Human Factors Engineering Program for the US-APWR

June 4, 2008

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US-APWR Overview

- **Plant**
  - ✓ Evolutionary 4 loop PWR
  - ✓ Based on Japanese -APWR – Tsuruga Units 3&4
  - ✓ 1700 Mwt
  - ✓ 4 train active safety systems
  - ✓ Full digital I&C and HSI
- **Licensing Documentation**
  - ✓ Four topical reports submitted for digital I&C and HSI March to May 2007
    - Safety I&C System Description and Design Process
    - Safety System Digital Platform - MELTAC
    - HSI System Description and HFE Process
    - Defense in Depth and Diversity
  - ✓ Design Certification Document submitted December 2007
  - ✓ COLA for Comanche Peak 3&4 will be submitted later this year

US-APWR HSI Reference Design

- **US-APWR HSI System is being developed from MHI's Japanese Standard HSI System, with additional consideration for:**
  - ✓ US operating methods and procedures
  - ✓ US ergonomic and cultural differences
  - ✓ Updated Operating Experience Review
  - ✓ Updated plant specific HFE analysis and HSI design for the US-APWR

US-APWR HSI Reference Design

- **Japanese Standard HSI System:**
  - ✓ Development process included all NUREG 0711 elements
  - ✓ Including validation by approximately 200 Japanese nuclear power plant operators using a MCR simulator
  - ✓ Will be operational in several Japanese nuclear power plants in the near future
    - Tomari Unit 3 (New Construction Plant)
    - Ikata Unit 1&2 (MCR & I&C replacement/updating)
    - NTC-4 (New facility in Japanese PWR training center)
- **US-APWR HFE program reassesses each NUREG 0711 HFE program element, with emphasis on changes from prior experience**
  - ✓ DCD describes applicability of prior HFE and new activities specific to US-APWR

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

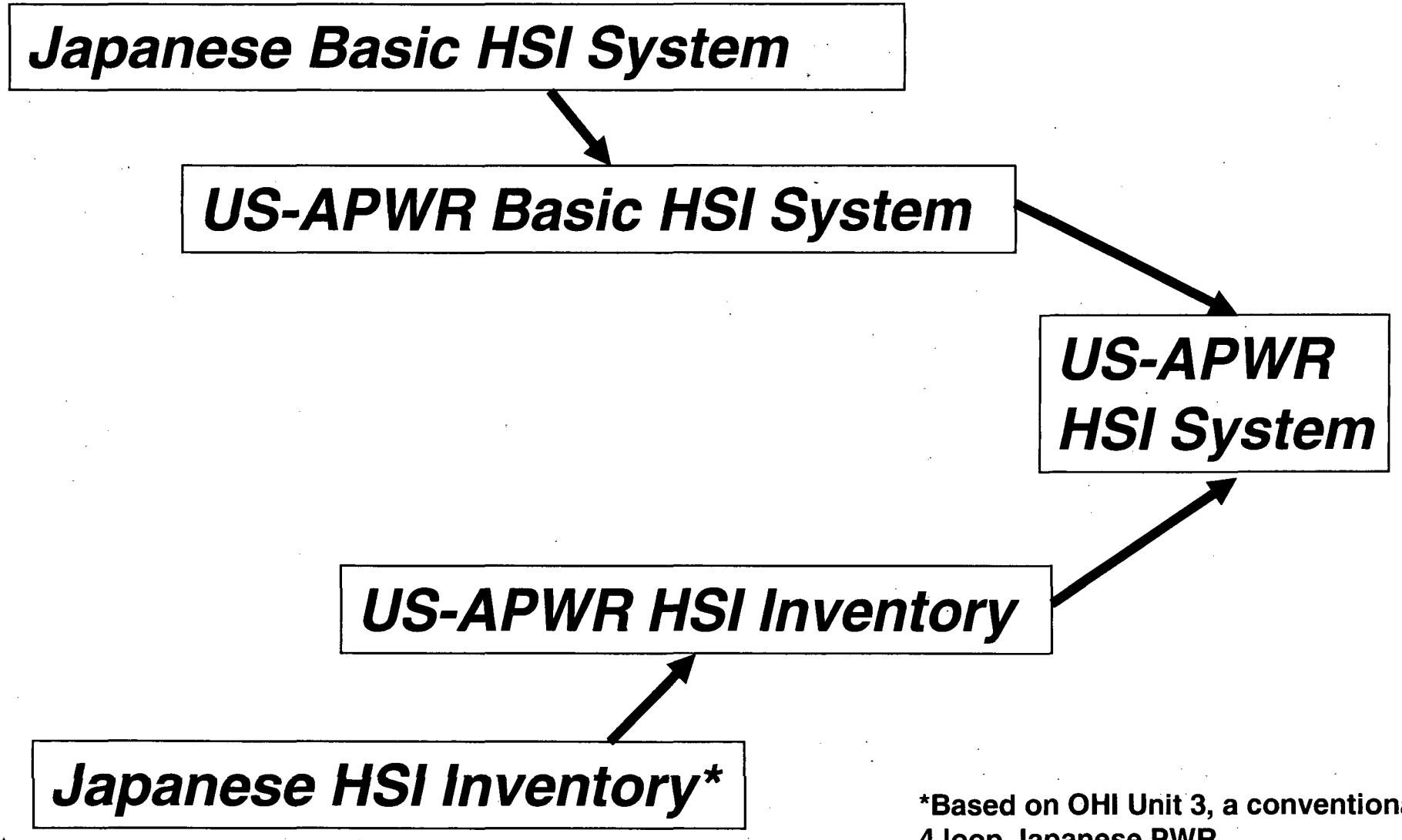
Japanese Plant HSI System
US-APWR HSI System

