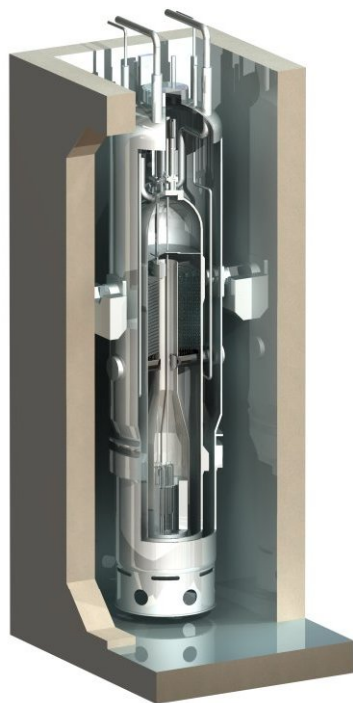




## Human Factors in Advanced I&C Design



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NP-OMM-PM-HFIC-001





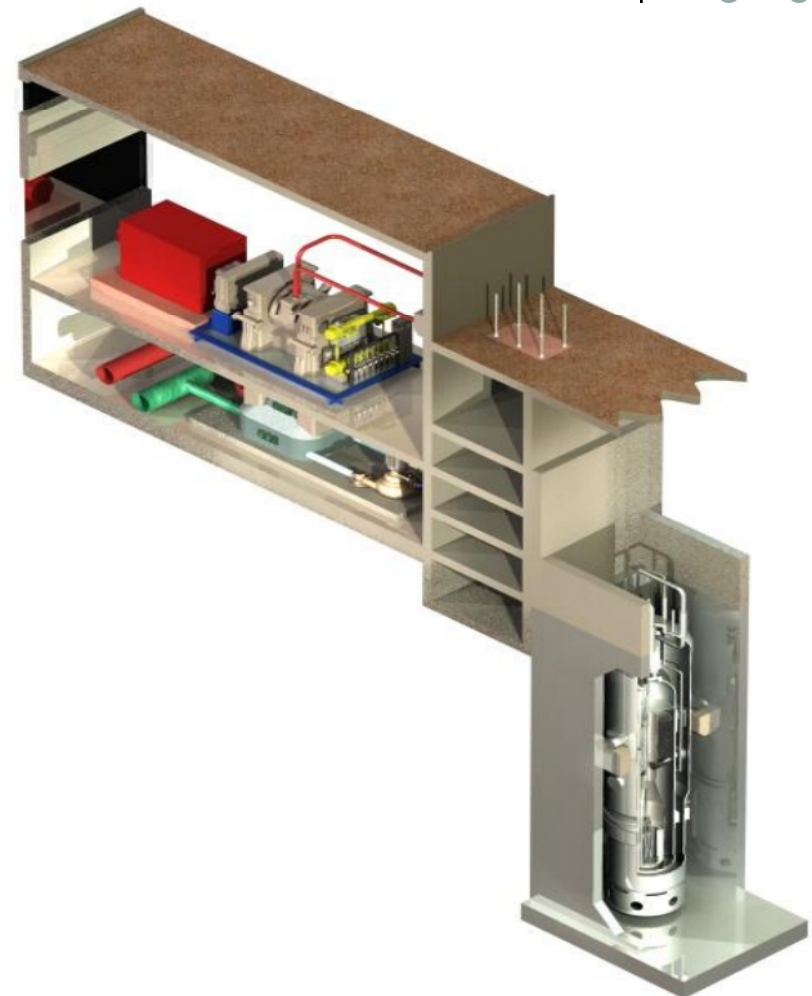
# Meeting Goals

- Describe Concept of operations for Multi-module NuScale Plant
- Provide overview of NuScale Multi-module Control Room MCR and I&C concept to support exemption request
- Describe NuScale staffing concept relative to 50.54(m) and exemption request regarding staffing of licensed personnel
- Identify and discuss any staff concerns regarding NuScale exemption process that follows NUREG-1791
- Describe I&C Concept
- Obtain feedback on process for exemption request and concept for I&C
- Consider topics and schedule for future meetings



