

# High Performance Computing For the Nuclear Industry

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NIC/ETEC Nuclear Supplier Workshop  
September 6-7, 2017  
Pollard Technology Conference Center  
Oak Ridge, TN



# DOE National Laboratories Have World-Leading High Performance Computing Capabilities

- DOE Office of Nuclear Energy has two Nuclear Energy Modeling and Simulation Programs:
  - Consortium for the Advanced Simulation of LWRs (CASL)
  - Nuclear Energy Advanced Modeling and Simulation (NEAMS)
- DOE Office of Science
  - Office of Advanced Scientific Computing Research
  - Oak Ridge Leadership Computing Facility (OLCF)
  - Argonne Leadership Computing Facility (ALCF)
- Expertise in performing analysis of nuclear reactors and systems using HPC resources and capabilities

# Consortium for the Advanced Simulation of LWRs (CASL)

## CASL MISSION

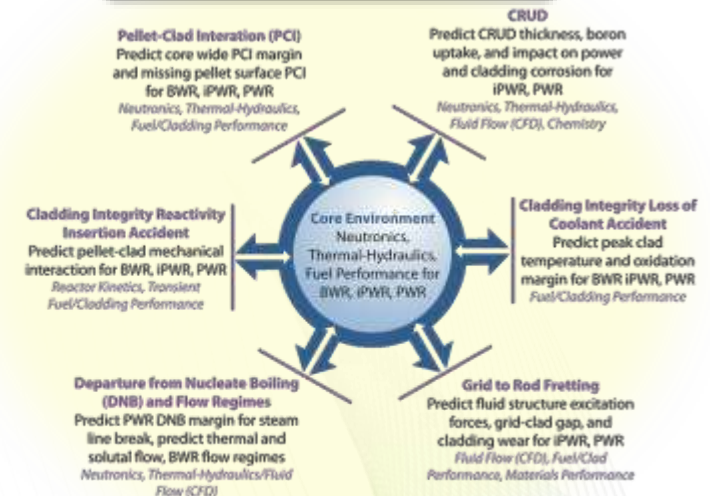
Provide leading-edge modeling and simulation (M&S) capabilities to improve the performance of currently operating and future light water reactors (LWR's)

- First DOE Energy Innovation Hub established in 2010 for a 10 year period
- An industry-laboratory-university partnership
- Developing a Virtual Reactor encompassing advanced nuclear reactor modeling and simulation (M&S) capabilities
- CASL has expertise in reactor core neutronics, thermal-hydraulics, fuel performance, structural analysis, etc.

## CASL Founding Partners



## CASL Challenge Problems



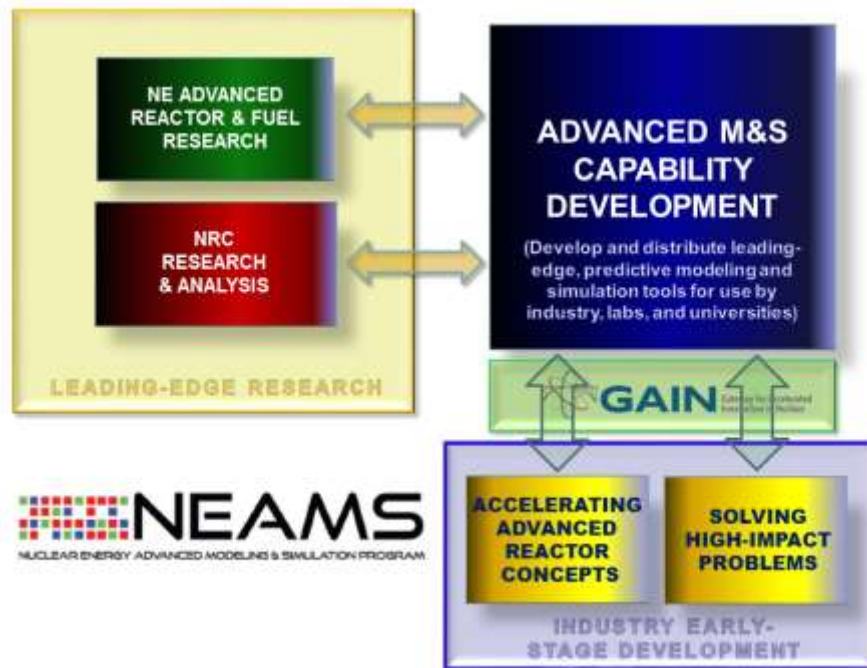
# CASL Expanding Reactor Applications of our Virtual Reactor

- CASL is focused on the analysis of current or future NPPs
- Includes more than 15 different reactors
- Collaborating with more than 13 different organizations, including fuel vendors, utilities, and government agencies on reactor applications
- CASL has the expertise, tools and access to computing hardware to perform advanced simulations with high resolution and physics fidelity

Plant	Org	Units	Type
Watts Bar	TVA	2	W 4-loop
Sanmen	WEC	1	AP1000
Krško	WEC/JSI	1	W 2-loop
McGuire	Duke	2	W 4-loop
Catawba	Duke	2	W 4-loop
Palo Verde	APS	1	CE Sys 80
Callaway	WEC	1	W 4-loop
TMI	Exelon	1	B&W
Byron	Exelon	1	W 4-loop
NuScale	NuScale	1	SMR
Davis-Besse	Areva	1	B&W
Oconee	Duke	1	B&W

