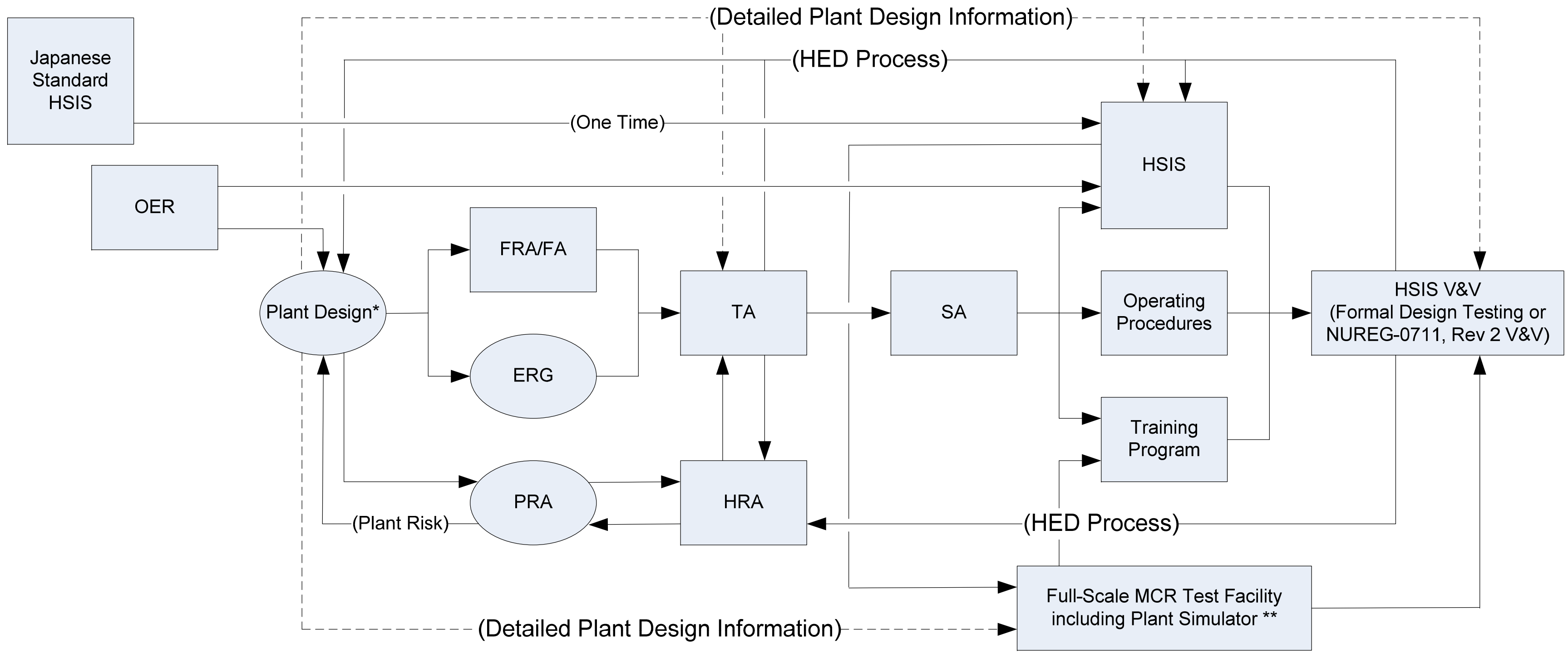
Staffing Analysis

- The staffing assumptions impact requirements for the HSI design including the number of physical interfaces, data processing, operating procedures, display screens, alarms, controls, and support aids needed to support the accomplishment of the tasks. The acceptability of the staffing assumptions shall be continuously examined as the design proceeds.
- The HFE program shall demonstrate, through V&V activities, that the staffing is sufficient for safe plant operation
- For US-APWR SA is covered by ITAAC and the Program Plan in DCD Chapter 18. Implementation Procedure is developed during Phase 2.
- SA will be conducted for each new project using the methodology defined in the Topical Report.

