

generation

mPower

*I&C Design and Simulation
HFE and MCR Concepts*

March 22, 2012

© 2012 Babcock & Wilcox Nuclear Energy, Inc. All Rights Reserved. This document is the property of Babcock & Wilcox Nuclear Energy, Inc.



B&W mPower™ I&C Philosophy

- Highly-Reliable, Integrated and Scalable Digital I&C System
- I&C System Must Have Highest Degree of Licensing Certainty
 - Complies with Regulatory, URD Requirements
 - Minimizes Regulatory Challenges with Digital I&C...Cyber-security, Diversity, Independence
- Integrated, Modernized Human-Factored Design
- High-level of Plant Automation
 - Control of Startup, Shutdown, Load Following...support staffing plan
- Deliver Comprehensive O&M Strategy
 - Use of commercially-available components
 - Managed obsolescence



Key Design Attributes of mPower I&C System

- Three+-Layer I&C System

[▶

-

-

▶

▶

▶

]

- Diverse Actuation System (DAS)

[CCI per Affidavit 4(a)-(d)]

[•

]

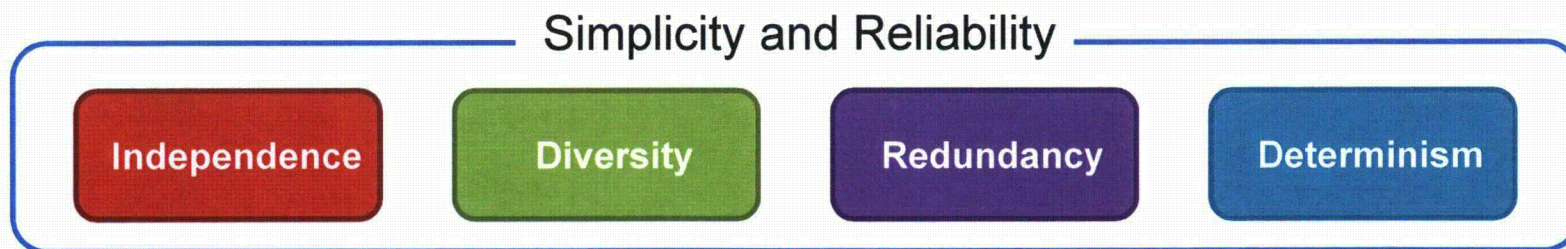
- Separate sensors for DAS (as required by analysis)

- [] coincidence

[CCI per Affidavit 4(a)-(d)]

mPower Plant Control System (mPCS) Development Process

- Traditional systems engineering approach ensures that the mPCS will meet two fundamental directives:
 - NRC Requirements
 - B&W Internal Requirements
- Main Focus on defining basic system architecture, interactions, and hazards analysis.

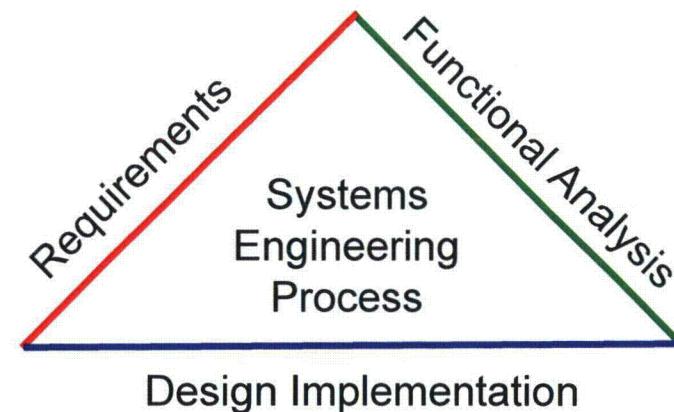


I&C Formative Requirements and Guidance

- The four key sources of authoritative requirements to use as regulatory basis:
 - 10 CFR 50, 10 CFR 52
 - 10 CFR 73.54
 - IEEE 603-1991
 - IEEE 7-4.3.2
- Other relevant documents will be referenced when derived requirements are related to the source document.
 - Regulatory Guides
 - Interim Staff Guidance
 - Branch Technical Positions
 - Industry Standards

