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Operating Crew Performance with Advanced Technologies

Insights from Experiments and Simulator Training

March 12, 2020

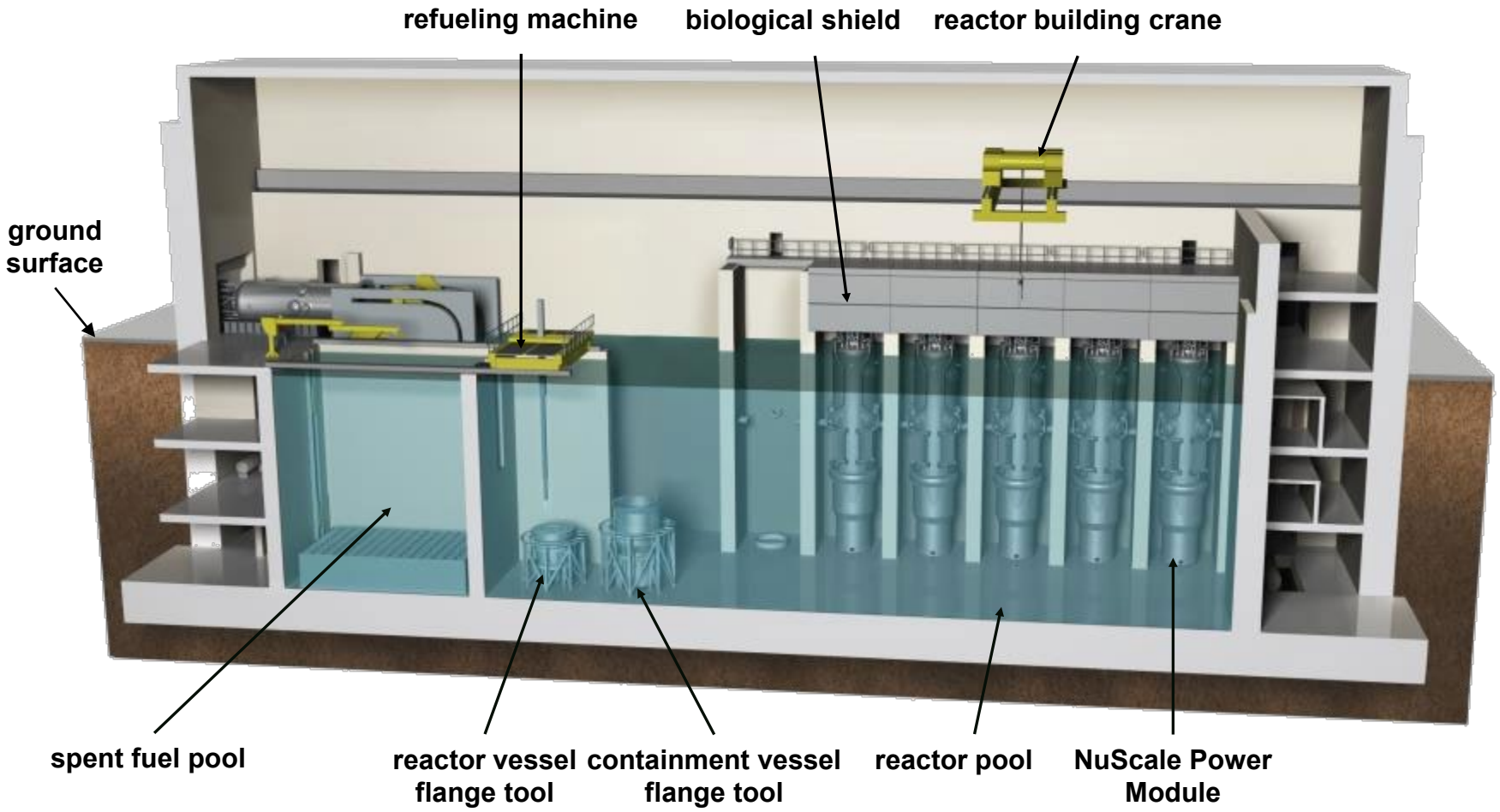
Tim Tovar
Manager, Plant Operations

Doug Bowman
Supervisor, Plant Operations

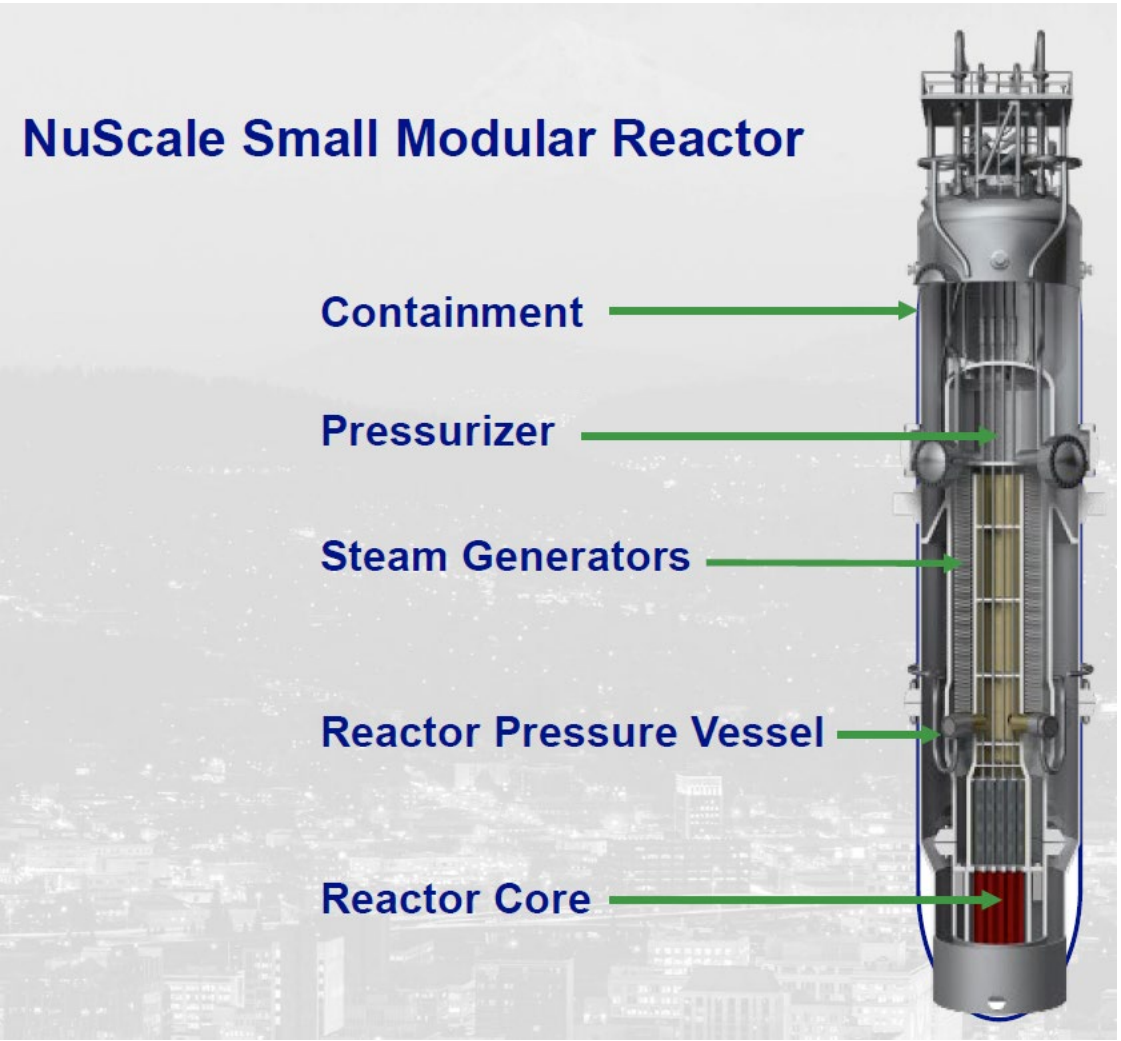
Agenda

- Background
  - NuScale technology
  - driving forces for extensive simulator development/training
- Staffing plan validation (SPV)
- Integrated system validation (ISV)
- Insights from NuScale simulator training and testing
- Remote simulator capabilities
- Live simulator demonstration

Reactor building houses NuScale Power Modules™, spent fuel pool, and reactor pool

