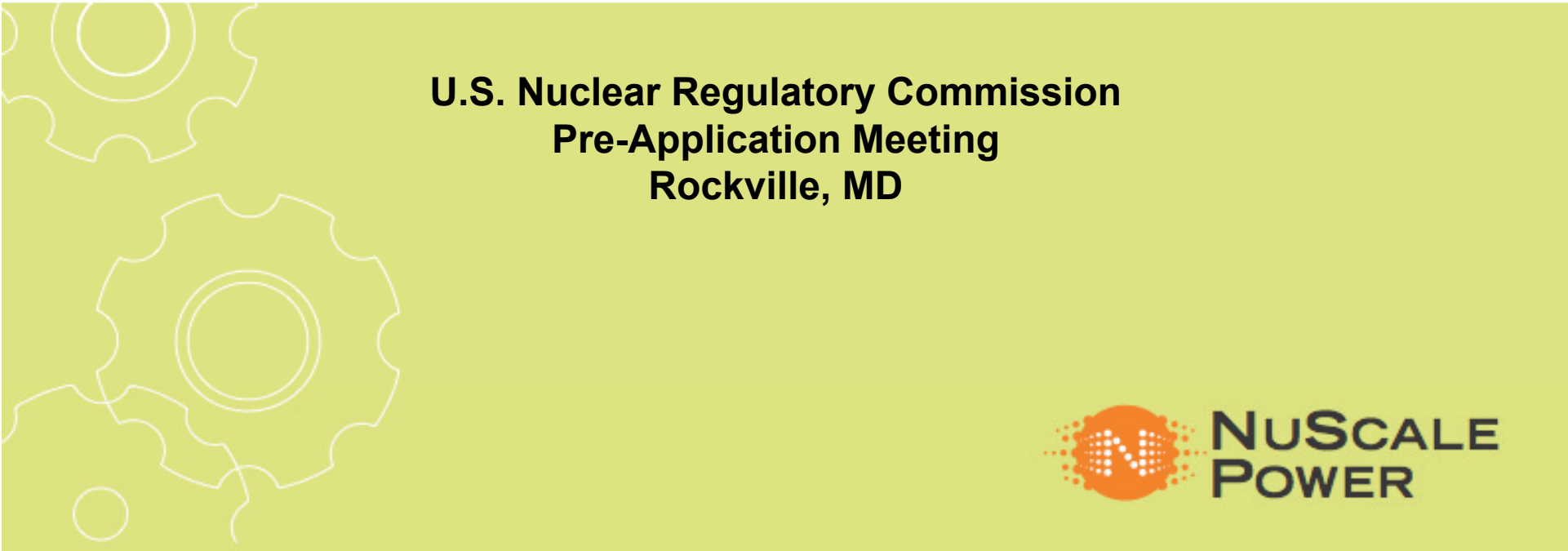




# Codes and Methods

Wendell Wagner, Senior Safety Analyst

June 2, 2010



U.S. Nuclear Regulatory Commission  
Pre-Application Meeting  
Rockville, MD



# Outline

- Requirements
- Methods
  - Loss of Coolant Accident (LOCA)
  - Non-LOCA
  - Containment Performance
- Fuels Performance
- Core Design
- Subchannel Analysis
- Systems Analysis Codes
- Dose Consequence Methods

# Requirements

- 10 CFR 50.46
- Regulatory Guide 1.203, Transient and Accident Analysis Methods
- NuScale Level B Software Development and Maintenance Procedures
- NuScale Safety Analysis Code Development Guidelines

# Methods: LOCA

- NuScale ECCS Evaluation Model (EM)
  - Developed following guidance described in Regulatory Guide 1.203
  - Conforms to 10 CFR 50, Appendix K
  - Simplified design eliminates LBLOCA from ECCS evaluation
- Code Base
  - N-RELAP5 (Primary and Secondary System Response)
  - SIMULATE (Core Neutronics, Axial and Radial Power)
  - FRAPCON/FALCON (Steady State Fuel Temp for Initial Stored Energy)
- Status
  - Draft LOCA PIRT LTR currently under internal review
  - LOCA Evaluation Model Requirements Document complete
  - Code assessment database being developed based on LOCA PIRT
  - Integral facility testing program on schedule
  - Preliminary calculations completed with RELAP5/3.3 to inform development plans

