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Power for all humankind

Perspectives on Key I&C Challenges in New Reactor Design

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Brian Arnholt
Supervisor, Instrumentation and Controls Engineering

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Who is NuScale Power?

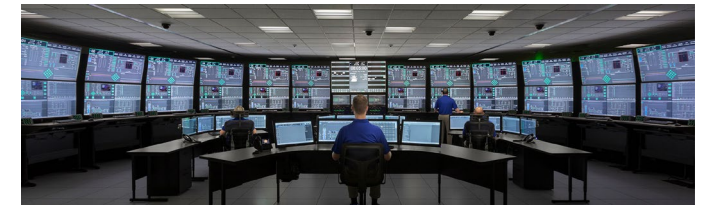
- NuScale Power was formed in 2007 for the sole purpose of completing the design and commercializing a small modular reactor (SMR) – the NuScale Power Module™
- Initial concept was in development and testing since the 2000 U.S. Department of Energy (DOE) MASLWR program
- Fluor Corporation, a global engineering and construction company, became lead investor in 2011
- >560 patents granted or pending in nearly 20 countries
- >400 employees in 5 offices in the U.S. and 1 office in the U.K.
- Rigorous design review by the U.S. Nuclear Regulatory Commission (NRC)—NuScale received Design Approval in August 2020
- Total investment in NuScale to date is greater than US\$1.2B



NuScale Engineering Offices Corvallis



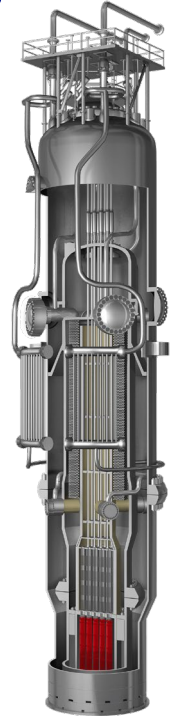
One-third Scale NIST-2 Test Facility



NuScale Control Room Simulator

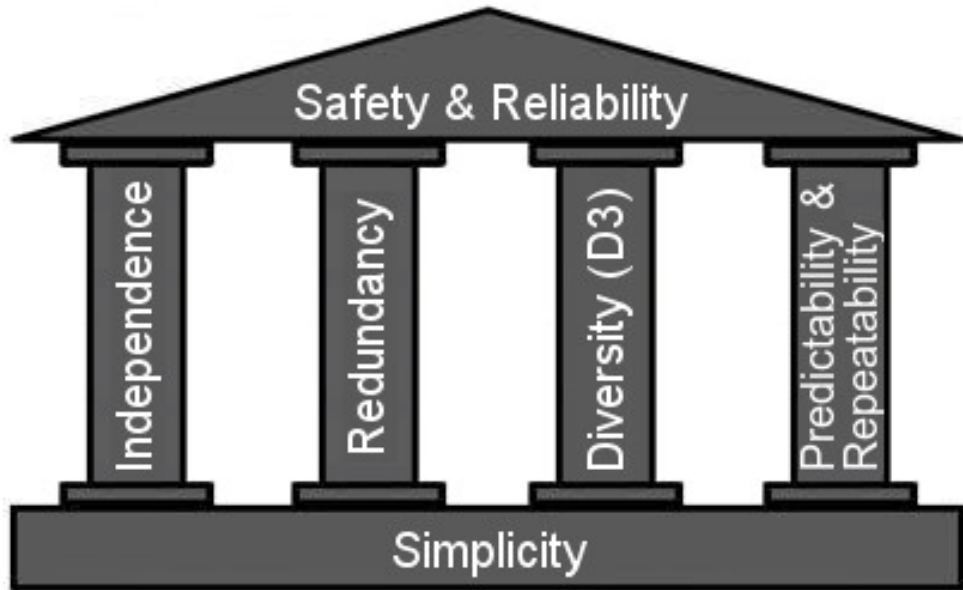
Key NuScale Small Modular Reactor Development I&C Design Challenges

- Regulatory Challenges: Design and Licensing of a First-of-a-Kind Reactor Protection System
 - NuScale Highly Integrated Protection System design approved in June, 2017
- First of a Kind Sensor Development
 - Unique design features present technical challenges to NPM sensor designs
- Supply Chain Development
 - Building relationships with strategic suppliers
- Operator Staffing
 - NuScale Control Room Staffing Plan approved in early 2021
- Cyber Security
 - Integration of cyber security into the design at the very beginning through to the supply chain

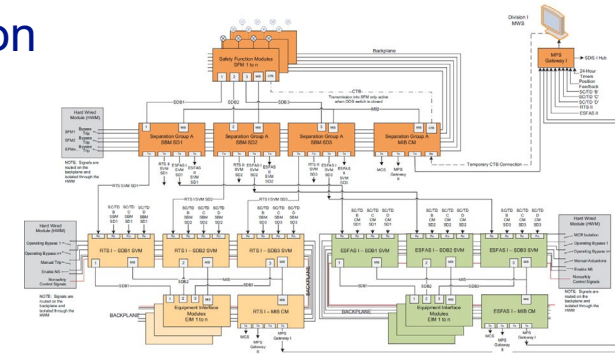


It Starts with Simplicity

- To meet the challenges of developing a new safety I&C system it had to start with a simple platform to build the RPS
- NuScale Power and Rock Creek Innovations jointly developed the Highly Integrated Protection System (HIPS) Platform
- The HIPS Platform is designed to provide a robust platform for safety-related and important-to-safety applications
- The HIPS Platform is a hybrid analog and digital logic-based system
 - to take advantage of the well-proven and simple safety channel approach of the existing protection system architectures
 - take advantage of the digital logic capabilities to provide comprehensive diagnostics and self-test capabilities