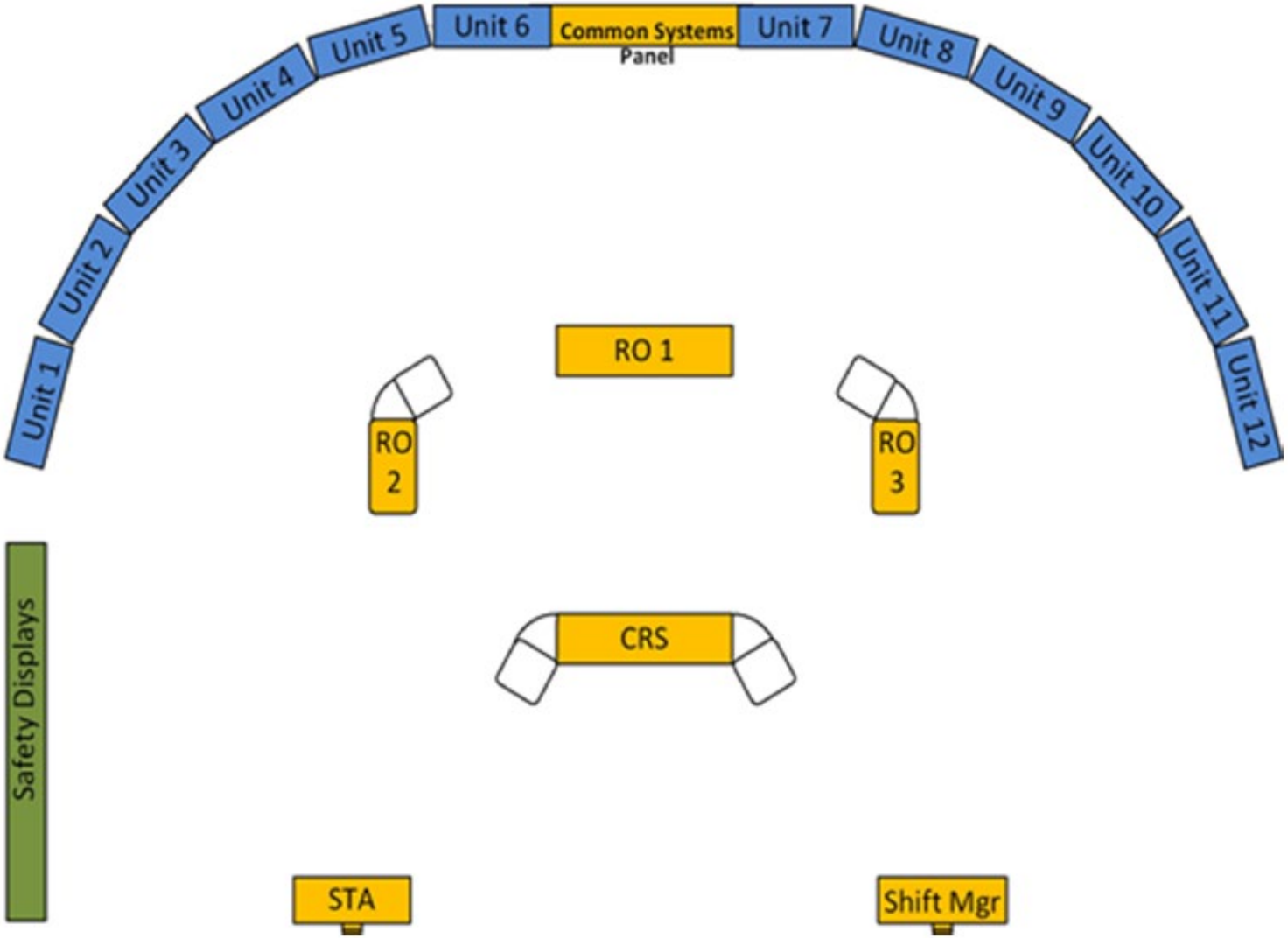


NuScale Technology



- Passive safety systems
- Single safety positions
- Modules in direct contact with the ultimate heat sink
- No safety-related AC or DC power
- No operator action for design-basis events
- Two simple important human actions for beyond-design-basis events

Control Room Layout / Concept of Operations



Licensed Operators for a 12-Unit Plant

10 CFR 50.54(m) Staffing Requirements

Table 1. Minimum Requirements[1] Per Shift for On-Site Staffing of Nuclear Power Units by Operators and Senior Operators Licensed Under 10 CFR Part 55

Number of Nuclear Power Units Operating[2]	Position	One Unit	Two Units		Three Units	
		One Control Room	One Control Room	Two Control Rooms	Two Control Rooms	Three Control Rooms
None	Senior Operator	1	1	1	1	1
	Operator	1	2	2	3	3
One	Senior Operator	2	2	2	2	2
	Operator	2	3	3	4	4
Two	Senior Operator		2	3	3[3]	3
	Operator		3	4	5[3]	5
Three	Senior Operator				3	4
	Operator				5	6