Other Remaining HFE Program Elements

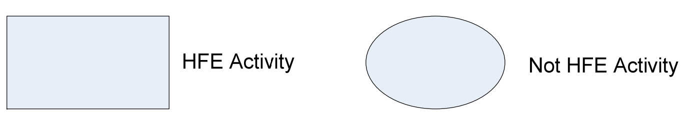
- For US-APWR the HFE program elements are covered by ITAAC and the Program Plans in DCD Chapter 18. Implementation Procedures are developed during Phase 2b and 3.
  - ✓ HSI Design
  - ✓ Operating Procedure Development
  - ✓ Training Program Development
  - ✓ Integrated HSI system V&V
  - ✓ Design Implementation
  - ✓ Human Performance Monitoring
    - Scope of site specific HFE Team
- Each program element will be conducted for each new project using the methodology defined in the Topical Report.

HFE Element Implementation Flow



* Includes Safety Analysis and D3 Coping Analysis

** Plant design details for simulator start with conventional 4 loop PWR then US-APWR



Topical Report and DCD RAIs

Topical Report RAIs (summary)

Elements/Issues	MUAP-07007 Section	DCD Section	Follow-up RAI No. (18.0-X)
Applicability to Operating Plants	-	-	1,6,7,25
Program Management	5.1	18.1	3,8,9,10,11,12, 17,18,20,24
Operating Experience Review	5.2	18.2	27,28
Functional Requirements/Function Allocation	5.3	18.3	30,31,71
Task Analysis	5.4	18.4	32, 37
Staffing Analysis	5.5	18.5	38
Human Reliability Analysis	5.6	18.6	40, 42,43,44
HSI design	5.7	18.7	66,67,68,69,70,71,72,73,74, 75,76,77
Operating Procedure Development	5.8	18.8	45,46,50,51,52,54
Training Program Development	5.9	18.9	55,58,59,60,64,65
Verification & Validation	5.10	18.10	78,79,80
Design Implementation	5.11	18.11	81
Human Performance Monitoring	5.12	18.12	83
Japanese HFE Program Documentation	-	-	85
US-APWR DCD and COL Items	-	-	86

DCD Chapter 18 RAIs (summary)

Elements	MUAP-07007 Section	DCD Section	RAI No. (18-X)
Program Management	5.1	18.1	6,7,8,9,10,11,12,13,14,15, 16,17,18,19
Operating Experience Review	5.2	18.2	3,45,46,48,49
Functional Requirements/Function Allocation	5.3	18.3	28,29,30,31,32,33,34,35
Task Analysis	5.4	18.4	4,5,27,43,64
Staffing Analysis	5.5	18.5	1,2
Human Reliability Analysis	5.6	18.6	24,25,26
HSI Design	5.9	18.7	50,51,52,53,54,55,56,57,58,59,60, 61,62
Operating Procedure Development	5.7	18.8	37,38,39,40,,41,42,44
Training Program Development	5.8	18.9	36, 47
Verification & Validation	5.10	18.10	63
Design Implementation	5.11	18.11	21,22,23
Human Performance Monitoring	5.12	18.12	20

Applicability to Operating Plants

(TR 18.0-1,6,7,25)

- TR revised
  - ✓ Appendix D added to clarify "plant specific" and "site specific" and to clarify scope of Basic HSI System (18.0-1)
    - E.g. plant is US-APWR, site is CPNPP 3&4
  - ✓ HFE program documentation (18.0-6)
    - Plant licensing documentation provides HFE program plan for each element
      - The US-APWR DCD Chapter 18 exemplifies this
      - Similar plans will be included in LAR for operating plants
    - Plant specific Implementation Procedure and Report for each element
      - US-APWR reports MUAP-08014 and MUAP-09019 exemplify Implementation Procedures and Reports for OER, FRA/FA, HRA, TA
- Explanation
  - ✓ HFE input for the methodology of NEI 96-07 from HFE program (18.0-7)
  - ✓ Regulatory compliance demonstrated through plant licensing documentation (18.0- 25)
    - HFE program plan, description of plant specific HSI features (eg. MI)
    - US-APWR DCD Chapter 18 exemplifies scope of the plant specific licensing documentation

Program Management

(TR 18.0-3,8, 9,10,11,12,17,18,20,24)

