

SCALE Support by the DOE/NNSA Nuclear Criticality Safety Program

Douglas G. Bowen, Ph.D.
Nuclear Data and Criticality Safety Group Leader
Reactor and Nuclear Systems Division
Oak Ridge National Laboratory

Nuclear Criticality Safety Program Execution Manager

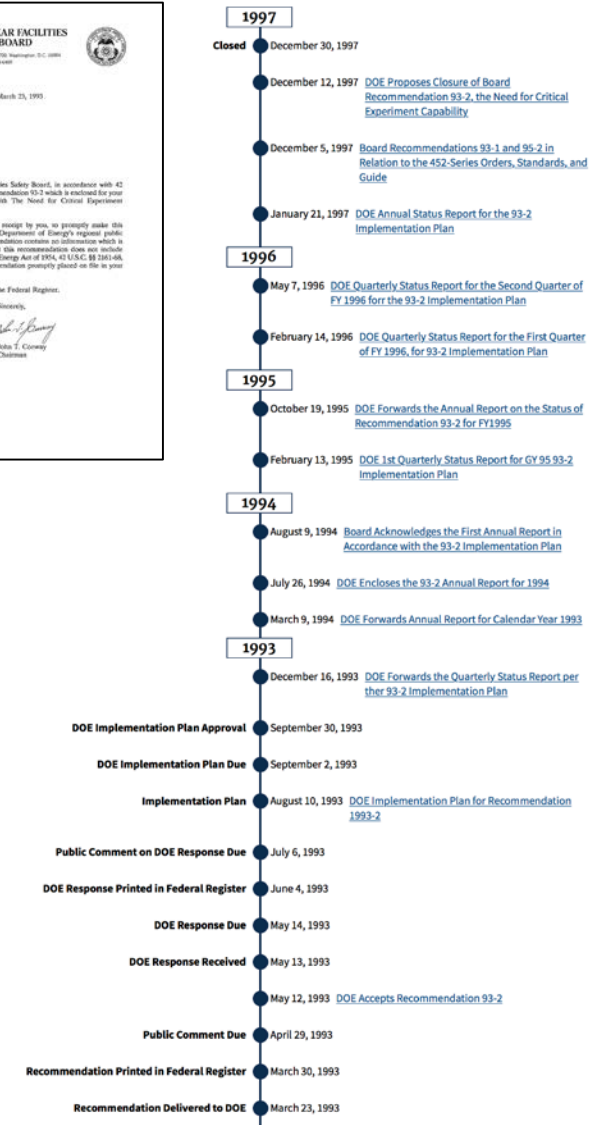
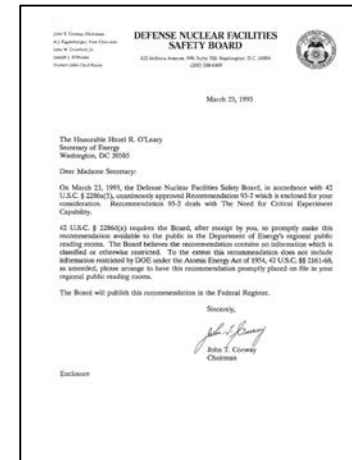
Agenda

- Brief Nuclear Criticality Safety Program (NCSP) overview
- Analytical Methods to support Nuclear Criticality Safety work in the DOE complex and beyond
- NCSP support of the SCALE package over the years
- NCSP future support



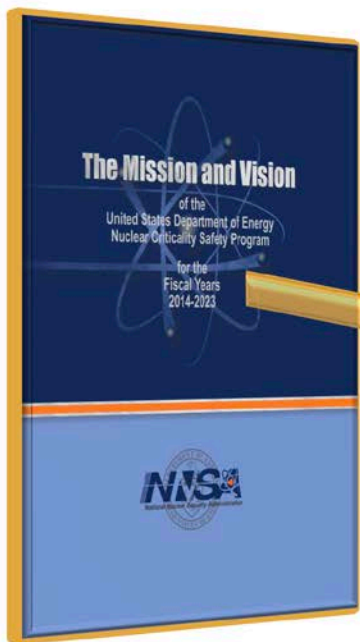
Background / History

- Defense Nuclear Facilities Safety Board (DNFSB) Recommendations 93-2 and 97-2:
 - 93-2 (3/23/1993): Need for a general-purpose critical experiment capability that will ensure safety in handling and storage of fissionable material.
 - 97-2 (5/19/1997): Need for improved criticality safety practices and programs to alleviate potential adverse impacts on safety and productivity of DOE operations.
- 97-2 encompassed ongoing DOE activities of 93-2 while broadening scope to address important cross-cutting safety activities needed to ensure NCS throughout the Complex.
- DOE Implementation Plan for Board Recommendation 93-2 and 97-2 resulted in establishment of the US Nuclear Criticality Safety Program (NCSP)

