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I&C Design and Simulation
HFE and MCR Concepts

March 22, 2012

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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

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Key Design Attributes of mPower I&C System

- Three+-Layer I&C System

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

- Diverse Actuation System (DAS)

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  - Separate sensors for DAS (as required by analysis)
  - [ ] coincidence [CCI per Affidavit 4(a)-(d)]

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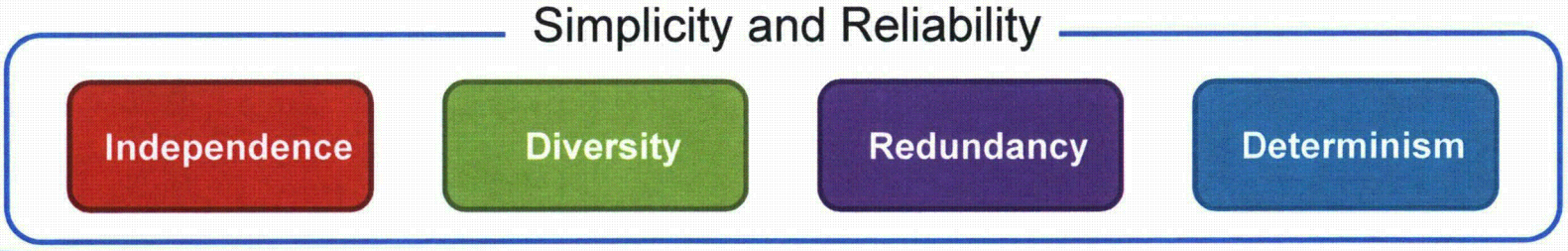
mPower Plant Control System (mPCS) Development Process

- 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.



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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

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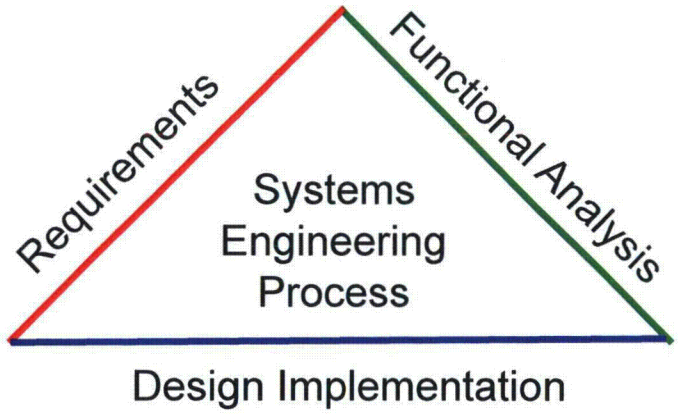
Systems Engineering Approach

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



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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

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

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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

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Top Level I&C Block Diagram

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

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

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I&C System Allocation for Standard 2-Unit Plant

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

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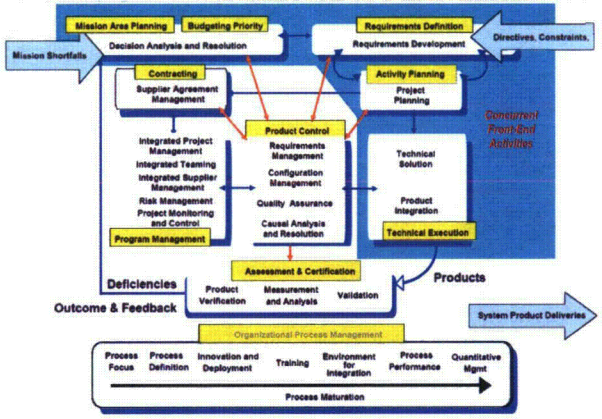
Application of CMMI to Software Quality Assurance