Systems Engineering Approach

- mPCS is being developed through a rigorous systems engineering process:
 - Functional Analysis
 - Requirements development
 - Design Implementation



Systems Engineering Approach applied to mPCS Design

- The classic systems engineering “V” model guides the process
- Going down the left side, [requirements, in increasing detail, down to the smallest assembly
- Going up the right side, testing, in decreasing detail, up to the top assembly
- Horizontal Lines indicate verification of requirements for a given level]

[CCI per Affidavit 4(a)-(d)]

Systems Engineering: Functional Analysis

- Functional Analysis Determines what the system needs to do.
- Functional Analysis is an organized, intuitive vehicle for developing requirements.
- Aspects of functional analysis used in this phase are:
 - Use cases
 - Graphical symbols that define what the system must do at a high level
 - Primarily use cases define how a external entity (actor) *uses* the system
 - Activity diagrams
 - An activity diagram defines how an individual function is accomplished
 - A multitude of activity diagrams can fall under a single use case



Top Level I&C Block Diagram

- Layered Approach Supports Independence, Isolation and Cyber-security Imperatives

[

]

[CCI per Affidavit 4(a)-(d)]

7-9



I&C System Allocation for Standard 2-Unit Plant

[

]

[CCI per Affidavit 4(a)-(d)]

7-10

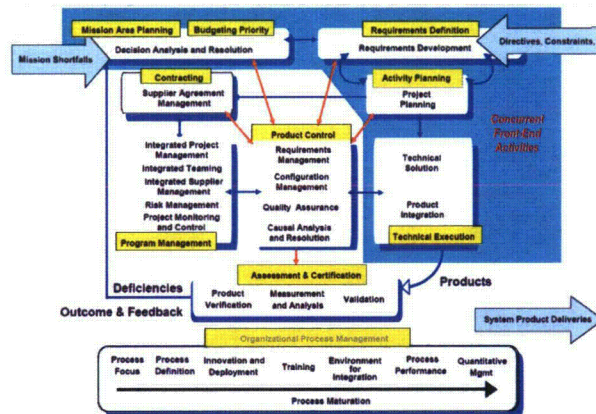
Application of CMMI to Software Quality Assurance

NRC Regulations

GDCs

10 CFR 50, Appendix E

CMMI Assessed Software Development Process



RGs and Standards

Regulatory Guides

Industry Standards

BTP 7-14 Framework

Life Cycle Activity Groups	Planning Activities	Requirements Activities	Design Activities	Implementation Activities	Integration Activities	Validation Activities	Installation Activities	Operation & Maintenance Activities
Software Management Plan	Requirements Specification	Design Specification	Code Listings	System Build Documents			Operations Manuals	
Software Development Plan		Hardware & Software Architecture					Installation Configuration Tables	
Software QA Plan								Design Indicators
Integration Plan								
Installation Plan								
Maintenance Plan								
Training Plan								
Operations Plan								
Software Safety Plan	Requirements Safety Analysis	Design Safety Analysis	Code Safety Analysis	Integration Safety Analysis	Validation Safety Analysis	Installation Safety Analysis	Operation Safety Analysis	
Software V&V Plan	V&V Requirements Analysis Report	V&V Design Analysis Report	V&V Implementation Analysis & Test Report	V&V Integration Analysis & Test Report	V&V Validation Analysis & Test Report	V&V Installation Analysis & Test Report	V&V Change Report	
Software CM Plan	CM Requirements Report	CM Design Report	CM Implementation Report	CM Integration Report	CM Validation Report	CM Installation Report	CM Change Report	

Note: A separate document is not required for each topic identified, however, project documentation should encompass all of the topics.

- Ensure Regulatory Compliance
- Ensure Appraisal Sufficient for NRC Review



Engineering Simulator Development

Engineering Simulator Initiative Scope

- Current
 - Develop Control Logic Schemes and Operator Interfaces
 - Integrate Thermal-hydraulics (RELAP) and Core Neutronics (CASMO/SIMULATE) into Coupled Environment
 - Support HFE analysis
 - Emulate Control Room HSI in HFE development (electronic mockup)
- Future Potential
 - Logic Validation Testing
 - Setpoint methodology verification
 - Support PRA development
 - Build ANS/ANSI 3.5 Simulator



Initial Simulation and Modeling Roadmap



Process Model: Turbine Island & BOP

- Built in GSE software using standard components

- Model based on B&W and Bechtel supplied data

- [
 - ▶
 - ▶
 - ▶
 - ▶
 - ▶]

[CCI per Affidavit 4(a)-(d)]

- Model updated as new data & design modifications become available



Process Model: Turbine Island & BOP

[

]

Integration with HFE

- HFE involved in simulator development
- HFE present at all milestone meetings
- Sample screens supplied to HFE as supplemental material for reference, mark-up, revisions, etc.