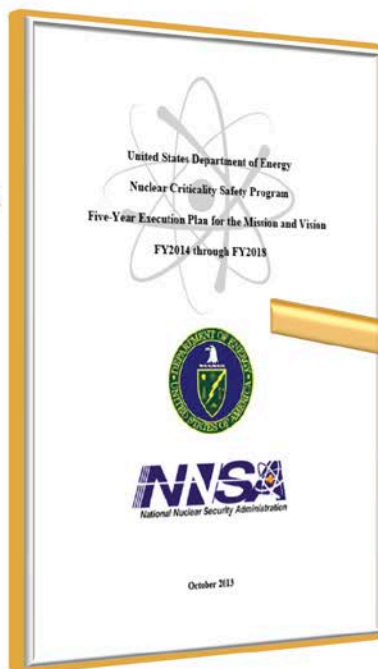


NNSA Nuclear Criticality Safety Program

10 Year Mission & Vision



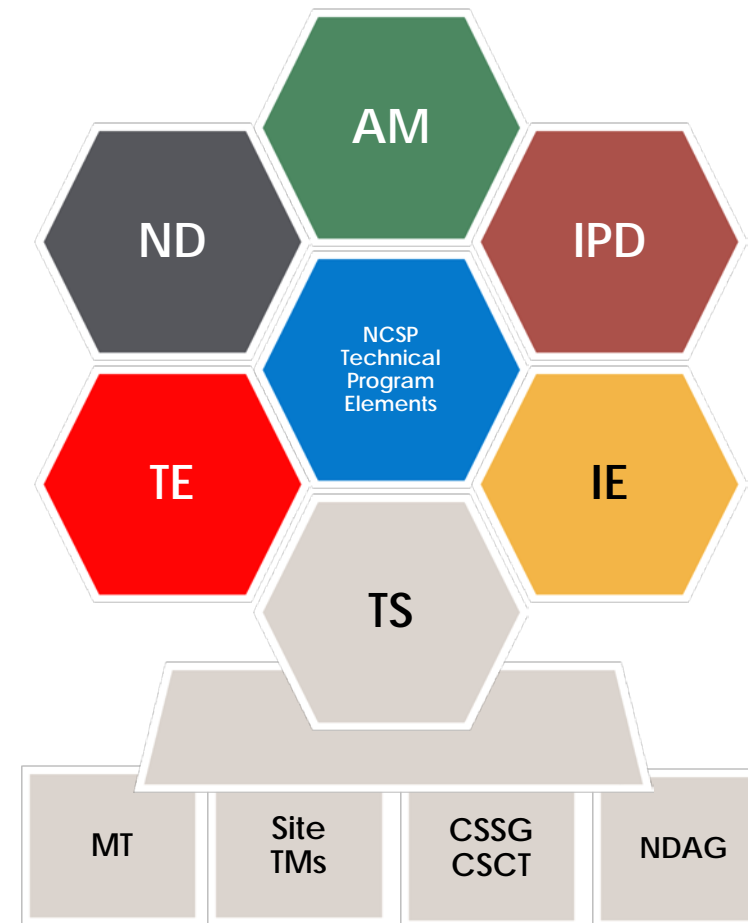
5 Year Plan



Work Tasks



NCSP Technical Program Elements



- AM** = Analytical Methods
- IPD** = Information Preservation and Dissemination
- IE** = Integral Experiments
- ND** = Nuclear Data
- TE** = Training and Education
- TS** = Technical Support
- CSSG** = Criticality Safety Support Group
- CSCT** = Criticality Safety Coordinating Team
- MT** = Management Team
- NDAG** = Nuclear Data Advisory Group
- TM** = Task Managers