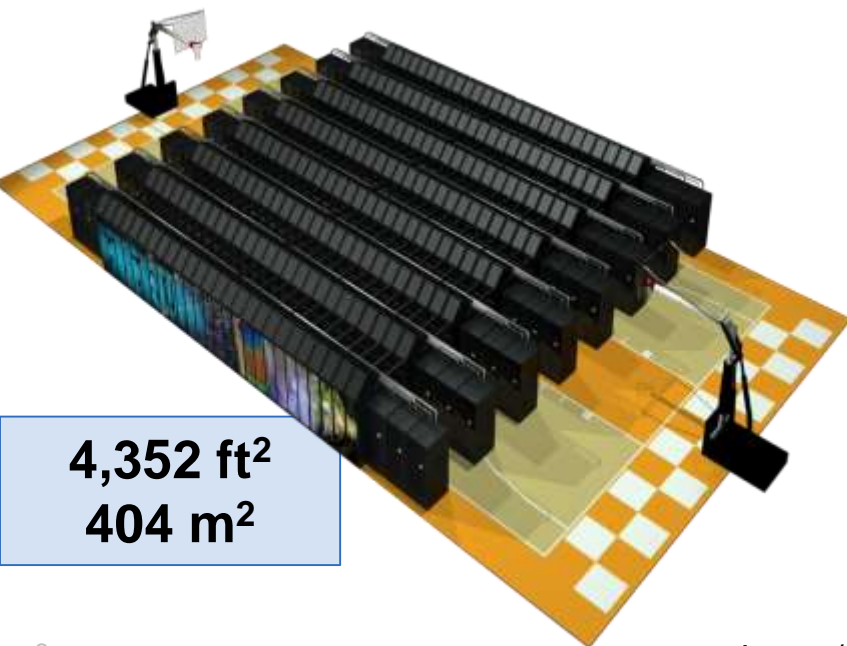
# Nuclear Energy Advanced Modeling and Simulation (NEAMS)

***The NEAMS Mission: provide leading-edge computational tools, currently not available to industry, for accelerating early-stage development of advanced reactor concepts and promoting innovative solutions to important nuclear industry problems; these advanced M&S capabilities will –***



- Enable transformative scientific discovery and insights otherwise not attainable or affordable
- Solve problems identified as significant by industry, and consequently expand validation, application, and long-term utility of these advanced tools
- Enhance opportunity for industry to commercialize advanced concepts
- Allow industry to implement innovations that improve the economics of both existing and future nuclear power plants

# Oak Ridge Leadership Computing Facility “Titan” Hybrid System: Cray XK7 with AMD Opteron and NVIDIA Tesla processors



4,352 ft<sup>2</sup>  
404 m<sup>2</sup>

## SYSTEM SPECIFICATIONS:

- Peak performance of 27.1 PF (24.5 & 2.6)
- 18,688 Compute Nodes each with:
- 16-Core AMD Opteron CPU (32 GB)
- NVIDIA Tesla “K20x” GPU (6 GB)
- 512 Service and I/O nodes
- 200 Cabinets
- 710 TB total system memory
- Cray Gemini 3D Torus Interconnect

# Summit will replace Titan as the OLCF's leadership supercomputer in 2019:



## Smart Supercomputer for AI & Machine Learning

- Much more powerful GPU-accelerated nodes
- Much more memory per node and total system memory
- Faster interconnect
- Much higher bandwidth between CPUs and GPUs
- Much larger and faster file system

Feature	Titan	Summit
Peak Flops	27 PF	200 PF
Application Performance	Baseline	5-10x Titan
Number of Nodes	18,688	~4,600
Node performance	1.4 TF	> 40 TF
Memory per Node	32 GB DDR3 + 6 GB GDDR5	512 GB DDR4 + 96 GB HBM
NV memory per Node	0	1600 GB
Total System Memory	710 TB	>10 PB DDR4 + HBM + Non-volatile
System Interconnect (node injection bandwidth)	Gemini (6.4 GB/s)	Dual Rail EDR-IB (23 GB/s)
Interconnect Topology	3D Torus	Non-blocking Fat Tree
Processors	1 AMD Opteron™ 1 NVIDIA Kepler™	2 IBM POWER9™ 6 NVIDIA Volta™
File System	32 PB, 1 TB/s, Lustre®	250 PB, 2.5 TB/s, GPFS™
Peak power	9 MW	13 MW

# ACCEL: Helping Industry Succeed with HPC

Accelerating  
Competitiveness through  
Computational  
Excellence



- Focused outreach to drive industry use of Oak Ridge Leadership Computing Facility
  - Industry solving important, large scale, real world problems
  - HPC can streamline R&D and reduce time to market
- No set asides: industry competes with academia and lab researchers worldwide for HPC resources
- User agreement developed to allow some proprietary work with commitment to publish meaningful scientific results
- Users range from startups to Fortune 50 companies
- In FY16, 13% of OLCF projects were with industry partners





# ACELL Provides Access To...

**Talent**



**Training**



**Tools**



**So that industry can:**

Accelerate innovation

Reduce risk

Lower costs

Solve the seemingly intractable

Predict the future