- TR revised
  - ✓ Generic HFE program goals (18.0-3)
    - Implemented in conjunction with plant design process
    - A high degree of operating crew situation awareness
    - Operation vigilance and acceptable workload levels
    - Minimize operator error and provide for error recovery
  - ✓ HFE team responsibilities are in implementation procedures (18.0-8)
    - Overall procedure and procedures for each program element
  - ✓ HFE team review of plant documents (18.0-9,12,17)
    - Included in QA manual, review records, HEDs
    - Basis of verification is NUREG 0700 (direct or per Style Guide)
  - ✓ HFE team skills and tools (18.0-10,11,24)
    - HFE experts for each element
    - Responsibilities, tools in Implementation Procedures
- Explanation
  - ✓ HFE Issues Tracking is described in HFE Overall Implementation Procedure (18.0-18,20)

Program Management

(DCD 18-6,7,8,10,17)

- TR revised
  - ✓ Technology constraints (18-6)
- ITAAC added to DCD
  - ✓ HFE applicability to EOF (18-7,8)
    - Same process, responsibility of site specific HFE Team
- DCD revised
  - ✓ Technical Project Management skills for Design Team (18.0-10)
  - ✓ HFE control of subcontractors (18.0-17)

Program Management

(DCD 18-9,11,12,13,14,15,16,18,19)

- Explanation
  - ✓ Program plan/procedure documentation explained (18.0-12)
  - ✓ HED tracking database (18-13)
  - ✓ HFE integration plan/schedule (18-14, 15)
  - ✓ QA manual controls HFE process (10-9, 11, 16, 18)
    - integration with plant, personnel qualifications, documentation, corrective actions after HFE program is complete
    - Specific documents are defined in each HFE program element plan
  - ✓ Static/dynamic models (18-19)

Operating Experience Review
(TR 18.0-27, 28)

- Explanation
  - ✓ US-APWR OER Program Plan requires a procedure and report (18.0-27)
    - OER Procedure and Report in "US-APWR Human System Interface Verification and Validation (Phase 1a) Technical report" (MUAP-08014)
      - Submitted for Staff review December 2008
  - ✓ US-APWR OER report identifies issues pertinent to the US Basic HSI System and US-APWR HSI System (18.0-28)
    - Including issues obtained in the Japanese OER that impacted the Japanese Standard HSI System
    - see next slide for example

Japanese OER Examples

➢ Nuclear operating experience

Item from NUCIA	Issue/Scope	Human Factors Aspect Issue	Human Factors Issue addressed by Basic HSI System or US-APWR
1983-Kansai-T022	Miss operation in periodic test Reactor trip during over speed test for turbine governor control system	The plant was disconnected from grid at 9:00 on November 1for the 4th periodic inspection and over speed test for turbine governor control system was performed. The turbine and reactor was automatically tripped when the over speed test for governor controlled system was performed (the reactor power was 5 % and number of turbine revolutions 1800 rpm) at 9:32 on the same day. (Cause of Occurred Event) During the over speed test for governor controlled system, the test was conducted on manual control because turbine speed up was inoperable on automatic operation. As a result of plenty of steam flow by manual operation, because of too fast to speed up, turbine first stage pressure was increased and exceeded 10% of full power, therefore the permissive P-7 signal was initiated then trip condition for turbine over speed was allowed, finally reactor trip occurred. The cause of inoperable condition of automatic operation is unidentified.	Basic HSI system No additional features. US-APWR HED – The restriction on manual turbine speed-up will be described in the operating procedure and training material.

➢ Non-nuclear operating experience

Issue/Scope	Human Factors Aspect Issue	Human Factors Issue addressed by Basic HSI System or US-APWR
Improvements Regarding the Choice of the Type of Touch Panel Operation Device	There are following three types of touch panel operation devices that can be used in a control panel for monitoring and controlling a fossil fired power plant or for similar purposes in other industries. -Infrared type -Ultrasonic type -Resistive touch type These three touch screen features are summarized in attached table 4a. One of them is the infrared type, which was mainly used in many applications since its capability to withstand contamination by water droplets or the like was highly valued. However, the infrared type had a parallax problem where the touched location and the sensed location did not coincide, thereby degrading the operability.	Basic HSI System Considering the fact that the control panel itself will be placed in a relatively environmentally favorable location such as the main control room, we have come to a conclusion that we do not have to take contamination such as water droplets into consideration. Accordingly, the ultrasonic type touch panel, which has superior performance in terms of the resolution for position detection and the operability, has been chosen. The above ultrasonic touching technology is applicable to both of Operational VDUs and Safety VDUs US-APWR No additional feature