# Methods: Non-LOCA

- **Initiating Events**
  - Non-LOCA transients / accidents applicable to NuScale design identified
  - ATWS and Station Blackout to be treated as special events
- **Code Base**
  - N-RELAP5 (system response)
  - SIMULATE3 and 3K (3D kinetics)
  - SCANR (Subchannel Analyzer for NuScale Reactor)
  - FRAPCON/FRAPTRAN/FALCON (fuels performance)
  - LISNR (linear analysis of loop instability)
- **Status**
  - Non-LOCA PIRT completed (MSLB + LOOP and CRBW + LOOP)
  - Draft Non-LOCA Evaluation Model Requirements Document completed
  - Preliminary calculations completed with RELAP5/3.3 to inform development plans

# Methods: Containment Performance

- Acceptance Criteria
  - General Design Criteria
  - Standard Review Plan
- Code Base
  - N-RELAP5 (system and containment response)  
(Note: A specialized containment code is not necessary because the V&V efforts for N-RELAP5 LOCA analysis include the containment performance analysis.)
- PIRT
  - The LOCA PIRT includes coverage of containment phenomena
- NuScale Methodology
  - Coupled containment / reactor vessel heat transfer
  - External / environmental effects not analyzed
  - Conservatism will include condensation modeling, reactor exterior boiling, and reactor vessel direct convection cooling

# Fuels Performance

- Figures of Merit
  - SAFDLs
  - 10 CFR 50.46 – PCT (Note: no heat-up expected for DBA LOCAs)
  - Cladding Oxidation & Strain, Internal Rod Pressure, Fuel Centerline Temperature
- Codes under evaluation
  - FRAPCON
  - FRAPTRAN
  - FALCON
- Code Applicability
  - Generally applicable to NuScale design
  - Crud/oxidation models may need to be refined / additional data
  - Empirically based 1-D modeling versus 3-D mechanistic
- Fuels Program Development LTR – first quarter 2011

# Core Design

- Code Base
  - Industry Experienced Codes from Studsvik Scandpower
    - INTERPIN-4 – Fuel Temperature Predictions
    - CASMO-4E – Lattice Physics Calculations
    - SIMULATE-3 – 3D Core Simulator (Steady State)
    - S3K – 3D Core Simulator (Transient)
- Methods
  - Development of Core Design Guidelines
    - Based on industry operating experience and SAFDLs
    - Ensures consistent implementation of best practices in physics modeling at NuScale
  - Parameter Uncertainties
    - Development of uncertainties on all parameters used for input to Safety Analysis/Setpoints/Fuel Performance
    - Working with code vendor to ensure detailed understanding of code limits and applicability



# Subchannel Analysis

- SCANR under development (based on COBRA-IIIC)
- Existing CHF correlations with applicable ranges implemented into SCANR (EPRI-1 and AECL-1995)
- Preliminary subchannel analyses being performed to support fuel development
- A CHF evaluation (consisting of a subchannel analysis code, CHF model, and uncertainty evaluation methodology) will be completed
- Physical models applicable to NuScale design to be implemented into SCANR
- Database for V&V to be established
- Code structure and I/O features to be improved for easy maintenance and user convenience
- Subchannel Analysis LTR – third quarter 2011

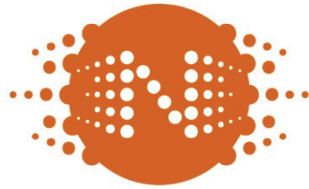
# Systems Analysis Codes

- N-RELAP5
  - Based on Mod 3.3
  - Conforms to 10 CFR 50, Appendix K
- Appendix K modifications
  1. ANS proposed 1971 decay heat model
  2. Baker-Just model for energy release, hydrogen generation, and cladding oxidation
  3. Moody model for 2 $\phi$  discharge rate calculation
  4. NuScale specific steady state CHF correlation
  5. Post-CHF regime transition and film boiling lockout
  6. Conservative hot region modeling (single assembly, cross flow, cladding swelling/rupture flow blockage, restricting flow changes period < 0.1 seconds)
- Helical Coil Steam Generator Program (non-LOCA)
  - Design based on physical test program
  - Program provides validated stand-alone RELAP5 model

# Dose Consequence Methods

- A combination of four codes will be used to calculate conformance to acceptance criteria (SAS2H/ORIGEN-S, PAVAN, ARCON96, RADTRAD 3.10)
- These codes are well known and have been used extensively for analyzing typical PWRs
- Source term and releases from fuel to be determined per Regulatory Guide 1.183 guidance
- Source term for a single module to be considered for licensing basis dose calculations
- Model/Methodology development is ongoing

*It is expected that NuScale dose calculations will fall under regulatory limits for all design basis accidents.*



# NUSCALE POWER

201 NW 3rd Street  
Corvallis, OR 97330  
541-207-3931  
[nuscalepower.com](http://nuscalepower.com)