NRC Regulations

GDCs

10 CFR 50, Appendix B

CMMI Assessed Software Development Process



Processes

Instructions

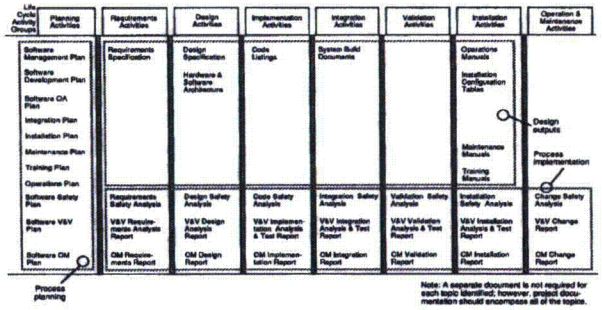
Procedures

RGs and Standards

Regulatory Guides

Industry Standards

BTP 7-14 Framework



- Ensure Regulatory Compliance
- Ensure Appraisal Sufficient for NRC Review

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Engineering Simulator Development

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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

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Initial Simulation and Modeling Roadmap

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

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Process Model: Turbine Island & BOP

- Built in GSE software using standard components
- Model based on B&W and Bechtel supplied data

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

- Model updated as new data & design modifications become available

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Process Model: Turbine Island & BOP

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

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

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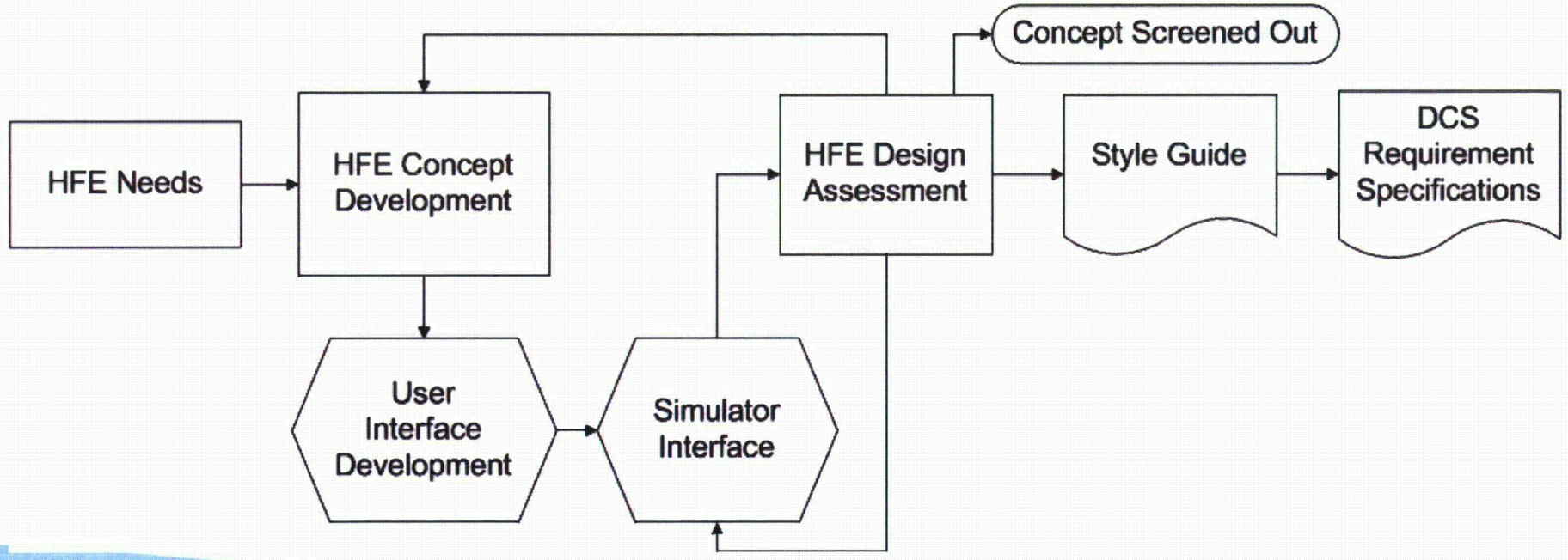
User Interface Development



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User Interface Selection

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

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Simulator and User Interface Integration