US DOE NCSP Contributors

US Contributors

- National Laboratories
 - Argonne (ANL)
 - Brookhaven (BNL)
 - Lawrence Livermore (LLNL)
 - Los Alamos (LANL)
 - Oak Ridge (ORNL)
 - Pacific Northwest (PNNL)
 - Sandia (SNL)
- Sites
 - Nevada National Security Site (NNSS)
 - Savannah River (SRNL)
 - Y-12
- Universities
 - Rensselaer Polytechnic Institute (RPI)
 - Georgia Institute of Technology (Ga Tech)
 - North Carolina State University (NCSU)
 - Massachusetts Institute of Technology (MIT)
 - University of Florida (Gainesville) (UF)
 - University of Tennessee (Knoxville) (UTK)

International Partners

- U.K.: AWE (JOWOG-30)
- France:
 - IRSN (Formal MOU with NCSP)
 - CEA (Nuclear Data)
- Belgium: Institute for Reference Materials and Measurements (IRMM) differential nuclear data measurements
- OECD/NEA
 - ICSBEP
 - WPEC
 - WPNCS

Fiscal Year 19 NCSP Budget – ORNL Analytical Methods

NCSP AM Task	FY19 (\$k)	FY20 (\$k)	FY21 (\$k)	FY22 (\$k)	FY23 (\$k)
AMPX Maintenance & Modernization	\$ 270	\$ 286	\$ 297	\$ 325	\$ 380
Development and Addition of Continuous-Energy Sensitivity Data Files to SCALE's VALID Library	\$ 34	\$ -	\$ -	\$ -	\$ -
Nuclear Data and Cross Section Testing using ENDF/B-VIII.0	\$ 89	\$ -	\$ -	\$ -	\$ -
Proposed Benchmark Intercomparison Study	\$ 50	\$ 50	\$ 50	\$ -	\$ -
Radiation Safety Information Computational Center (RSICC)	\$ 325	\$ 325	\$ 330	\$ 360	\$ 400
SCALE/KENO/TSUNAMI Maintenance and Support/Cross-Section Generation/Modernization/etc.	\$ 1,200	\$ 1,250	\$ 1,250	\$ 1,308	\$ 1,500
Sensitivity / Uncertainty Comparison Study with a Focus on Upper Subcritical Limits	\$ 46	\$ 50	\$ -	\$ -	\$ -
Slide Rule Application	\$ 31	\$ 30	\$ 30	\$ 30	\$ 40
Technical Data for the Pitzer Formulation of Solution Compositions to Include Uranium/Plutonium Solutions with Selected Admixed Absorbers	\$ 75	\$ -	\$ -	\$ -	\$ -
The Effects of Temperature on the Propagation of Nuclear Data Uncertainty in Nuclear Criticality Safety Calculations	\$ 100	\$ 100	\$ 100	\$ -	\$ -
Grand Total	\$ 2,220	\$ 2,091	\$ 2,057	\$ 2,023	\$ 2,320

NCSP Provided Key Support for SCALE 6.2 – Released April 2016

Innovative

- Modernized architecture for efficiency and quality
- Enhanced sensitivity and uncertainty analysis
- Problem-dependent temperature treatments for continuous-energy Monte Carlo
- Reference continuous-energy depletion

