

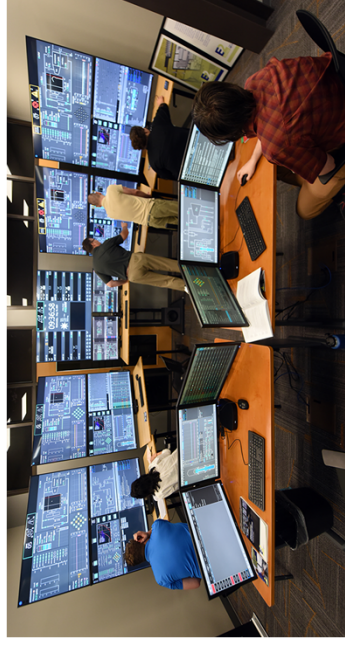
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NUCLEAR POWER PLANT SIMULATORS FOR USE IN SIMULATION-ASSISTED ENGINEERING AND NON-OPERATOR TRAINING



NRC Public Meeting on Draft Standard ANS-3.5.1
November 4, 2026

Dave Desaulniers, PhD
ANS-3.5.1 Working Group Vice-Chair



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Disclaimer

- ANS-3.5.1 is a draft standard, currently under development, and is not an official publication of the American Nuclear Society
- This presentation was developed by the ANS-3.5.1 Working Group. The content of this presentation does not necessarily represent the views of the American Nuclear Society



ANSI/ANS-3.5.1-202X



Nuclear Power Plant Simulators for Use
in Simulation-Assisted Engineering and
Non-Operator Training

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Meeting Objective



- Provide NRC staff with a clear understanding of the intent, scope, and structure of ANS-3.5.1
- Facilitate NRC questions and early feedback relevant to potential future endorsement



Hitachi GE Vernova Nuclear Energy, Ltd

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Presentation Overview



This presentation will discuss:

- Background
- Overview of the standard
- Next Steps
- Potential interfaces with NRC requirements & guidance



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Scope, Purpose, Intended Users



Establishes requirements and guidelines for the use of simulations in:

- optimizing the design, operation and maintenance of nuclear plants, and
- training of nuclear power plant (NPP) facility personnel other than licensed reactor operators

Guide the user through the process of selecting / modifying / developing a simulator appropriate to the application

Intended users:

- NPP designers
- Engineering and training staff for NPPs



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Application



Example applications include:

- control loop tuning
- instrumentation and control (I&C) hardware testing
- single point vulnerability analysis
- power uprate analysis
- pre-outage analysis of plant configurations for maintenance and modifications
- human factors engineering assessments and tests
- safety assessment studies
- procedure development, verification, and validation
- training and plant/system familiarization for plant personnel other than licensed operators

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Example Applications



NuScale used simulation for various stages of small modular reactor design and NRC licensing



GE Vernova Hitachi
BWRX 300 SAE Simulator



X-Energy Conceptual Design Control Room



Barakah NPP Virtual Simulator

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Why we need ANS-3.5.1



Current simulator guidance in ANS-3.5 is limited to the use of simulators for operator training and examination.

NPP simulator technology and modelling have evolved significantly since their introduction in the 1970's. Today, simulators are increasingly being used for applications beyond licensed operator training, including:

- engineering design development and validation
- plant modifications and procedure validation
- I&C development, testing, and commissioning
- human factors engineering
- plant performance and operational studies
- non-licensed personnel training



Industry operating experience demonstrates that substantial value has been realized through the use of simulation to support these activities.

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Why we need ANS-3.5.1



Simulations are increasingly an important adjunct to engineering and training decisions. The credibility of those decisions depends upon:

- whether the simulator has the necessary scope
- whether it has the required capabilities
- whether its fidelity is appropriate for the intended use
- how assumptions, simplifications and discrepancies are addressed
- how models and results are verified and validated
- how configuration is controlled
- whether simulation limitations are understood when results are applied

The objective is to establish that the simulation is fit for the specific engineering or training purpose.