HSI Inventory

Plant specific alarms, displays, controls, procedures:

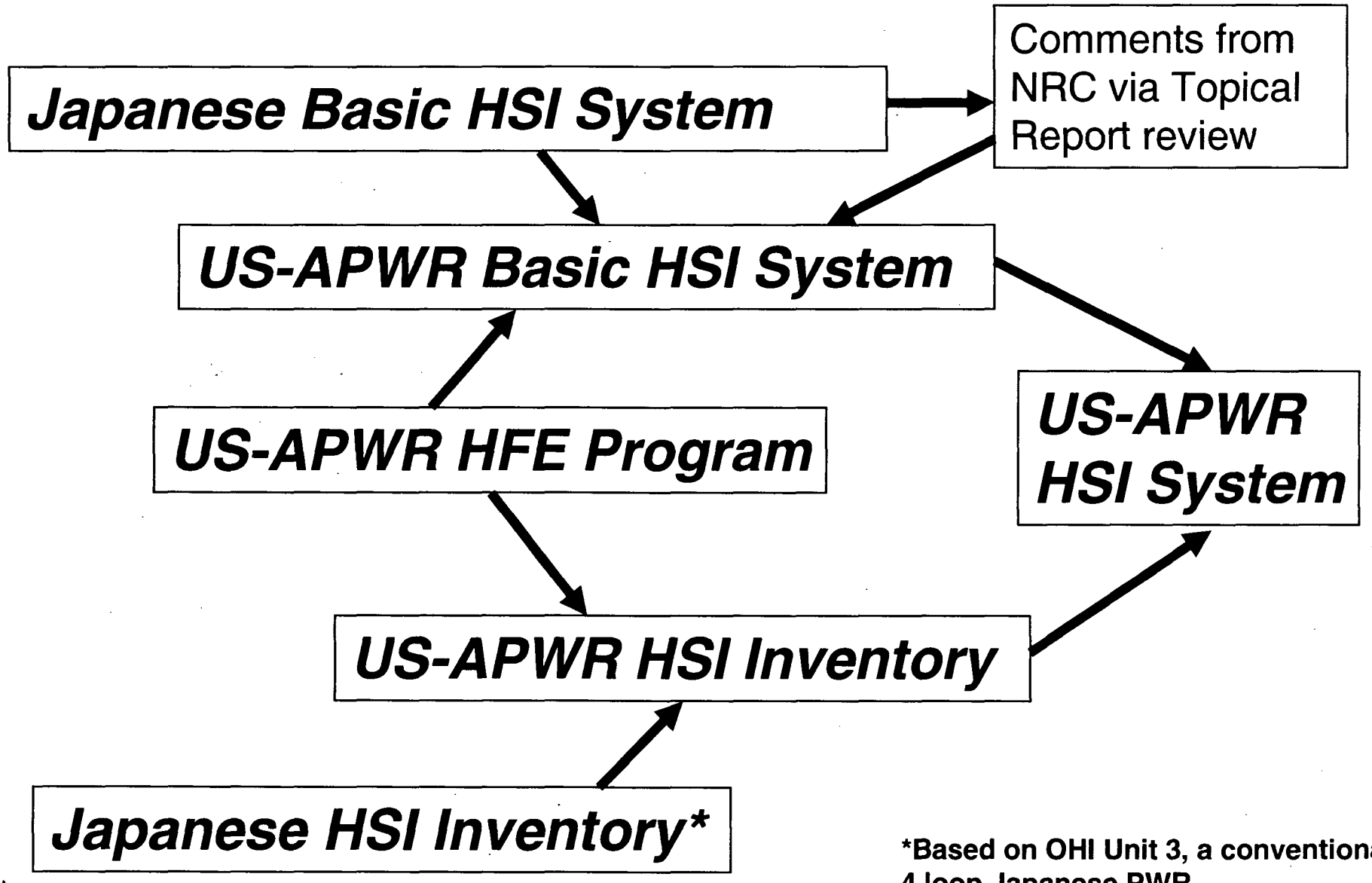
- For all plant systems and tasks
- For all HSI media
- eg. the specific instruments, components and alarms shown on the LDP