Operating Experience Review
(DCD 18- 3,45,46,48,49)

- DCD revised
  - ✓ Source of OER (18-3)
    - NUREG 6400 and subsequent US and Japanese LERs and SERs
    - Chapter 18 will be revised to delete plant specific OER for potential US-APWR applicants
- Phase 1a V&V report MUAP-08014 will be revised
  - ✓ Correct references (18-46)
- Explanation
  - ✓ Training for personnel who conducted OER (18-45)
  - ✓ OER HEDs encompasses all issues related to human performance, not just risk significant (18-48)
  - ✓ Plant personnel interviews were conducted during Phase 1 V&V (18-49)

Functional Analysis and Allocation
(TR 18.0-30, 31, 71)

- Explanation
  - ✓ US-APWR FRA/FA report includes prior FRA/FA analysis that is pertinent to the US-APWR (18.0-30,71)
    - The Standard Japanese HSI has been applied only to conventional PWRs that have the same historical function allocations as PWRs in the U.S.
      - Unchanged FA is described in the US-APWR report
      - Therefore, there is no reason for the Staff to review the FRA/FA for the Japanese reference plant in more detail
  - ✓ TR provides key elements of FRA/FA (18.0-31)
    - Additional FRA/FA content is described in plant licensing documentation FRA/FA plan
      - Eg. DCD Section 18.2 provides a comprehensive FRA/FA Implementation Plan

Functional Analysis and Allocation

(DCD 18- 28,29,30,31,32,33,34,35)

➢ Explanation

- ✓ MUAP-09019 submitted June 2009 includes the FRA/FA Implementation Procedure and Report

Task Analysis

(TR 18.0-32: Situation Awareness Analysis)

- Explanation
  - ✓ A key design basis of the Basic HSI System
    - Ensure situation awareness by displaying key information related to a small set of critical safety and power production functions, and their support systems
  - ✓ Basic HSI includes LDP SDCV features which directly support situation awareness for critical functions and support systems
    - – Not in Auto, Trend arrows
    - – OK Monitor, BISI, CSF Status, Partial Trip
    - – Indications and alarms
    - Features were demonstrated to be effective in Phase 1 V&V
      - – Through specific scenario tests and converging measures
      - – Effectiveness will be reconfirmed for plant specific applications in Phase 2 V&V using the same methods
  - ✓ Task analysis in Phase 2b encompasses the operators supervisory role in monitoring critical functions
    - Includes monitoring automated systems and execution of backup actions if the system fails

Task Analysis
(TR 18.0-37: GOMS Timing Analysis)

- Explanation
  - ✓ GOMS is used to estimate the time required for risk important human actions (HA)
    - Provides preliminary confirmation that the HA can be completed within the time limits identified in the PRA and safety analyses
  - ✓ A second table-top method provides an independent check
    - Conducted by operations experts
  - ✓ TA Implementation Procedure includes three analysis methods - OSD, GOMS and the table top evaluation
    - These methods fulfill the NUREG-0711, Rev. 2 criteria for Task Analysis.

Task Analysis
(DCD 18- 4,5,27,43,64)

➢ Explanation

- ✓ A plant specific TA is provided for the US-APWR (18- 4, 5)
- ✓ MUAP-09019 submitted June 2009 includes the TA Implementation Procedure (18- 27)
- ✓ TA is based on single RO (18- 43)
  - Based on Phase 1 V&V, two RO condition is not limiting

Note:
Response for 18-64 is outstanding

Staffing Analysis

(TR 18.0-38)

- Explanation
  - ✓ Staffing basis in Topical Report
    - – Minimum staffing is based on the V&V experience in Japan, described in Appendix B
    - – Maximum staffing is based on current operating practices in the US for conventional PWRs
  - • Tests conducted during Phase 1 V&V confirm the Basic HSI System supports both minimum and maximum staffing
    - – Resolution of outstanding HEDs is in progress
  - ✓ For the US-APWR the Staffing Analysis program element will be conducted during Phase 2b
    - • Encompasses staffing for all safety significant tasks