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Current Status



- Current draft (Revision 30) is substantially complete with a few topics remaining to be addressed:
 - improvements to Use Type guidance
 - harmonization of language and processes across Use Types
 - further revision and definition of configuration control
 - addition of diagrams for understanding
 - consideration of potential AI impacts
- Draft developed with substantial engagement by nuclear industry professionals and organizations



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Working Group Membership & Expertise



18 active members (domestic & international)

Utility, Nuclear Steam Supply System (including new-build) vendors, simulator vendors, and regulatory agency participants with 580 collective years of experience in nuclear power

413 years simulation-related

133 years operator training

115 years human factors engineering

61 years ANS-3.5 Working Group



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Structure of the Standard

How the Standard Is Structured

The standard is organized around a
Use Type framework



Section 1 — Scope, Purpose & Background

- Defines applicability and how to use the standard.

Section 2 — Acronyms & Definitions

Section 3 — General Requirements

- Use Type selection
- Use Type A requirements
- Use Type B requirements
- Use Type C requirements
- Use Type D requirements

Section 4 — Configuration Management

Section 5 — References

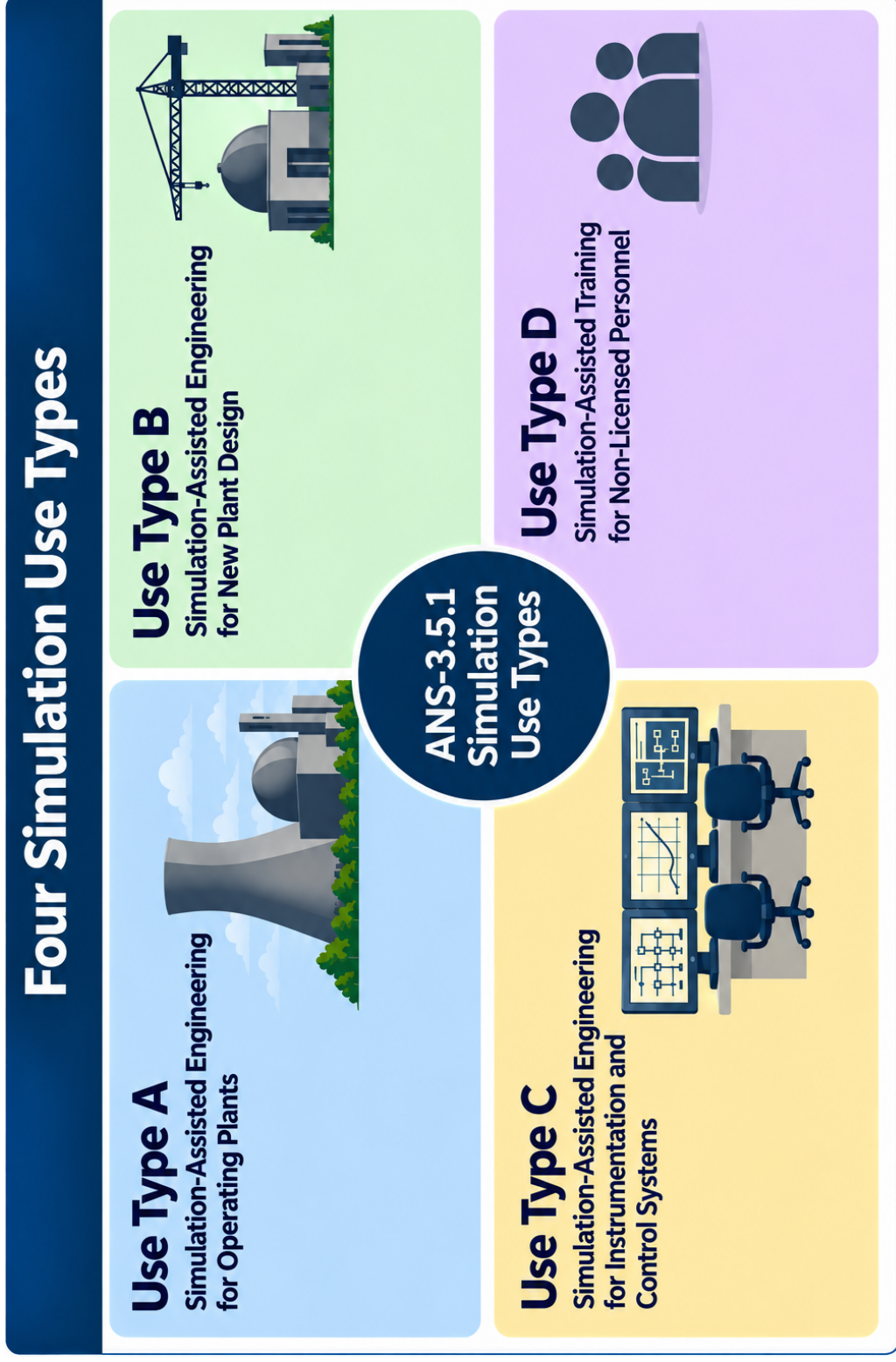
Appendices

- A:** Simulation fidelity and acceptable simulator differences
- B:** Approaches for coupling external I&C systems
- C:** Additional guidance for non-licensed personnel training