5 operators x 6 control rooms = 30

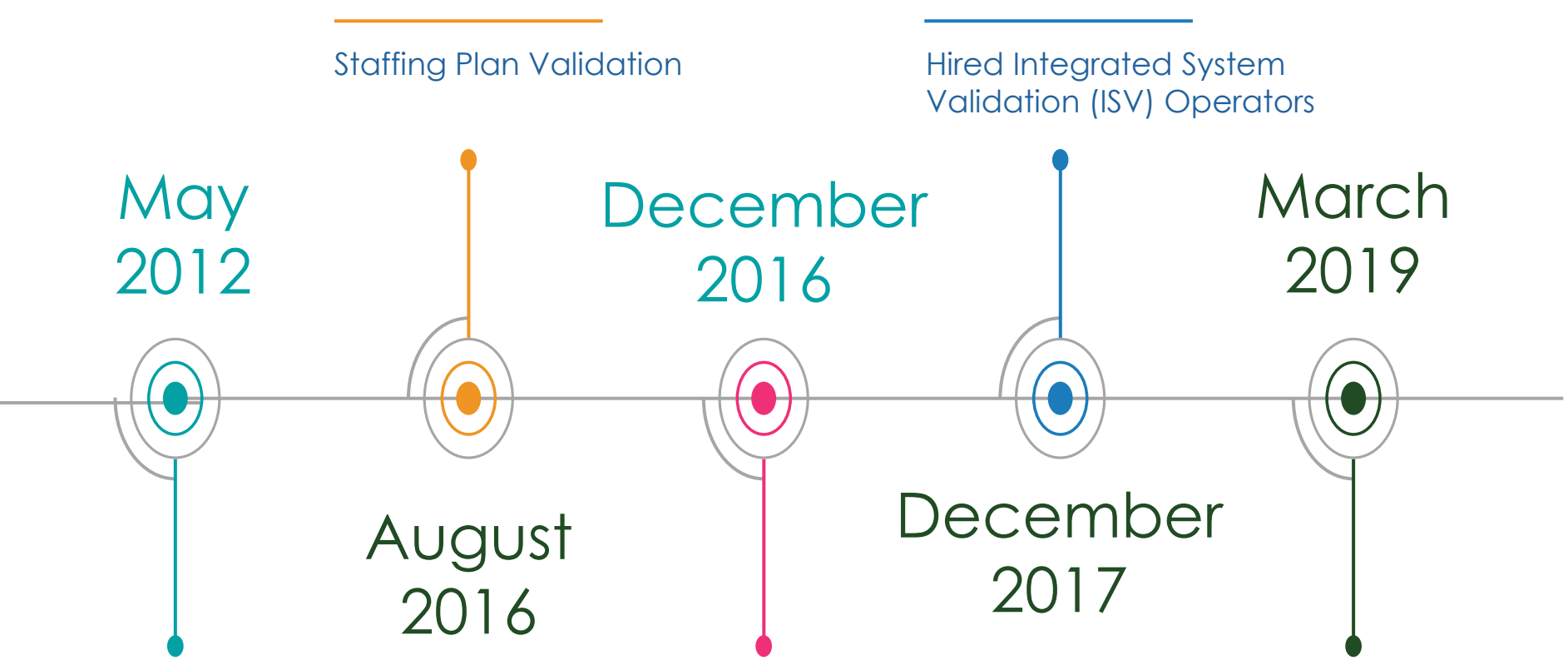
30 operators x 6 shifts = 180

Simulator

- GSE Systems simulator with 38 interacting models
- Human-system interface (HSI)

  human factors and operating experience integrated into the HSI
  - at-a-glance critical safety function / defense-in-depth displays
  - tiered notification system
    - alarms
    - cautions
    - notifications
  - trend display
  - process library (procedures and automations)
  - task ownership and status communication
  - human error precursor reduction

Human Factors Engineering (HFE) Timeline



Integrated System Validation (ISV)

- Verifies the integrated system supports safe operation
  - performance-based evaluation of hardware, software, and personnel
  - three crews of operators
  - trained similar to a license class
  - 12 full-scope scenarios

Classroom Training

- 56 classroom lectures over nine weeks including
  - systems training
  - conduct of operations
  - technical specifications
  - abnormal and emergency operating procedures (AOPs/EOPs)
  - emergency action levels (EALs)
- 11 simulator sessions to complement classroom training

Simulator Training

- 36 simulator sessions for each crew over 10 weeks
- three simulator proficiency exams
- one week of ISV-style practice scenarios
- final audit exam using ISV protocols

Results

- When the DCA is approved, the minimum licensed operator requirements will be codified such that 10 CFR 50.54(m) will not apply to the NuScale design
- Allows operation of 12 reactors from a single control room with six licensed operators