Staffing Analysis
(DCD 18- 1,2,27)

- ➢ TR revised
  - ✓ Delete SA as COL applicant responsibility (18- 1)
- ➢ Explanation
  - ✓ TR SA pertains only to MCR (18- 2)
    - Intent is to support Basic HSI System only

HRA
(TR 18.0-40, 42, 43, 44)

- TR revised
  - ✓ Process to integrate risk-important HAs into the HFE program
    - HFE design team identifies performance shaping factors
    - HRA assumptions validated by operators using table top
    - V&V Team designs V&V activities to specifically address human performance for risk-significant HAs
    - Associated tasks and scenarios are specifically addressed during FRA, TA, HSI design, procedure development, and training development
- Explanation
  - ✓ MUAP-09019 includes HRA Implementation Procedure and results including
    - Method used to identify risk important HAs
    - HA characterization evaluation which provides input to other program elements

HRA
(DCD 18- 24,25,26)

- Explanation
  - ✓ MUAP-09019 submitted June 2009 includes the HRA Implementation Procedure

HSI Design

(TR 18.0-66,67,68,69,70,72,75 requirements)

- TR revised
  - ✓ Inputs to HSI design (18.0-67,72,75)
    - OER, FRA/FA, HRA, TA, SA, IEC-60964, regulatory guidance
  - ✓ Sources of plant specific requirements (18.0-70)
    - E.g. electrical/mechanical flow diagrams, functional diagrams, tech manuals, design bases documents, setpoint and operating range documents, accident analysis, the D3 coping analysis
- Explanation
  - ✓ Requirements for HSI (18.0-66)
    - Inputs are defined within each Implementation Procedure
  - ✓ I&C system constraints imposed on the HSI design (18.0-68)
    - Program management (Section 5.1.1.2), FRA (Section 5.3.1), TA (Section 5.4.3), HSI Design (Section 5.7.3.1)
  - ✓ Compliance to regulatory criteria (18.0-69)
    - SRP and RG 1.206 identify applicable criteria
    - Design compliance from experience, execution of HFE program

HSI Design

(TR 18.0-71 concept of operations)

- TR revised
  - ✓ Concept of operations
    - Crew composition
    - Roles and responsibilities of individual crewmembers
    - Personnel interaction with plant automation
    - Use of control room resources by crewmembers
    - Methods used to ensure good coordination of crewmember activities
      - – Large display panel, LCSs, Tagging
      - – Distribution of plant data via unit bus, station bus
      - – Voice and video communications systems
        - » Described in plant licensing documentation

HSI Design

(TR 18.0-73,74,75,76 design and test process)

- TR revised
  - ✓ Development of the HSI design concept (18.0-73)
    - Japanese Basic HSI System is starting point
      - – Japanese performance issues are tracked using HEDs
    - US Basic HSI developed through Phase 1 OER and V&V
  - ✓ Process which integrates plant specific HSI inventory with Basic HSI and thereby achieves the key HFE design goals, including (18.0-74)
    - Minimizing interface management and probability of error
    - Situation awareness and crew interaction
  - ✓ Test and evaluation methods (18.0-76)
    - Three phase test program, as detailed in MUAP-09019
    - Results of Phase 1 are also in MUAP-09019
- Explanation
  - ✓ Basic HSI System style guide is developed from the Japanese style guide with (18.0-75)
    - English translation, changes for resolution of HEDs from Phase 1

HSI Design

(TR 18.0-77 HSI design documentation)

- TR revised
  - ✓ HSI documentation
    - Basic HSI System
      - Topical Report
        - » Design basis and functional specifications
      - Style Guide
      - HSI Nomenclature
      - Component Control Design Guide
    - Plant specific HSI System:
      - Graphic display and panel layout drawings
      - HSI database
      - Logic and algorithm diagrams
      - Detailed room and console configuration diagrams

HSI Design

(DCD 18- 50,51,52,53,54,55,56,57,58,59,60,61,62)