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Use Type Overview



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Determination of Use Type



Simulator Applications

Engineering



Facility Application

Operating NPP

System Application



Not I&C
Use Type A



I&C
Use Type C



New NPP Design

System Application



Not I&C
Use Type B



I&C
Use Type B & C



Training



Training Content Application

Operator Licensing



Use Type
See applicable revision
of ANS-3.5

Not Operator Licensing



Use Type D

Training for non-licensed
personnel (e.g., maintenance,
I&C, operations support)

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General Approach



- Standard does not prescribe an acceptable simulation technology (e.g., allows for both physical and virtual simulators)
- Standard does not prescribe an acceptable pedigree of simulator (e.g., simulator not required to meet ANS-3.5)
- Standard provides users a process for selection / modification / development and use of simulators for simulation-assisted engineering and training applications
- Ensures a level of rigor appropriate to the application



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Risk-informed Requirements & Implementation



Proper implementation of requirements and guidelines of this standard is dependent on the application of risk insights.

Risk and hazard considerations include:

- deterministic safety analyses
- operating experience
- risk insights
- hazard assessments

Additional considerations include:

- complexity of the simulation
- deterministic criteria
- regulatory / compliance implications
- deviation from prior simulations
- industry codes and standards

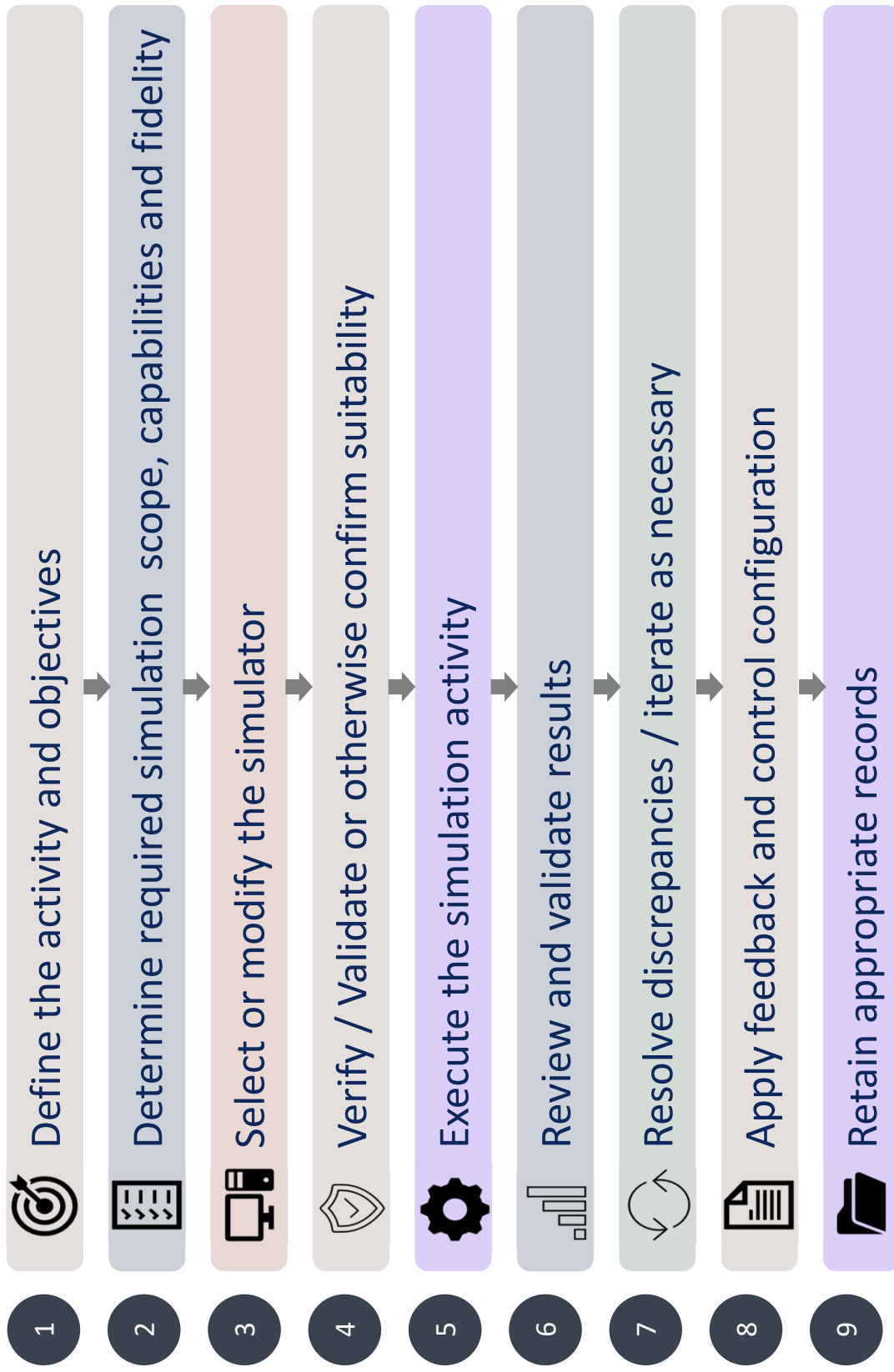
These considerations influence decisions such as:

- specification of simulation fidelity
- establishing precision and accuracy requirements for simulation inputs and outputs
- determination of acceptable verification and validation (V&V) methods
- specification of acceptance criteria
- treatment of simulator discrepancies
- limitations on use of simulation results



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Process Overview



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Process Overview



1



Define the activity and objectives

- Identify the engineering or training need
- Define goals, success criteria, and intended uses
- Determine applicable Use Type (A, B, C, or D)



2



Determine required simulation scope, capabilities, and fidelity

- Define systems, components, and interfaces to be represented
- Identify required capabilities and data needs
- Establish fidelity appropriate to the use and risk (supported by Appendix A)



3



Select, modify, develop simulator

- Select, modify, develop simulator as needed
- Confirm it can meet the defined scope, capabilities, and fidelity



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Process Overview



4



Verify / Validate or otherwise confirm suitability

- Perform V&V activities appropriate to the Use Type
- Assess model accuracy, assumptions, and limitations
- Resolve significant discrepancies



5



Execute the simulation activity

- Conduct defined scenarios, test, or analyses
- Include operating conditions, perturbations, and human interactions
- Collect required data



6



Review and validate results

- Assess results against objectives and acceptance criteria
- Evaluate uncertainties and limitations
- Determine whether results are sufficient for the intended use



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Process Overview



7



Resolve discrepancies / iterate as necessary

- Investigate and resolve significant differences
- Refine models, inputs, or assumptions as needed
- Re-run simulations where required



8



Apply feedback and control configuration

- Incorporate validated changes into the simulator
- Maintain configuration control and pedigree
- Document assumptions, model changes, and limitations



9



Retain appropriate records

- Document methods, assumptions, results, and engineering decisions
- Retain records to support future reference and use of results.

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Use Type Applications & Features



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Use Type Applications & Features



Four Simulation Use Types

Use Type B

Simulation-Assisted Engineering for New Plant Design

Design development and optimization
 Development of operating conditions
 HFE/HSL assessments
 Staffing assessments
 Procedure development
Appendix A applies

ANS-3.5.1 Simulation Use Types

Use Type A

Simulation-Assisted Engineering for Operating Plants

Use Type C

Simulation-Assisted Engineering for Instrumentation and Control Systems

Use Type D

Simulation-Assisted Training for Non-Licensed Personnel



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Use Type Applications & Features



Four Simulation Use Types

Use Type C

**Simulation-Assisted Engineering
for Instrumentation and
Control Systems**

I&C development
Tuning and implementation
Validation and testing
Commissioning support
Appendices A&B apply