# Overview NuScale Power Module Design

- **Simple and Robust Design with passive heat removal systems**
- Maximizes safety and security through use of passive systems, modularity, and multiple fission product barriers
  - Natural circulation eliminates failure modes and need for pumps
  - Integrated power module eliminates unnecessary piping and improves reliability
  - Large-break LOCAs eliminated by design and small break LOCAs do not challenge the safety of the plant
  - Probability of post-DCD design revisions are significantly reduced due to simplicity of the design
- The NuScale design is based on decades of LWR experience and incorporates numerous innovative safety and security enhancements



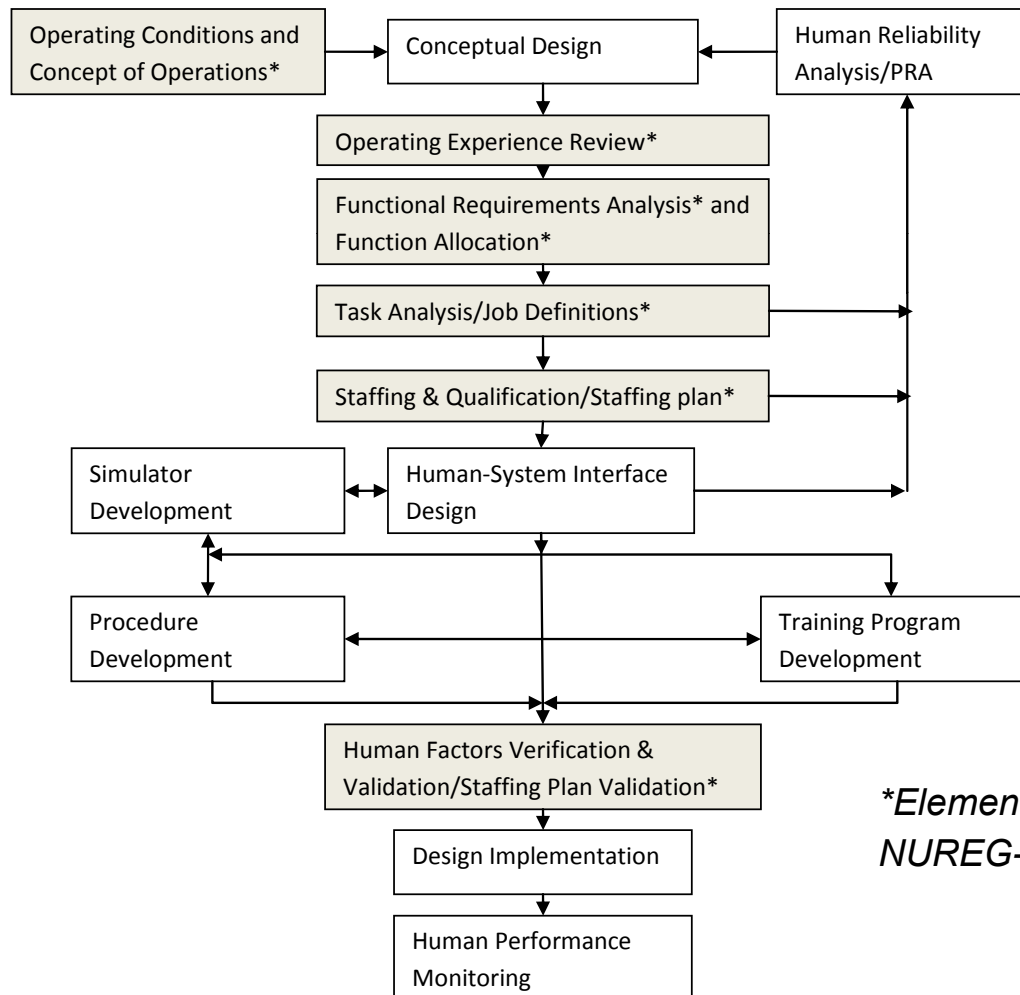


# Licensing - HFE Governing Documents

- Title 10 Code of Federal Regulations
  - NUREG-0800 Standard Review Plan
    - NUREG 0711-Human Factors - Engineering Program Review Model - contains 12 elements including:
      - Training - NUREG-1220
      - Procedures - NUREG-0899
      - Staffing – NUREG-1791 / 10 CFR 50.54(m)
      - HSI - NUREG-0700
      - Operator Actions - NUREG-1764