Efficient

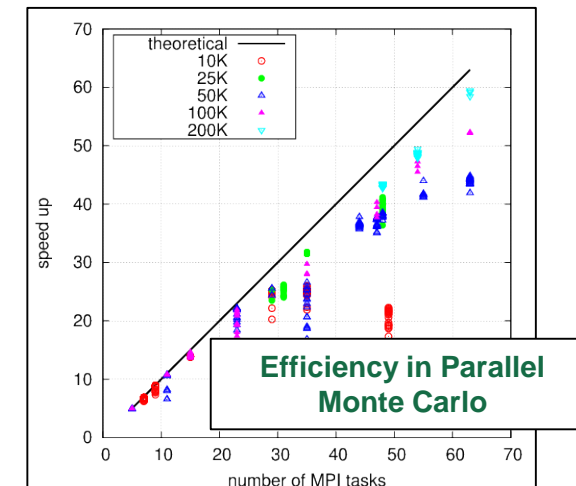
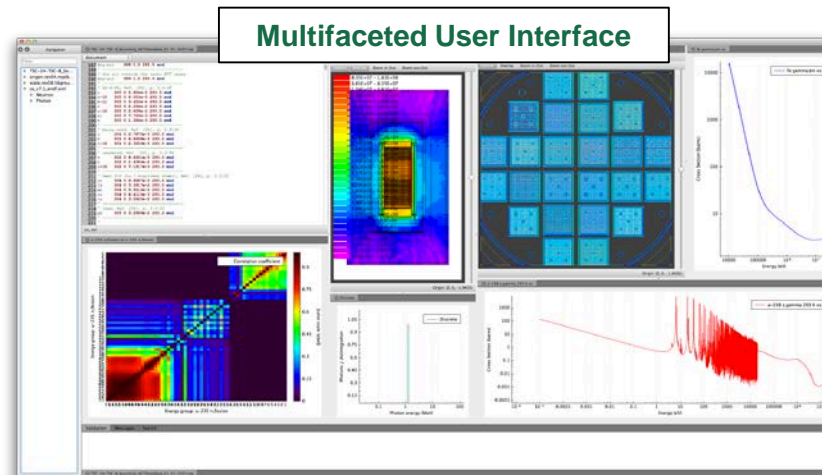
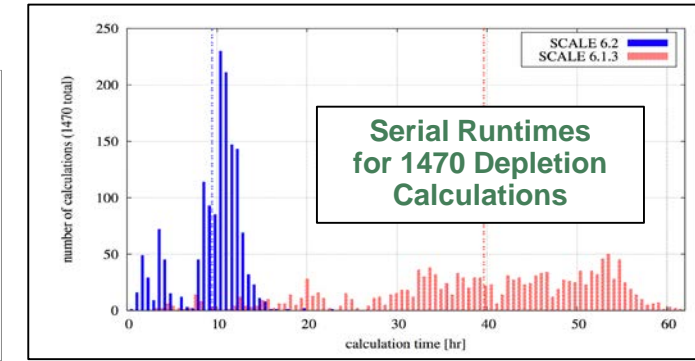
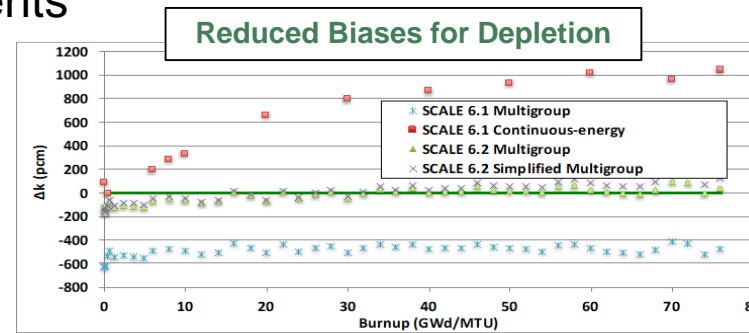
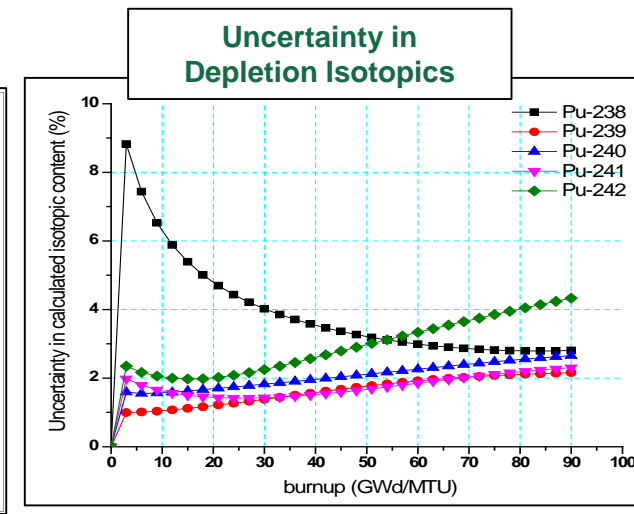
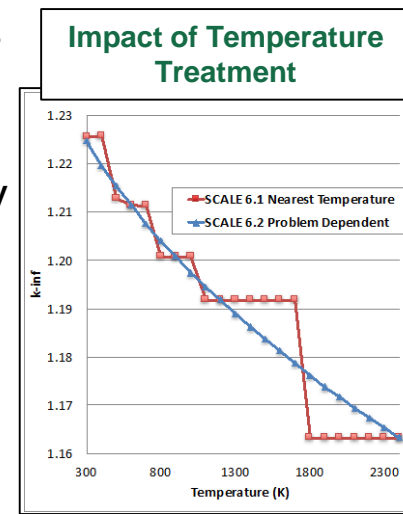
- Accelerated lattice physics capabilities
- Reduced memory requirements
- Parallel calculations