[Sample screens included:

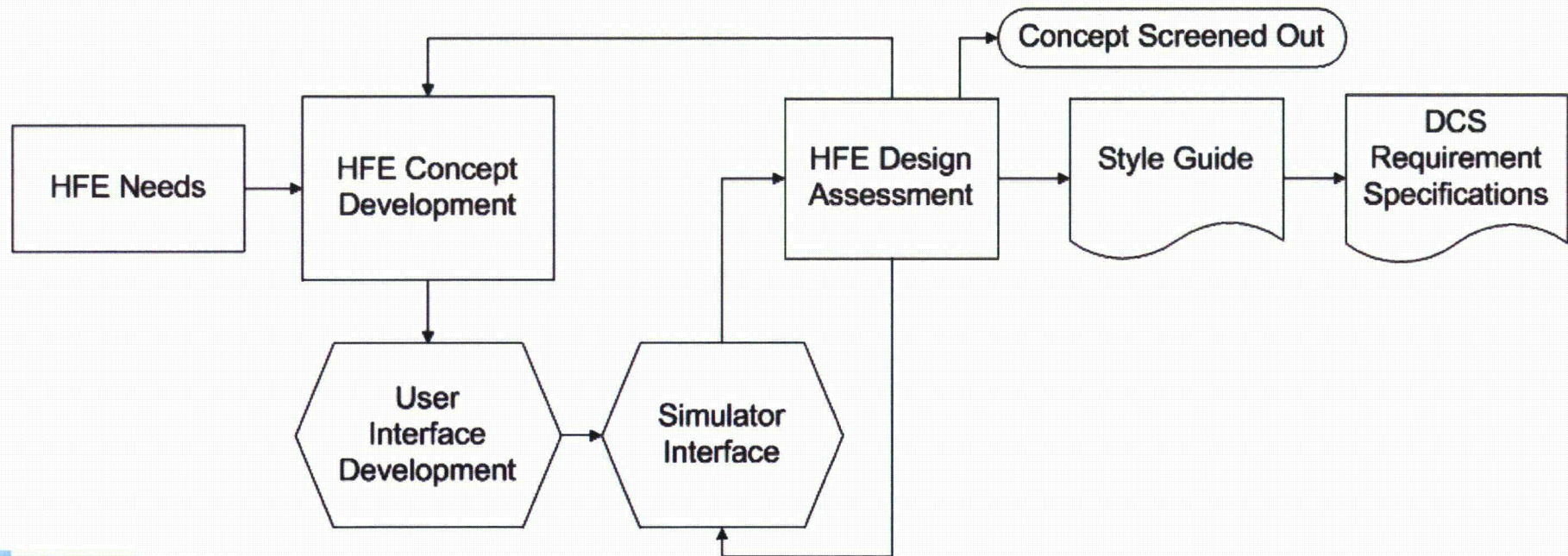
▶

▶

]

[CCI per Affidavit 4(a)-(d)]