# NuScale HFE process elements based on NUREG 0711



*\*Elements identified in NUREG-1791*



# Licensing considerations

- 10 CFR 50.54(m):
  - Provides minimum requirements for RO and SRO shift staffing and requires a licensed RO or SRO to be present at the controls at all times for each fueled nuclear power unit
  - There is no provision for more than two units in a single control room or three units on a single site



## Licensing - Applicability of NRC Standard Review Plan (*NUREG-0800*)

- **Approximately 95% of the regulatory basis for NRC design review of a multi-module NuScale plant currently exists. Of the 255 sections in the SRP:**
  - 217 are directly applicable without modification
  - 25 do not apply because
    - They relate to BWR designs
    - They apply to components that have been eliminated in the NuScale design
  - 13 topics to be addressed
    - All relate to HFE and I&C for multi-module operation



# Licensing – HFE Topics for Multi-Module I&C & Operator Staffing (Chapters 7, 13, 14, 18, & 19)

Section	Title
7.7	Controls Systems (HSI and Concept of Operation)
7.8	Diverse I&C Systems (Reduce human error and protection from Common cause failures)
7.9	Data Communication Systems (HSI for alarms and cues for manual actions)
13.2.1	Reactor Operator Requalification; Reactor Operator Training (Staffing & Training)
13.2.2	Non-Licensed Plant Staff Training (Concept of operation, Staffing and Training)
13.3	Emergency Planning (Concept of operation and procedures)
13.4	Operational Programs (Concept of operations and HSI)
13.5.2.1	Operating and Emergency Operating Procedures (HSI and reduce human error)
14.3.5	Instrumentation and Controls: Inspections, Tests, Analyses, and Acceptance Criteria
14.3.9	HFE: Inspections, Tests, Analyses, and Acceptance Criteria (HSI and reduce human error)
14.3.10	Emergency Plan: Inspections, Tests, Analyses, and Acceptance Criteria (HSI & reduce human error)
18	Human Factors Engineering (Issue Integration and Evaluation)
19	Probabilistic Risk Assessment (Identify and protect against potentially risk important actions)





# Concept of operations

- 480 MWe plant with 12 NuScale Power Modules
  - Module - reactor/turbine/generator are independent of other Modules
  - Proposed staffing for Multi-module Main Control Room
    - 3 control clusters consist of 4 Modules in each
    - 1 Licensed RO per cluster
    - 1 CRS (Licensed SRO)
    - 1 STA (Licensed SRO)
    - 1 Shift supervisor (Licensed SRO)



# Concept of Operation

## - Licensed Operator Role

- Maintains responsibility for plant safety and operation by selecting operating state, monitoring and verifying parameters, and initiating manual trip of a Module, if trends indicate that auto trip is imminent
- Five major actions are:
  - Initiate Module startup
  - Initiate Module shutdown
  - Provide oversight and permission for automatic controls (e.g., reactivity manipulations) to continue past predefined hold points
  - Set or correct setpoints to control Module operating state or plant functions
  - Initiate corrective action if Module or plant system fails to operate properly



# Concept of operation – I&C

## Impact on MCR Operator Roles

- Human Factored HSI design
- Simple Design with natural circulation and passive heat removal systems
- Advanced diagnostics and advisory support
- Extensive Automation of Control functions
- Extensive Automation of surveillance and testing