Accurate

- Code and data enhancements to minimize historical biases
- Greatly expanded test suites for validation and verification

Easy to Use

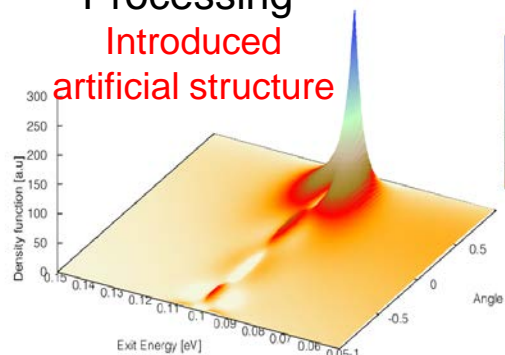
- Integrated user interface
- Simplified input



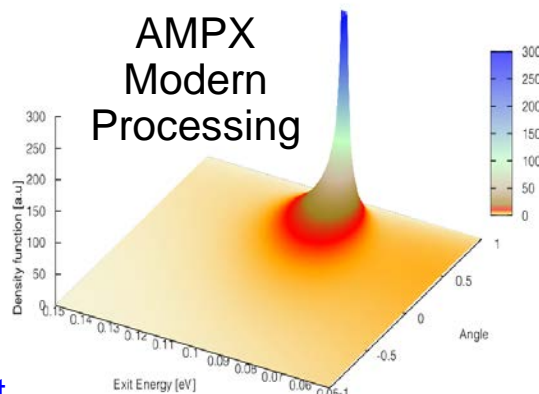
NCSP Provides Key Support for AMPX Maintenance & Modernization

AMPX Legacy Processing

Introduced artificial structure

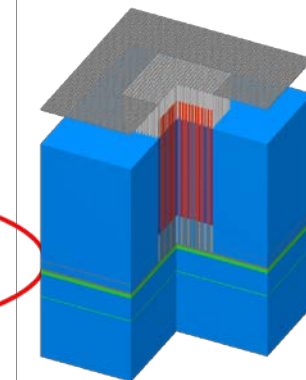
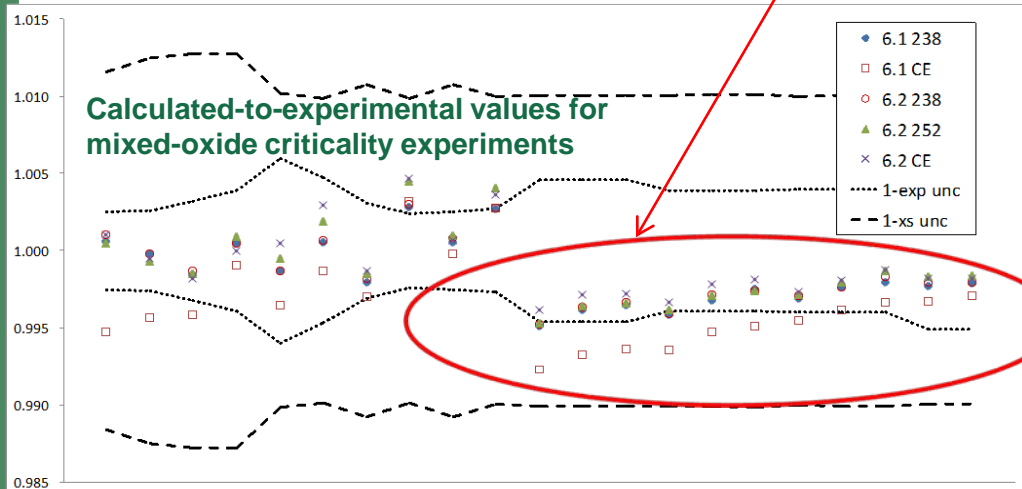


AMPX Modern Processing



H₂O incident energy 0.1 eV

AMPX Modernization addressed bias in CE data with SCALE 6.1



MIX-COMP-THERM-004 Critical Experiment

AMPX now included with SCALE distribution so users can create their own libraries!