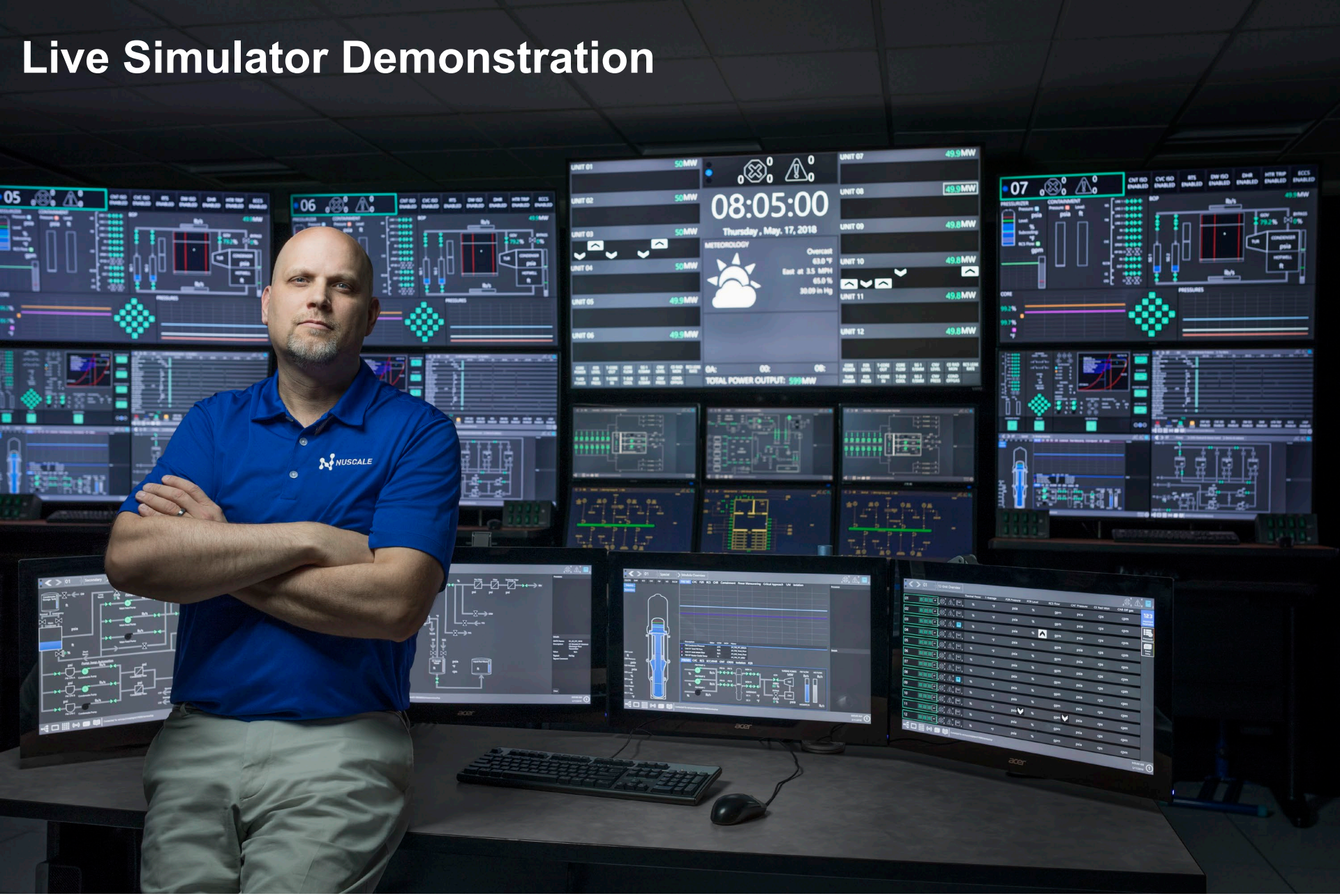
Insights from Simulator Training and Testing

- Simple design and human factors integrated into the HSI
  - human errors are reduced
  - operation is intuitive
  - safety is enhanced
  - training time is reduced
  - examination is simplified
  - entry requirements more appropriate to the design
  - costs are reduced

Remote Simulator

- DOE infrastructure awards to University of Idaho, Oregon State University, and Texas A&M
- SMR control room simulator for universities
  - research
  - educating next-generation nuclear workers
  - public outreach
- real-time, cloud-based, NuScale simulator

Live Simulator Demonstration



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Acronyms

- AOP – abnormal operating procedure
- CFR – code of federal regulations
- DCA – design certification application
- EAL – emergency action level
- EOP – emergency operating procedure
- HFE – human factors engineer
- HSI – human-system interface
- ISV – integrated system validation
- RO – reactor operator
- RSR – results summary report
- SPV – staffing plan validation
- SRO – senior reactor operator
- SMR – small modular reactor
- STA – shift technical advisor

Tim Tovar
Manager, Plant Operations
ttovar@nuscalepower.com

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