- The HIPS platform is designed based on basic fundamental design principles:
 - independence
 - redundancy
 - diversity and defense-in-depth (D3)
 - predictability and repeatability



Unique NuScale Design Features Differences that Impact I&C Design

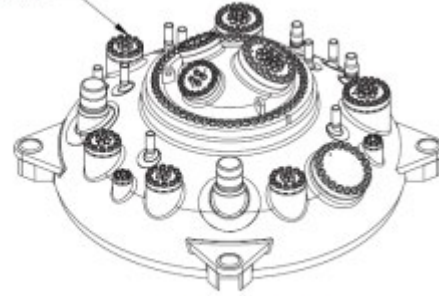
- Natural circulation as a function of power level
 - Testing during changing flow conditions between shutdown and power operations.
- most of the reactor module is under water during normal operation and during most of the refueling evolution
- containment is flooded during refueling
- vacuum conditions in containment during normal operation
- volume of containment is significantly smaller than typical PWR containment
- no reactor coolant system piping
- higher containment temperatures during normal operation and higher containment design-basis event (DBE) temperatures and pressures
- higher containment radiation levels during normal operation and higher containment DBE radiation levels



NuScale Power Module Sensor Design



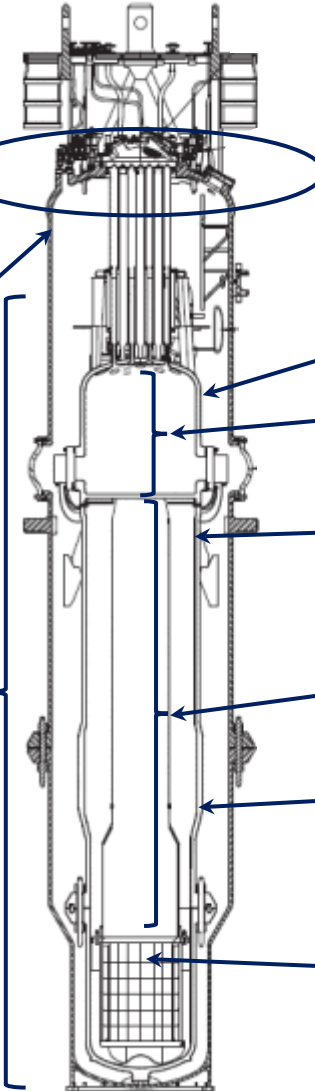
ELECTRICAL PENETRATION ASSEMBLY



CNV TOP HEAD ASSEMBLY

Containment Pressure Sensors

Containment Level Sensors



Reactor Coolant Pressure Sensor

Pressurizer Level Sensors

RCS Temperature Sensors

RPV Riser Level Sensors

Reactor Coolant Flow Sensors

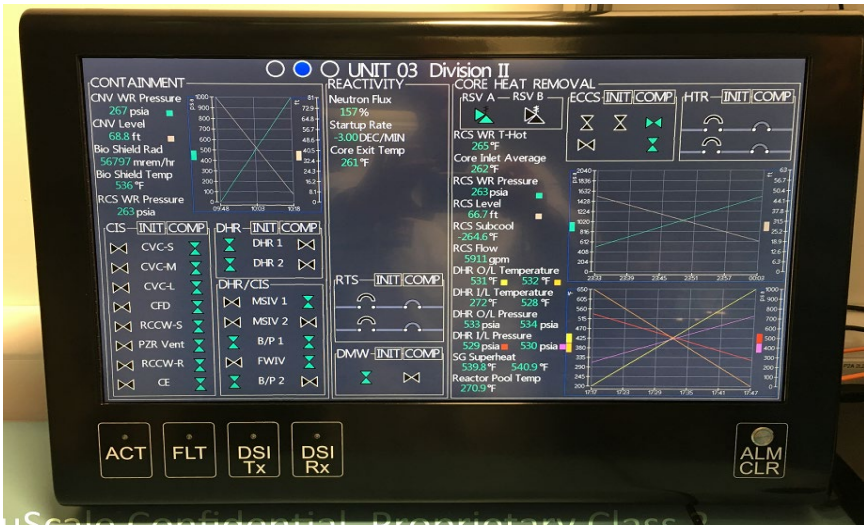
Incore Neutron Flux & Temperature Sensor Assemblies



NPM flow sensor testing

Supply Chain and Manufacturing Development

- Distributed control system supplier selection in final negotiation phase.
 - Scope includes design, testing and manufacturing.
- First-of-a-Kind Sensor Applications
 - Phased approach has been used to select the sensor technologies to meet the NuScale design and performance requirements to support commercialization
 - Pressure, level and flow sensor technology development.
 - Challenges with harsh environment – high temperature and pressure.



FPGA-based Safety Display and Indication System

Prototype design and testing	
Highly Integrated Protection System	Complete <input checked="" type="checkbox"/>
Safety Display and Indication System	Complete <input checked="" type="checkbox"/>
Flow sensors	Complete <input checked="" type="checkbox"/>
Level sensors	Complete <input checked="" type="checkbox"/>
Pressure sensors	Complete <input checked="" type="checkbox"/>
Incore Flux Detectors	Complete <input checked="" type="checkbox"/>

Cyber Security by Design

- The NuScale plant I&C architecture has been developed from the onset with a multi-tiered defensive security architecture designed in accordance with NRC regulatory requirements and industry guidance in mind.
 - Module and plant protection systems are non-microprocessor based using field programmable gate arrays that are not vulnerable to internet cyber-attacks.
 - The Cyber Security Assessment Team is embedded in the design lifecycle, analyzing potential vulnerabilities and offering design solutions.
- NuScale is committed to implementing cyber security into the design and procurement processes

Cyber Security Built In from the Beginning

**LET'S CHANGE THE POWER
THAT CHANGES
THE WORLD**