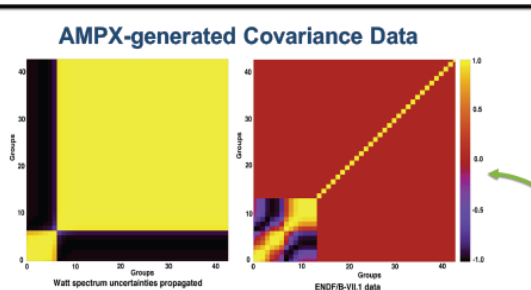
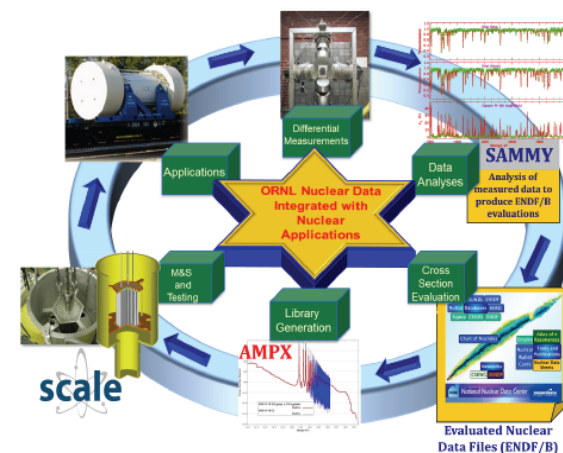
What is AMPX?

AMPX is a modular code package of computer programs used to produce multigroup (MG), continuous-energy (CE), and cross section covariance data libraries needed for nuclear analyses.

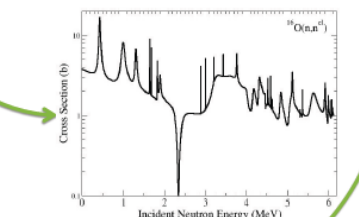
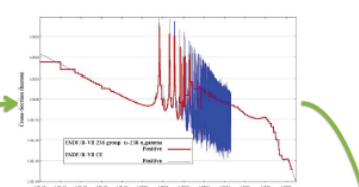
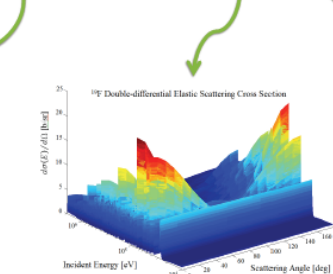
AMPX accepts and processes basic cross section data in the Evaluated Nuclear Data File (ENDF/B) format to generate a variety of libraries that can be used with modern transport codes to perform nuclear analyses.

SCALE relies upon AMPX to process ENDF/B-formatted nuclear data evaluations to produce MG, CE, and covariance data libraries.

AMPX provides nuclear data libraries to support the Consortium for Advanced Simulation of Light Water Reactors (CASL).

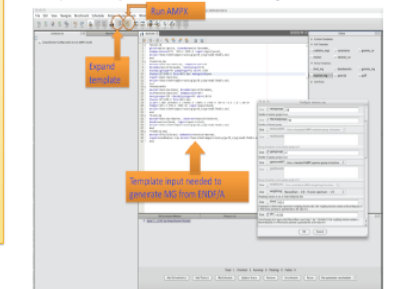


AMPX



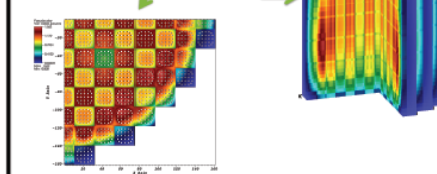
- ### AMPX Processing Capabilities at a Glance
- Temperature-dependent CE cross section data
 - Resonance self-shielding for resolved and unresolved resonance data
 - Probability tables for the unresolved resonance region
 - Energy and angle distributions for secondary particles
 - Particle yield and decay data
 - Cross section covariance data for S/U analyses
 - Runtime and testing

AMPX Graphical User Interface (GUI) to Prepare Input Files for Library Generation