ANS-3.5.1 Simulation Use Types

Use Type A

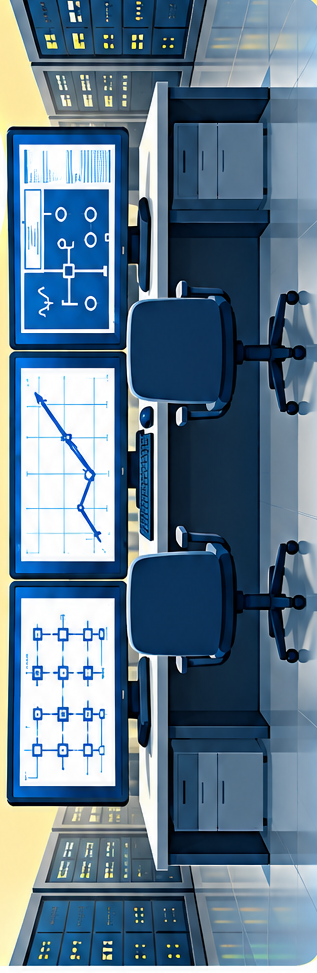
Simulation-Assisted Engineering
for Operating Plants

Use Type B

Simulation-Assisted Engineering
for New Plant Design

Use Type D

Simulation-Assisted Training
for Non-Licensed Personnel



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Use Type Applications & Features





Use Type A
Simulation-Assisted Engineering
for Operating Plants



Use Type B
Simulation-Assisted Engineering
for New Plant Design



Use Type C
Simulation-Assisted Engineering
for Instrumentation and
Control Systems

Four Simulation Use Types

Use Type D

Simulation-Assisted Training for Non-Licensed Personnel

Non-licensed operators
Shift supervisors (non-licensed tasks)
I&C, electrical and mechanical maintenance
Radiation protection and chemistry
Engineering personnel

Appendices A&C apply





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Appendix A - Guidance for the determination of necessary simulation fidelity and acceptable simulator differences

- Operational fidelity
 - scope of the procedure(s) / system(s) to be tested
 - purpose and objectives of the test
 - intended use and implications of the test results
 - precision and accuracy requirements for simulator inputs and outputs
 - operations to be performed during testing
 - necessary simulator inputs and outputs
- Physical fidelity of HSLs and the operating area environment
 - fidelity of essential HSLs
- Resolution, documentation, and recordkeeping of discrepancies
- Common to all Use Types



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Appendix B – Approaches to coupling external I&C systems to a simulator

- Describes five most common solutions for coupling control processor and input / output (I/O) cards with a simulator:
 - stimulated control processor with I/O
 - stimulated control processor without I/O
 - virtual stimulation of control processor
 - simulation of a control processor with a translator
 - manual simulation of a control processor
- Describes four most common mixed solutions for coupling an HSI, including alarm / trend functionality, with a simulator:
 - stimulated HSI
 - virtual stimulated HSI
 - simulated HSI with a translator
 - manual simulation of an HSI
- Supports Use Type C





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Appendix C - Information supporting requirements of simulation-assisted training for non-licensed NPP personnel

- Addresses the following considerations in the determination of necessary simulation scope, capabilities, and fidelity:
 - categories of personnel to be trained
 - learning objectives of the training
 - manner in which the simulator will be used
 - the training method in which the simulator will be used
 - tasks, procedures, or scenarios to be simulated
 - necessary simulator inputs and outputs
 - precision and accuracy requirements for simulator inputs and outputs
 - trainee assessment criteria
 - intended use and implications of the knowledge, skills, and/or abilities to be gained through the training
- Selection or modification of simulator
 - physical vs. virtual simulators
- Supports Use Type D



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Next Steps – from draft standard submittal to publishing



 Submit draft standard to ANS Standards Committee for approval of technical content (July 2027)



 Distribute to ANS Consensus Committee for balloting / open to the public for review and comment (working group to address each comment)



10 months

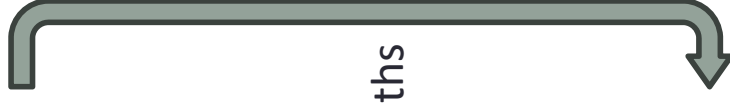
 ANS Standards Board verifies conformance to consensus process