# Current Regulatory Structure and Exemption Requests

- Requirements for control room staffing in 10 CFR 50.54(m) (2) (i), (ii), (iii), and (iv).
- Issues to be considered as exemptions
  - 50.54 (m) (2) (i) provides minimum requirements for RO and SRO shift staffing. There is no provision for more than three nuclear power units on a single site, and no more than two units for a single control room.
    - NuScale exemption: twelve Modules operated from a single control room
  - 50.54 (m) (2) (iii) requires a licensed RO or SRO to be present at the controls at all times for each fueled nuclear power unit.
    - NuScale exemption: licensed RO present at the controls at all times for a cluster of four fueled Modules

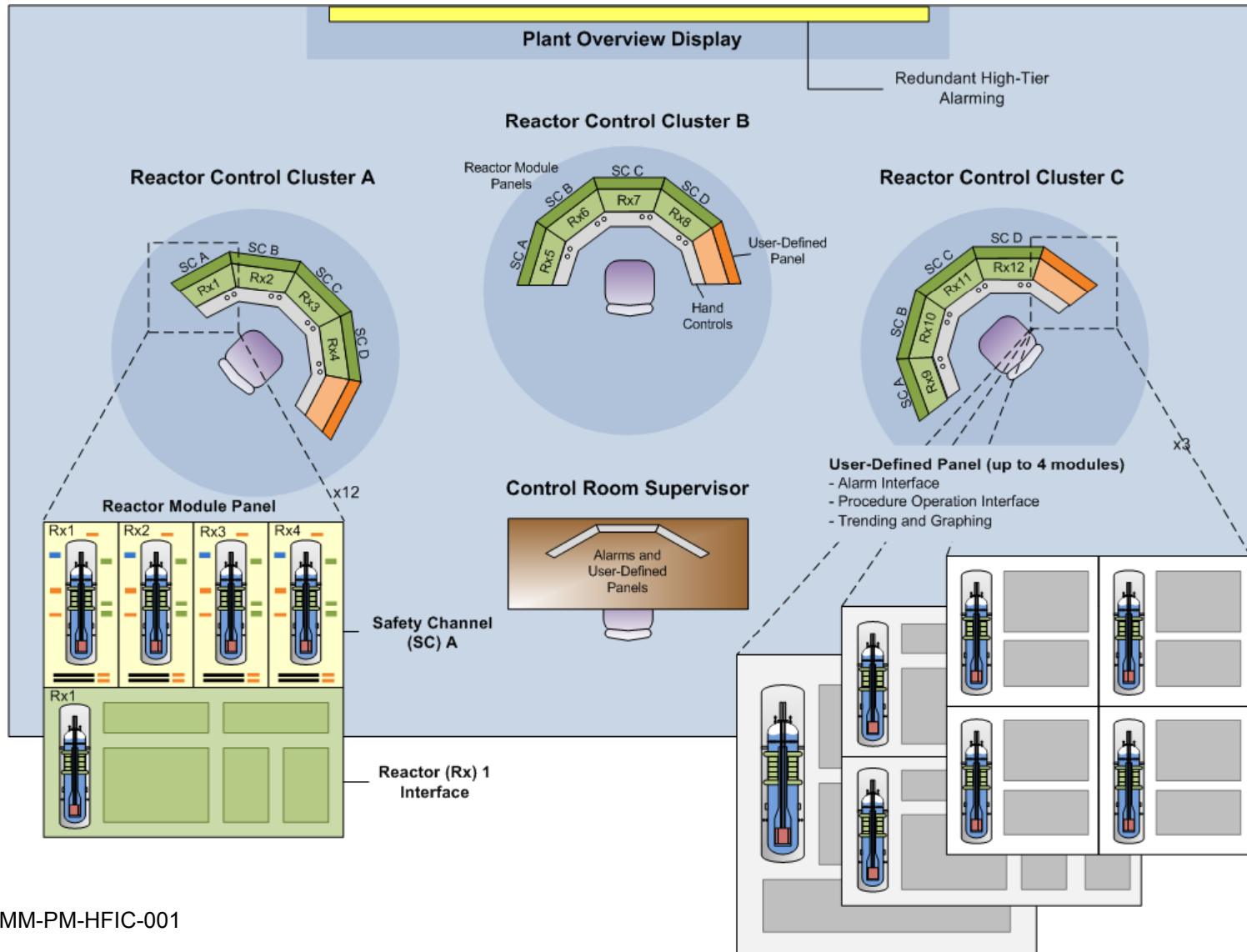


# Regulatory Basis for Exemption Request

- Content of submittal complies with 10 CFR 50.12 Specific exemptions & NUREG-1791 “Guidance for Assessing Exemption Requests ....”
  - Concept of Operations/Operating conditions
  - Operating experience
  - Functional Requirement Analysis and Functional Allocation
  - Task Analysis
  - Job definition
  - Staffing Plan/Staffing Plan Validation