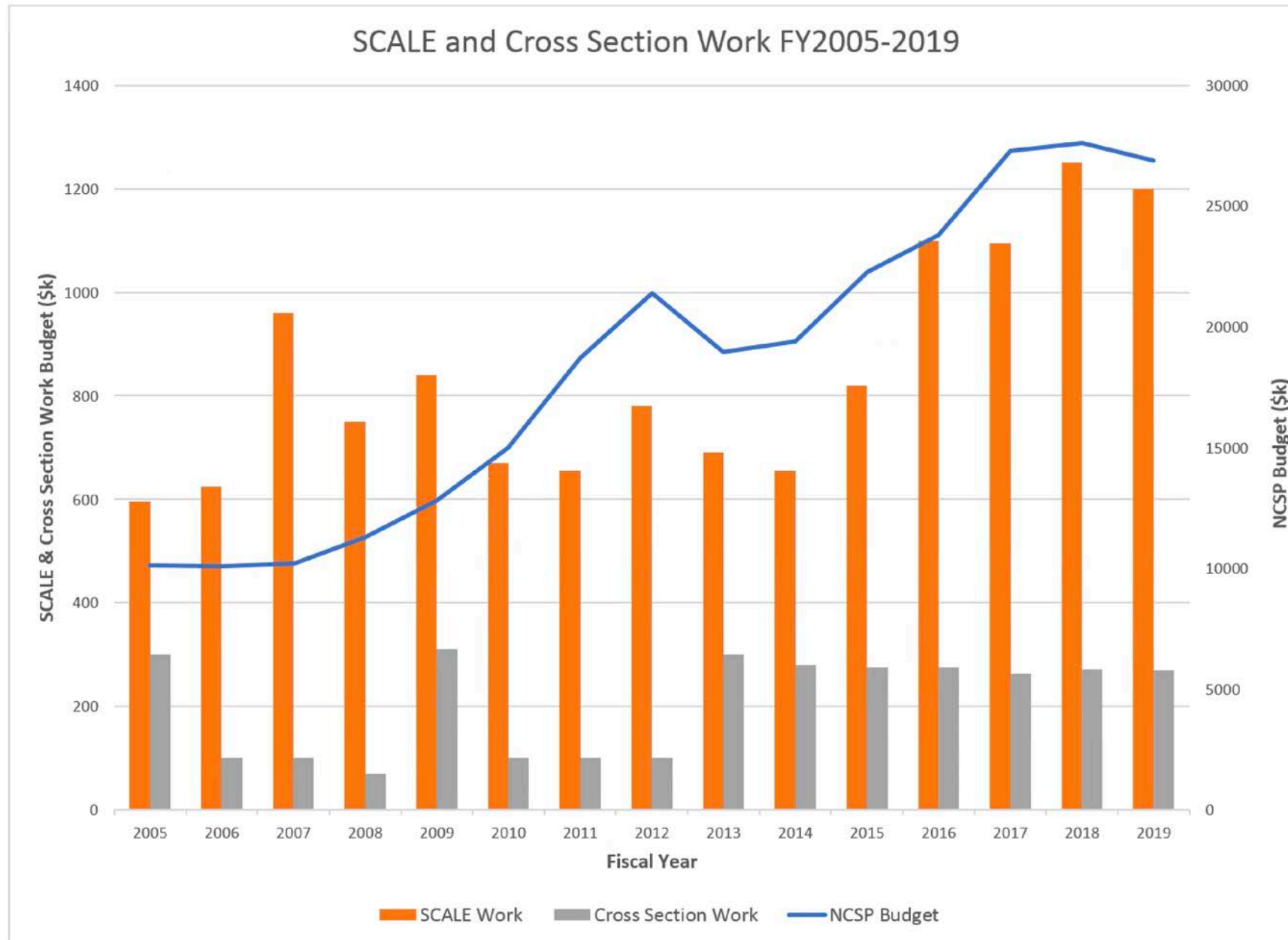


Library

SCALE



SCALE Support by the NCSP – FY2005 through FY2019



NCSP Support of SCALE in the Future

- NCSP support tends to follow trends in the DOE/NNSA NCS community
 - SCALE/MCNP maintenance, modernization, and development funding has grown over the years with the NCSP budget but this trend may not continue into the future
 - CSSG tend to recommend funding for tasks that more directly support facility staff
 - TE and IE elements are receiving much of the focus these days
- NCS staff are trained to preclude criticality accidents via NCS evaluations and implementing and maintaining process criticality safety limits for facility staff
 - Applying analytical methods to this goal is about ~10% of their job
- **Challenge:** continuously enhance ORNL AM tools for those supporting NCSP missions
 - ORNL SCALE work directly competes with comparable work at other sites



Questions