- TR revised
  - ✓ Basis of priority of automatic protective functions over manual control except during maintenance (18- 52)
- DCD revised
  - ✓ ITV is not standard for US-APWR (18- 52)
  - ✓ Control error prevention methods (18- 57)
- Explanation
  - ✓ Radioactivity control is within Containment Integrity as in most Westinghouse PWRs (18- 50)
  - ✓ Conformance to NUREG0711 criteria for information sources from each HFE program element (18- 51)
  - ✓ Style Guide will be available for audit by 12/2009 (18- 56)
  - ✓ HRA input into design (18- 57)

Note:
Response for 18-53, 55 are in TR RAI response 18.0-71, 72
Response for 18-54 is in TR RAI response 18.0-73
Response for 18-58-62 are outstanding

Operating Procedure Development

(TR 18.0-45,46,50)

- TR revised
  - ✓ Procedure basis (18.0-46)
    - Task analysis, guidelines from system designers, prior plant references, HEDs requiring procedure emphasis
- Explanation
  - ✓ Interface between procedure development and HFE (18.0-45)
    - For US-APWR demonstrating compliance to NUREG-0800 Section 13.5 is COLA responsibility
    - For HSI modernization in operating plants, compliance will be demonstrated in the plant specific licensing document
  - ✓ EOP development (18.0-50)
    - Entry conditions are the same as Westinghouse PWR
      - – Symptoms requiring reactor trip or safety injection
    - Highest level EOP lead operators to event specific EOPs, or symptom-based EOPs
    - Draft ERG will be completed by the end of 2009
    - Detailed design-specific bases and equipment details by 2012

Operating Procedure Development

(TR 18.0-51,52,54)

- TR revised
  - ✓ V&V and modification process (18.0-51)
    - Process used to verify that the procedures are correct
    - Procedure validation using an integrated full scope system simulation
    - Process for modifying procedures
  - ✓ Compliance to CBP criteria in ISG-05 (18.0-52)
    - Including criteria for backup procedures
  - ✓ Procedure accessibility (18.0-54)
    - Figures for the MCR and RSR
    - Requirements for local controls
    - Description of the hierarchical numbering within the procedure writer's guide

Operating Procedure Development

(DCD 18- 37,38,39,40,,41,42,44)

- DCD revised
  - ✓ To explain US-APWR Procedure Writer's Guide (18-37)
  - ✓ Clarify V&V encompasses degraded HSI (18-41)
- TR revised
  - ✓ Storage and laydown for paper procedures (18-42)
  - ✓ Procedure changes after validation (18-44)
- Explanation
  - ✓ Contents of HFE Implementation Plan
    - Procedure Writer's Guide developed during Phase 2 (18- 38)
    - HFE Program Implementation Procedure describes
      - Two phase procedure development (18- 39)
      - Procedure V&V process (18-40)
  - ✓ References in TR (18-41)
  - ✓ V&V of CBP and paper is documented in Phase 1 V&V report and will be reassessed in Phase 2b (18-41,42)
    - Includes accessibility
    - Therefore NRC review of Japanese CBP V&V is unnecessary

Training Program Development

(TR 18.0-55,58,59,60,64,65)

- TR revised
  - ✓ Training program is developed in cooperation with the licensee's training department (18.0-55, 59, 64)
    - The training program development plan is provided in plant licensing documentation
    - Division of responsibility is in plant specific Implementation Procedure
  - ✓ Basis for the training program (18.0-58)
    - Plant design and HFE program documentation
    - HEDs requiring training emphasis
  - ✓ Training tools (18.0-60)
    - Full scale simulation,
    - Classroom training with comparable computer based simulation
  - ✓ Training program modifications and retraining (18.0-65)
    - Regulations, human performance monitoring, plant modifications

Training Program Development

(DCD 18- 36, 47)

- DCD revised
  - ✓ Training approach clarified to specify personnel, plant conditions, activities, locations (18- 47_1)
- TR revised
  - ✓ Training effectiveness (18- 47_6)
  - ✓ Retraining (18- 47_7)
- Explanation
  - ✓ Training program developed per NEI 06-13A and IAEA's systematic approach to training (18- 36)
    - Subject matter and technical content per Japanese experience
  - ✓ Conformance to NUREG0711 criteria (18- 47_2,3,4,5)
    - Details of development program are in Training Program Implementation Procedure
    - Including specific organization roles, qualifications, facilities and resources