US-APWR HSI System



*Based on OHI Unit 3, a conventional 4 loop Japanese PWR

US-APWR HSI System



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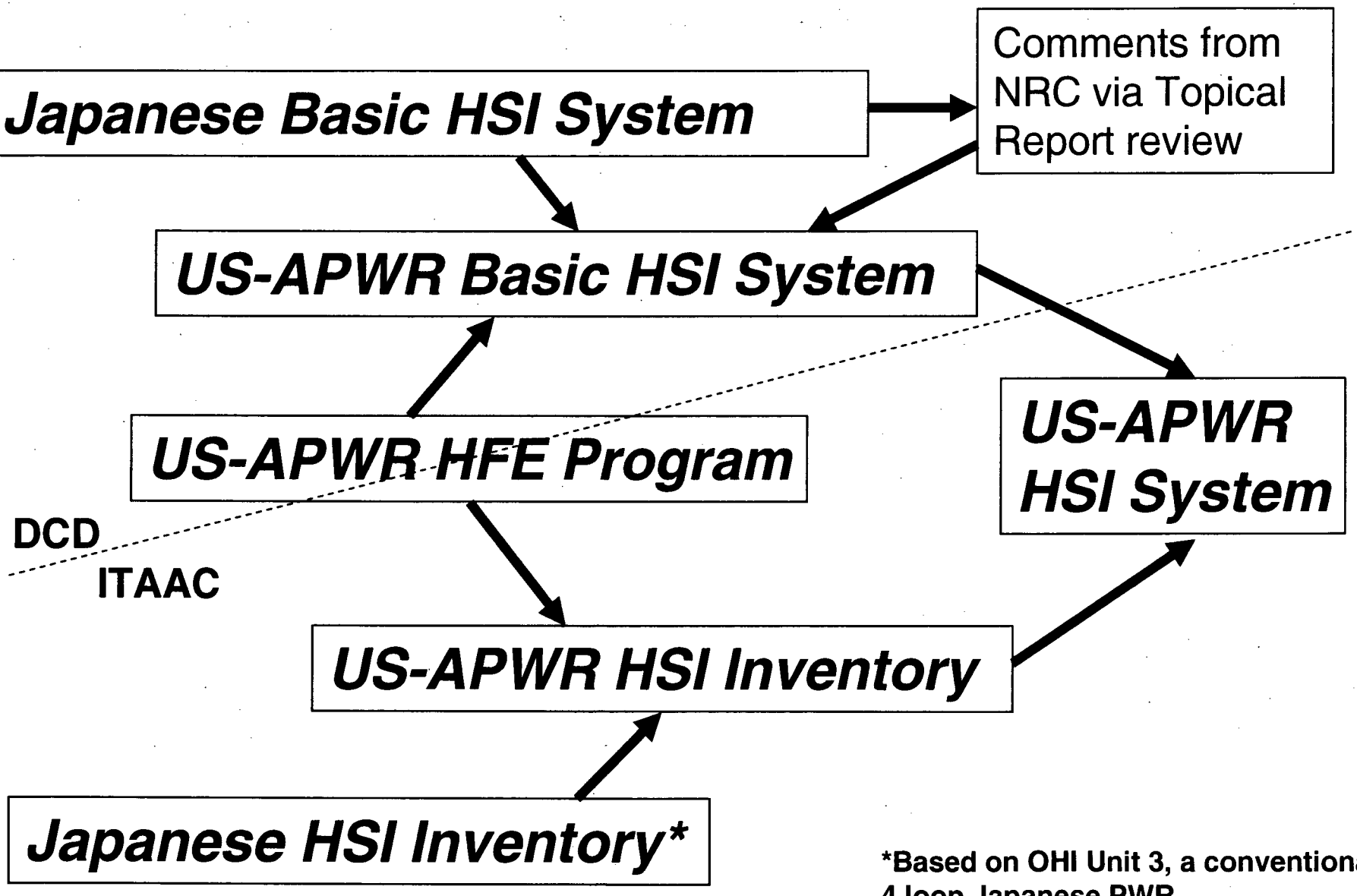