# Concept of Multi-module Control Room Layout





# NuScale HFE Process to Support 50.54(m) Exemption Requests for Licensed Personnel

- Nuclear Operating Experience Reviews
- Operating Experience from other industries including US Air Traffic Controllers (ATC)
- Human Factors Research
- Simulator Testing



# Nuclear Operating Experience Reviews

- US Nuclear Industry
- IAEA publications
- Canadian Experience - years of experience with more than three units operated from same control room





# Process for Evaluation of Operating Experience from Other industries

- Identify compiled Operating Experience information sources
- Use results to identify human error causes
- Assess applicability to NuScale HSI and concept of operation
- Evaluate NuScale concept to minimize error potential



# Human Factors Research

- Review of existing information on
  - Human Cognitive Reliability
  - Human multi tasking
  - Human task switching



# Simulator Development & Testing

- Goal of simulator testing for HFE - demonstrate and validate adequacy of NuScale plant staffing concept of operation
  - Phase 1 - PC simulator - target 6/09
  - Phase 2 - Simulator that mirrors operator controls for a single Module - target 12/09
  - Phase 3 – Simulator representing cluster of four Modules - target 4/10
  - Phase 4 - Simulator capable of testing important design considerations for MCR (full scope) - target 10/10



# Conclusions for MCR design and MCR staffing

NuScale believes that:

- Successful completion of HFE program outlined will demonstrate that requested exemptions are appropriate
- Exemption request and DCD documents should be submitted to and reviewed by NRC in parallel



# Instrumentation and Controls



# Conceptual Safety Related DCIS Overview

- Safety functions for each Module similar to existing plants
- Reactor Protection System initiates Reactor Trips
- Neutron Monitoring System
- ESFAS including passive emergency core cooling
- Safety related information systems keep operators informed



# I&C Topics for NuScale Design – Multi-Divisional VDU & Equipment

- Safety Channel & Divisional Separation complies with IEEE 603 for each Module
- Shared location, VDUs and potentially processors for a division within a cluster
- Dual Safety Trains are unique to each Module & in separate fire zones
- Multi-unit VDUs meet intent of ISG 4, “Highly Integrated Control Rooms – Communications Issues”



# I&C topics related to NuScale design

## – Diversity and defense-in-depth (D3)

- Diverse ATWS mitigation system will be provided
- D3 will take one of two approaches, or some combination of the two:
  - May choose to implement diversity and defense-in-depth as defined in current regulatory guidance, with separate Diverse Protection System
  - May choose to credit diversity via Field Programmable Gate Array (FPGA) technology as sufficient to not require an additional Diverse Protection System





# I&C topics related to NuScale design

## – Shared Plant Features

- Examples of shared components:
  - One containment cooling pool for all 12 Modules – need to display level and temperature in the MCR at each Module
  - MCR habitability RMS isolation – only one redundant set of radiation monitors and isolation controls
  - Electrical power supplies – divisional dc power distribution to multiple Modules from multiple sources, but not four separate sources for each Module
- Control, monitoring, alarming, and indication for shared functions needs to be supplied to all Module from redundant safety and nonsafety equipment that is not assigned to any Module, for reliability and availability



# Meeting Conclusion

## NuScale believes that:

- Successful completion of HFE program described will satisfy regulatory requirements for staffing exemption request
- I&C concept described meets intent of regulatory guidance, and supports concept of operations
- NuScale would like to request additional meetings later this year as we complete the D3 report and the network architecture