User Interface Development





User Interface Selection

[



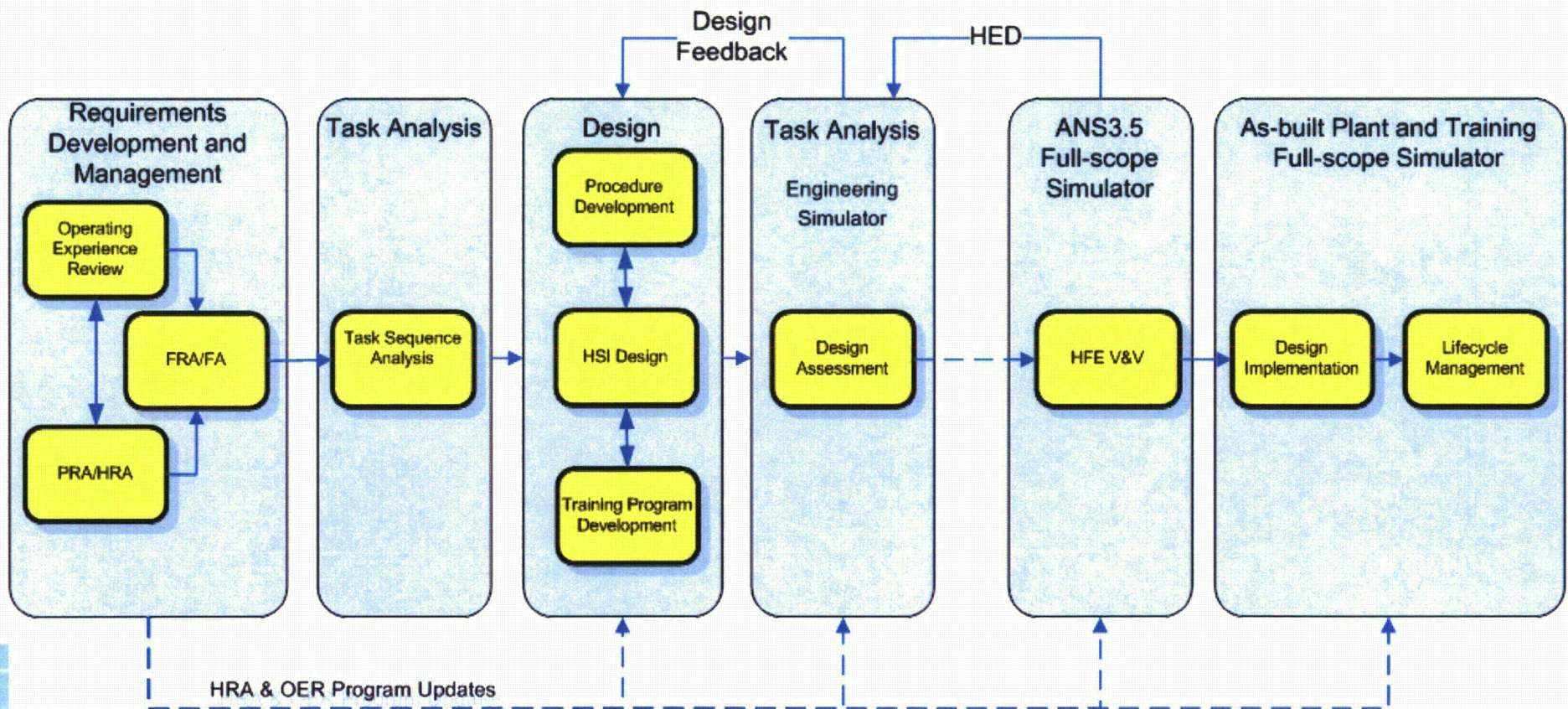
Simulator and User Interface Integration

[

]

[CCI per Affidavit 4(a)-(d)] 7-20

mPower HFE Process Overview





Graded Approach for HFE Program

[CCI per Affidavit 4(a)-(d)]

7-22



Initial Scope of HFE Program

[



Systems to be Designed Using HFE Best Practices

[

]

[CCI per Affidavit 4(a)-(d)]

7-24



Proposed Functional Control Room Layout

[

]

[CCI per Affidavit 4(a)-(d)]

7-25



Integrated Top Level Architecture Overview

[CCI per Affidavit 4(a)-(d)]



Initial Main Control Room Concept

[

[CCI per Affidavit 4(a)-(d)]

]

7-27



Main Control Room Mock-up

[

]



[Operator-at-the-Controls Work Station

]

[CCI per Affidavit 4(a)-(d)]



VDU General Configuration

[

]

[CCI per Affidavit 4(a)-(d)] 7-30



VDU Failure Mitigation

[



Navigation and Control VDUs (three)

[



Coordination with Alarm Trees (on Group-view)

[

]



Alarm and Multi-Trend VDUs

]

[CCI per Affidavit 4(a)-(d)]-34



Main Control Room Concept

[