V&V

(TR 18.0-78 Plan and Procedures)

- TR revised
  - ✓ Phased V&V plan
    - Phase 1 is generically applicable to all applications of the Basic HSI System and will not be repeated
    - Phase 2/3 will be repeated for each plant/site
      - – Phase 2/3 for US-APWR will be extensive
      - – Subsequent Phase 2/3 V&V will focus on changes from the US-APWR
    - TR provides key elements of V&V
    - V&V plan is in plant licensing documentation
      - – Eg. For the US-APWR DCD Section 18.10
    - Plant specific Implementation Procedures and Reports
      - – Eg. For the US-APWR MUAP-08014 and 09019
      - – US-APWR Phase 2 V&V procedure in development

V&V

(TR 18.0-79,80 Measurements)

- TR revised
  - ✓ V&V qualitative assessment methods (18.0-79)
    - Post-scenario operator forms (including 5-point Likert rating questions)
    - Post-scenario observer form
    - Final operator feedback forms (including 5-point Likert rating questions)
    - HED forms
  - ✓ Specific assessments for situation awareness (18.0-80)
    - Ability to maintain the ‘big picture’
      - Current plant state and direction of process variables
    - Ability to maintain awareness of the critical plant safety functions
    - Ability of the SRO to adequately supervise operator activities

V&V

(DCD 18- 63)

- TR revised
  - ✓ Process for V&V of procedures
  - ✓ Process for modification of procedures
- Explanation
  - ✓ 3 phase V&V is explained in MUAP-09019 HFE Overall Implementation Procedure
  - ✓ Results of Phase 1 are in MUAP-09019 Phase 1b V&V Report

Design Implementation
(TR 18.0-81)

- TR revised
  - ✓ Plant modernization process
    - Same analysis, design and V&V process as for new plants
    - Integrated validation using a full scope simulator
    - Inspections and tests to confirm the implemented HSI System is consistent with the validated HSI System
      - – Changes after validation, are assessed for risk significance – scope and safety functions
        - » Some or all of the previous HFE elements are re-executed

Design Implementation
(DCD 18- 21,22,23)

- Explanation
  - ✓ US-APWR Procedure for Design Implementation is developed during Phase 2b

Human Performance Monitoring

(TR 18.0-83)

- Original MHI Response
  - ✓ The human performance monitoring program is developed in cooperation with the training department of the COL or **existing applicant**. The human performance monitoring program will be described in plant licensing documentation
- TR revised
  - ✓ The words “existing applicant” will be changed to “potential applicant to apply HSI modernization”

Human Performance Monitoring

(DCD 18- 20)

- Explanation
  - TR which clarifies development of Human Performance Monitoring program is responsibility of licensee

Documentation for Japanese HFE Program
(TR 18.0-85)

- Explanation
  - ✓ Phase 1 V&V demonstrates the Basic HSI System
    - – Conforms to HFE design principles
    - – Will enable personnel to successfully and safely achieve operational goals
  - Achievement of these goals has been demonstrated through
    - – Person-in-the-loop testing
    - – Using a full scope dynamic simulator
    - – With licensed US operators
  - Therefore Phase 1 V&V compensates for a lack of formal documentation in the Japanese HFE program
  - For each application of the US Basic HSI System, MHI will generate plant specific Implementation Plans, Implementation Procedures and Reports for each HFE Program Element

US-APWR DCD and COL Items
(TR 18.0-86)

- Explanation
  - ✓ Program elements completed during the DCD review
    - – OER, FRA/FA, HRA and TA
  - ✓ Program elements covered by ITAACs
    - – SA, HSI Design, V&V, Procedures, Training, Implementation, Human Performance
  - The COL applicant is responsible for fulfilling the licensing commitments related to all ITAACs
    - – While MHI expects to lead most activities related to each of these program elements, the division of responsibility between MHI and the COL applicant is a commercial issue, which is outside the scope of licensing review