 ANS submits standard to ANSI for approval as an American National Standard



 ANS publishes ANSI/ANS-3.5.1 as an American National Standard

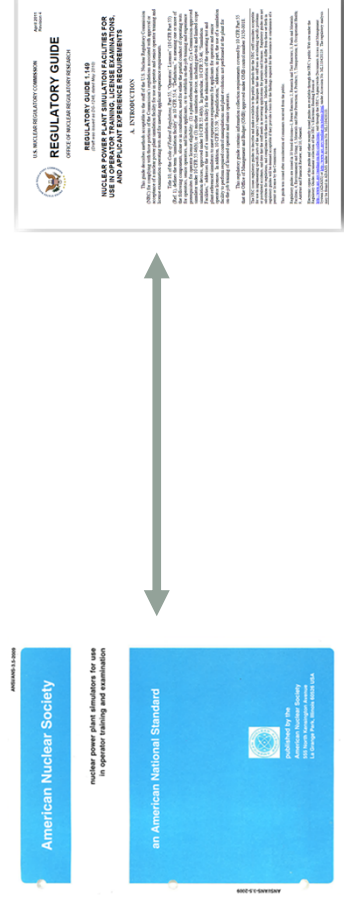


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Next Steps – NRC Participation / Endorsement



- ANS emphasizes the importance of NRC participation within the ANS working group
- facilitates NRC review and input within normal ANS drafting and approval processes and therefore aids in potential NRC endorsement
- past and current NRC participants on the working group include
Dr. David Desaulniers, Mr. David Rahn, and Dr. Brian Green
- ANS frequently communicates new standards to the NRC for endorsement consideration in regulatory guidelines





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Potential interfaces with NRC requirements & guidance

- 10 CFR 50.59 – Changes, tests, and experiments
- 10 CFR 50.65 – Requirements for monitoring the effectiveness of maintenance at nuclear power plants
- 10 CFR 50.120 – Training and qualification of nuclear power plant personnel
- 10 CFR 50 – Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants
- 10 CFR 52.79(a)(17) / 10 CFR 50.34(f)(2)(iii) – post-TMI requirement for HFE of main control room
- 10 CFR 53.730(a) – Human factors engineering design requirements
- 10 CFR 53.730(f) – Staffing plan
- 10 CFR 55 – Operators' licenses
- NUREG-0711, Human Factors Engineering Program Review Plan, Section 11.4.3.3, Validation Testbeds
- Proposed Rule – Regulatory Enhancements for Reactor Licensing, Decommissioning, and Operational Oversight

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Working Group



- K. Singh (Chair), EDF Energy retired, United Kingdom
- D. R. Desaulniers (Vice-Chair), U.S. Nuclear Regulatory Commission retired
- J. C. Yarbrough (Secretary), Xcel Energy
- J. B. Florence (Parliamentarian, Editor), NPPSim Consulting, LLC
- B. Green (Style Editor), U.S. Nuclear Regulatory Commission
- S. Akbar, Rolls Royce SMR, United Kingdom
- O. F. Ashy, Curtiss-Wright (USA)
- M. Cunningham, GE Vernova Hitachi Nuclear Energy
- C. Desouky, ENEC Operations, United Arab Emirates
- G. Grady, GSE Solutions, LLC
- W. Marquino, Bluestone Power Consulting
- J. Miller, Westinghouse Electric
- G. S. McCullough, Exitech Corporation
- E. Papadopoulos, L3H MAPPS, Canada
- K. Rizk, Atkins Realis, Candu Energy
- J. A. Ruiz, Westinghouse Electric, Spain
- R. Sanders, Corys
- S. Schumacher, Constellation Generation



Contact Information



Kashmir Singh

ANS-3.5.1 Chairman

EDF Nuclear Services, EDF Energy, United Kingdom
(retired Sep 2025)

Phone: +44 7721 507055 (M)

Email: kashmir.singh.cheltenham@gmail.com

QUESTIONS?



Acronyms

ANS	American Nuclear Society
CFR	Code of Federal Regulations
HFE	Human Factors Engineering
HSI	Human-System Interface
I&C	Instrumentation and Control
I/O	Input / Output
NPP	Nuclear Power Plant
TMI	Three Mile Island
V&V	Verification and Validation