*Based on OHI Unit 3, a conventional 4 loop Japanese PWR

US-APWR HFE Process

- **There are several phases in the US-APWR HFE Program**

  - ✓ Phase 1a – US Assessment of Japanese Basic HSI System
    - Identify any changes needed from Japanese Basic HSI System
    - Completion 12/2008
  - ✓ Phase 1b – US-APWR Basic HSI System
    - Design, verify and validate any changes needed from Phase 1a
    - Completion 6/2009

  - ✓ Phase 2 – US-APWR HSI System
    - Design, verify and validate HSI inventory for US-APWR
    - With site specific assumptions
    - Completion 6/2012

  - ✓ Phase 3 – Plant Specific HSI System (CPNPP 3&4)
    - Site specific design change process
    - If needed
    - Completion 9/2012

US-APWR HFE Process

- **There are several phases in the US-APWR HFE Program**

DCD

- ✓ Phase 1a – US Assessment of Japanese Basic HSI System
  - Identify any changes needed from Japanese Basic HSI System
  - Completion 12/08
- ✓ Phase 1b – US-APWR Basic HSI System
  - Design, verify and validate any changes needed from Phase 1a
  - Completion 6/09

ITAAC

- ✓ Phase 2 – US-APWR HSI System
  - Design, verify and validate HSI inventory for US-APWR
  - With site specific assumptions
  - Completion 6/12

COLA

- ✓ Phase 3 – Plant Specific HSI System (CPNPP 3&4)
  - Site specific design change process
  - If needed
  - Completion 9/12

Phase 1a

- **US Assessment of Japanese Standard HSI System**
  - ✓ Purpose is to identify any changes needed in the Japanese Basic HSI System for US applications
  - ✓ Phase 1a has two key activities
    - Operator Verification and Validation
    - Operating Experience Review

- **DAC closure report 12/08**
  - ✓ Identified in DCD submittal letter as

    "US operator static V&V results (including HFE analysis results)" Technical Report

Phase 1a – V&V

- **Conducted using static and dynamic simulation**
- **Simulation is based on OHI Unit 3, which is a 4 loop conventional PWR in Japan**
  - ✓ Plant model
  - ✓ HSI inventory
- **Simulation represents Japanese Standard HSI System with obvious changes required for US**
  - ✓ Converted to English and US engineering units
  - ✓ Physically adjusted for US population ergonomics
  - ✓ Operating procedures are CPNPP 1&2 modified for OHI
    - Based on early assessment by Luminant operators
      - Japanese procedures are guides, not sequential directives

Phase 1a – V&V

- **The Japanese Standard HSI System does not include all the basic HSI *features* of the US-APWR Basic HSI System**
  - ✓ Eg.
    - Bypassed and Inoperable Status Indication (BISI)
      - Spatially dedicated continuously visible (SDCV) at the system level
    - Tag-out
    - Customized trend set
    - Operational VDU disable function on Safety VDU
    - Diverse Actuation System HSI Panel (DHP)

- **Additional V&V for these US-APWR Basic HSI *features* will be conducted in Phase 1b**

Phase 1a – V&V

- **V&V is conducted by US operators and US HFE experts**
- **Based on formal V&V procedures and training material**
- **Participants identify Human Engineering Deficiencies**
  - ✓ HEDs are entered and tracked to resolution using the HFE Issues Tracking System (HED data base)
  - ✓ HEDs are expected due to
    - Simulation errors - incorrect representation of HSI System
    - HSI inventory errors - procedure/display mismatch
    - Personal preferences
    - Design deficiencies
  - ✓ HED database identifies basis for disposition of all HEDs