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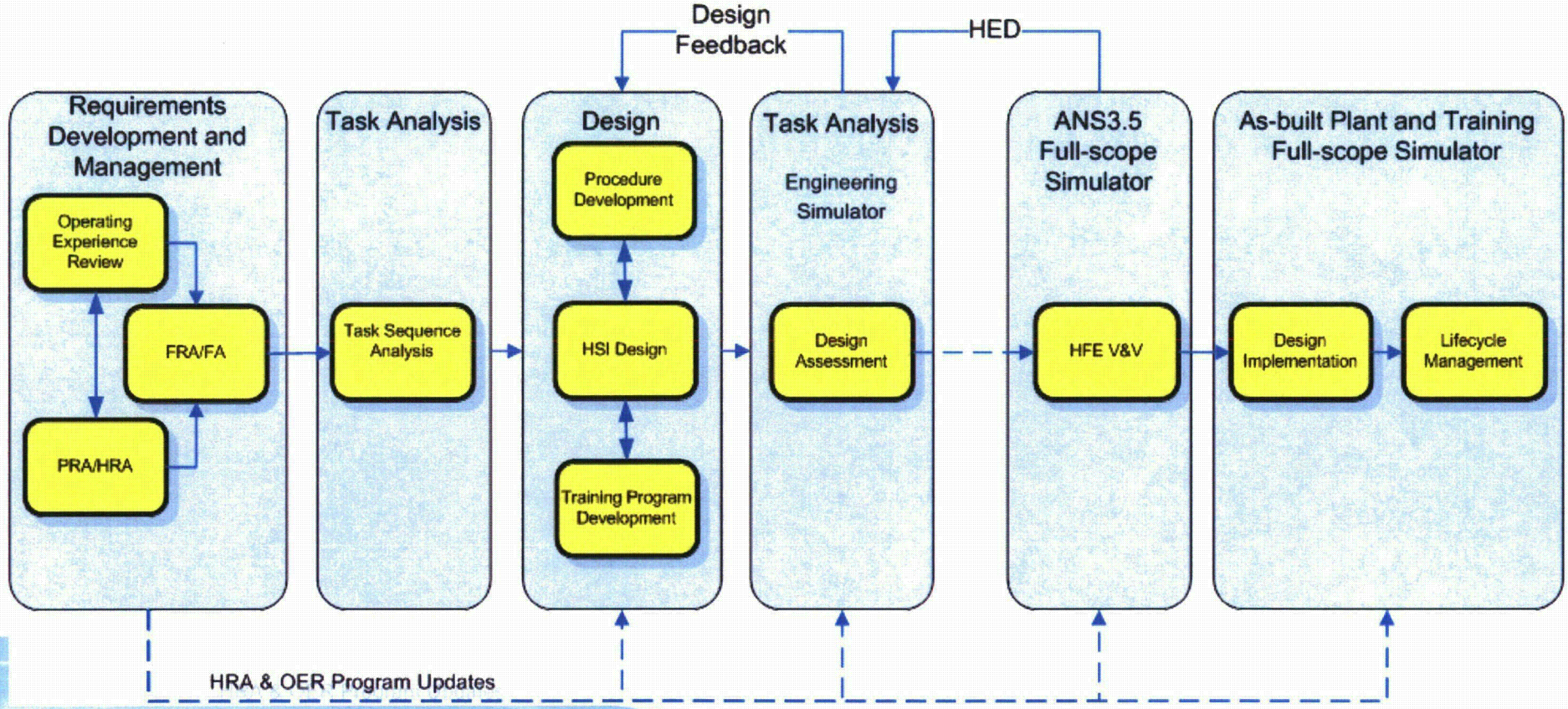
mPower HFE Process Overview



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Graded Approach for HFE Program

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

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Initial Scope of HFE Program

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

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Systems to be Designed Using HFE Best Practices

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Proposed Functional Control Room Layout

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

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Integrated Top Level Architecture Overview

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

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Initial Main Control Room Concept

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

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Main Control Room Mock-up

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

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[Operator-at-the-Controls Work Station

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

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VDU General Configuration

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

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VDU Failure Mitigation

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

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Navigation and Control VDUs (three)

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

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Coordination with Alarm Trees (on Group-view)

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

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Alarm and Multi-Trend VDUs

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

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Main Control Room Concept

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