Phase 1a - Verification

- **Verification is a review of static displays presented on a PC with screen size comparable to Operational VDUs**
  - ✓ By HFE expert
    - For NUREG0700 conformance
  - ✓ By US operators
    - For HSI usability
      - Can tasks be performed without
        - » Excessive screen navigation
        - » Excessive training
    - For HSI inventory and procedure consistency
      - A complete task verification for the US-APWR is conducted in Phase 2
    - Goal is to engage all operators who will be involved in validation

Phase 1a - Verification

- **Verification encompasses**
  - ✓ All Basic HSI *features*
  - ✓ All displays used during Validation
- **Review is unbounded, but guided by checklists**
- **V&V report documents**
  - ✓ Reviewers and qualifications
  - ✓ Display inventory
  - ✓ HED summaries
- **Some HEDs will be corrected prior to Validation**
    - HEDs that should be corrected
    - HEDs that can be corrected on time
  - ✓ Operators will be trained on other HEDs that impact Validation scenarios

Phase 1a - Validation

- **Validation is conducted using the MEPPI simulator facility**
- **By eight different operating crews from CPNPP 1&2**
  - ✓ 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)
- **Over a 4 day duration, each crew will**
  - ✓ Receive ~3 hours of class room training
  - ✓ Assess MCR ergonomics
  - ✓ Conduct several dynamic test scenarios
- **Dynamic tests were selected, with Luminant operator input**
  - ✓ Scenarios that typically challenge operator workload and/or performance

Phase 1a - Validation

- **Dynamic test scenarios**
  - ✓ Normal HSI (using normal and safety success paths)
    - 100% Power (Hands-on HSI familiarization)
    - Rod drop
    - Rx Trip
    - LOCA
    - SGTR
    - Heatup
    - Cooldown
  - ✓ Loss of all non-safety HSI (using only safety success paths)
    - 100% Power continued stable operation
    - Rod drop followed by Rx Trip (no ability for rod recovery)
    - LOCA
    - SGTR
    - Cooldown

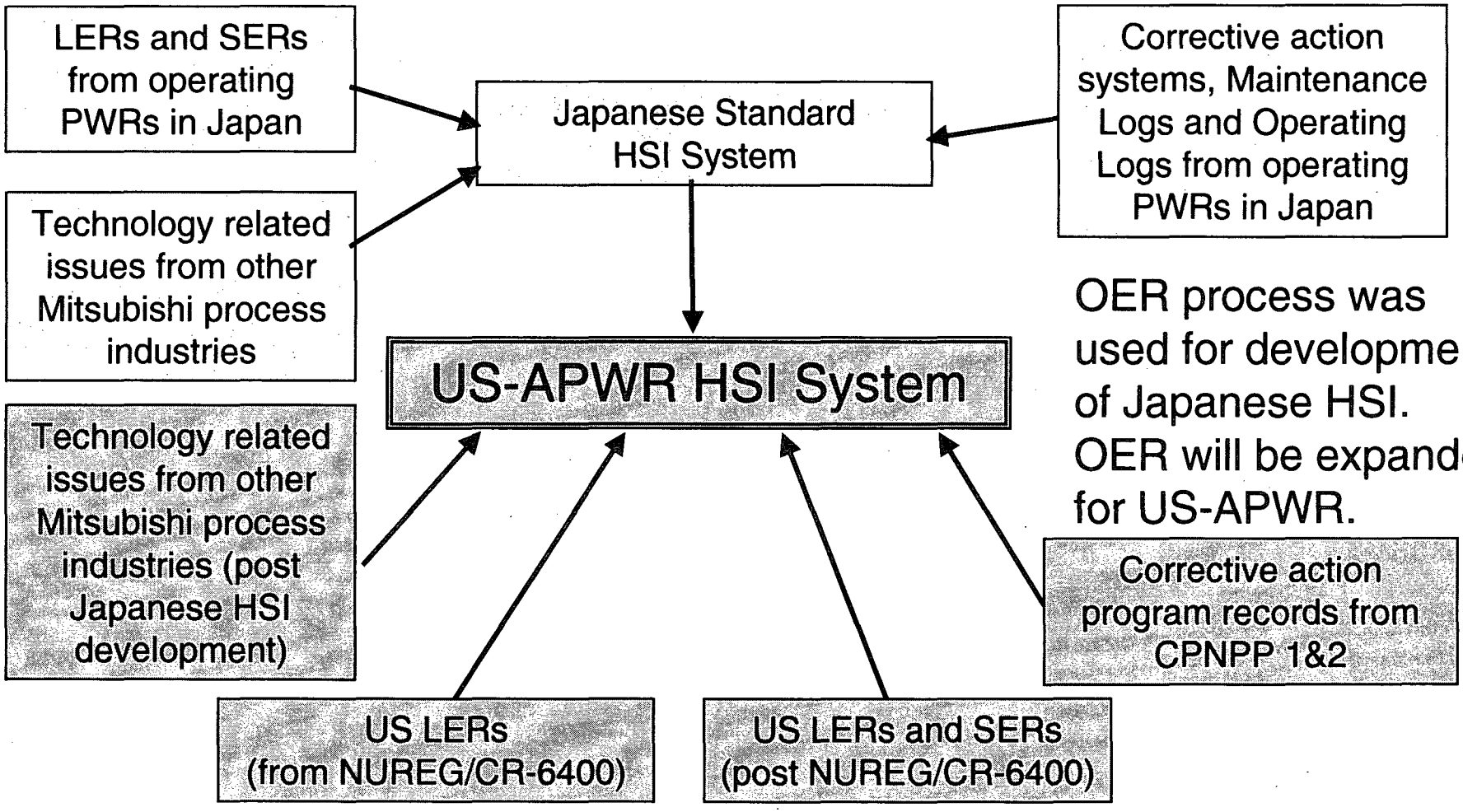
Phase 1a - Validation

- **Scenarios for abnormal events are conducted from 100% power to plant stabilization**
- **Due to time limitations, some scenarios have breakpoints with fast-forward reinitialization to accelerate time**
- **To identify HEDs**
  - ✓ Operators will be observed by HFE experts
  - ✓ After each scenario operators will
    - Complete evaluation forms
    - Be interviewed by HFE experts
- **Review is unbounded, but guided by checklists**
- **V&V report documents**
  - ✓ Participants and qualifications
  - ✓ Simulator configuration (HSI and plant model)
  - ✓ HED summaries

Phase 1A - Operating Experience Review

- **Object of the Operating Experience Review (OER)**
  - ✓ Ensure the US-APWR HSI System minimizes the potential for reoccurrence of previous human performance problems
    - Within the nuclear industry
    - Within process industries that utilize similar digital technology

Phase 1A - Operating Experience Review



OER process was used for development of Japanese HSI. OER will be expanded for US-APWR.

Phase 1A - Operating Experience Review

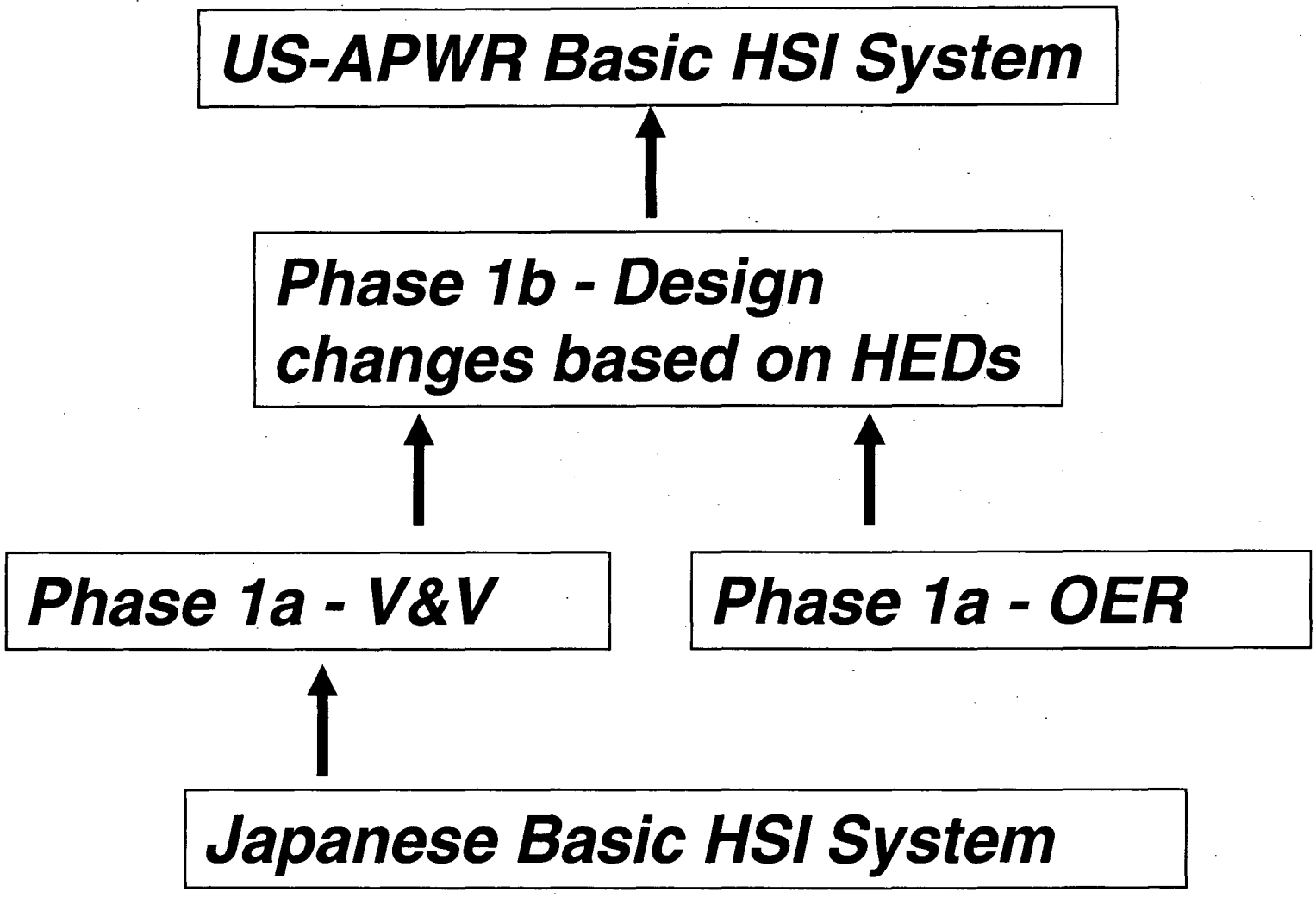
- **OER is based on a formal procedure**
- **Reviewers identify issues**
  - ✓ Considered to not be fully resolved by the US-APWR design
  - ✓ HEDs are entered and tracked to resolution in the HFE Issues Tracking System (HED data base)
  - ✓ HED database identifies basis for disposition of all HEDs
- **OER report documents**
  - ✓ Reviewers and qualifications
  - ✓ Information sources
  - ✓ HED summaries

Phase 1b

- **Design changes from the Japanese Standard HSI System, for the US-APWR HSI System, may result from Human Engineering Deficiencies identified in Phase 1A**
  - ✓ V&V
  - ✓ Operating Experience Review
- **Changes applicable to the US-APWR <u>Basic</u> HSI System will be developed, verified and validated in Phase 1b**
  - ✓ V&V program is still to be determined based on the extent of the required changes
    - Program will also include US-APWR Basic HSI System ***<u>features</u>*** not included in Phase 1a
- **DAC closure report 6/09**
  - ✓ Identified in DCD submittal letter as "HSI design" Technical report

- ***This completes development of the US-APWR <u>Basic</u> HSI System***

Phase 1 – Summary



Phase 2 Overview

- **Phase 2 - US-APWR HSI System**
  - ✓ The analysis and design elements of NUREG0711 are conducted to generate the US-APWR HSI Inventory
    - Specific alarms, displays, controls and procedures for the US-APWR plant systems based on
      - Function allocation
      - Task Analysis
      - HRA

      [OER applicable to HSI inventory, not Basic HSI System]
  - ✓ V&V will be conducted on a US-APWR simulator
    - V&V activities are similar to Phase 1 V&V, but expanded scope
    - HSI design and plant model are specific for the USAPWR
    - Phase 2 V&V will be completed 6/2012
  - ✓ Phase 2 will be discussed in detail at the next meeting

Phases 3 Overview

- **Phase 3 - CPNPP 3&4 Final HSI System**
  - ✓ V&V for plant specific changes, if any, will be conducted using the CPNPP 3&4 plant specific simulator
  - ✓ The simulator is subsequently used for operator training

Summary

- **The US-APWR HSI System is implemented based on the Japanese Standard HSI System**

- **USAPWR HFE program includes:**
  - ✓ V&V of Japanese Standard HSI System for US conformance
  - ✓ Additional US OER
  - ✓ Precise HFE analysis, detailed design and V&V for US-APWR plant systems
  - ✓ A simulator is used throughout multiple phases of the HFE design process