OAK RIDGE National Laboratory

SCALE Newsletter

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In This Issue

scale
Nuclear Systems Modeling & Simulation

Celebrating 40 Years of SCALE Development

The SCALE project was initiated in 1976 by the US Nuclear Regulatory Commission through precursor organizations of the current Office of Nuclear Materials Safety and Safeguards (NMSS) Division of Spent Fuel Management (DSFM) to aid in the review of storage and transport systems. SCALE was developed as an easy-to-use computational system to perform confirmatory computer analyses for licensing evaluations. SCALE was originally designed with integrated computational sequences that provide for convenient material input, cross section processing, criticality analysis with KENO, depletion and radioactive source term characterization with ORIGEN, radiation shielding analysis, and thermal analysis.

In July 1980, the initial version of SCALE was made available to the Radiation Safety Information Computational Center (RSICC) at Oak Ridge National Laboratory (ORNL). This system was packaged and released by RSICC as CCC-288/SCALE 0 (Fig 1).

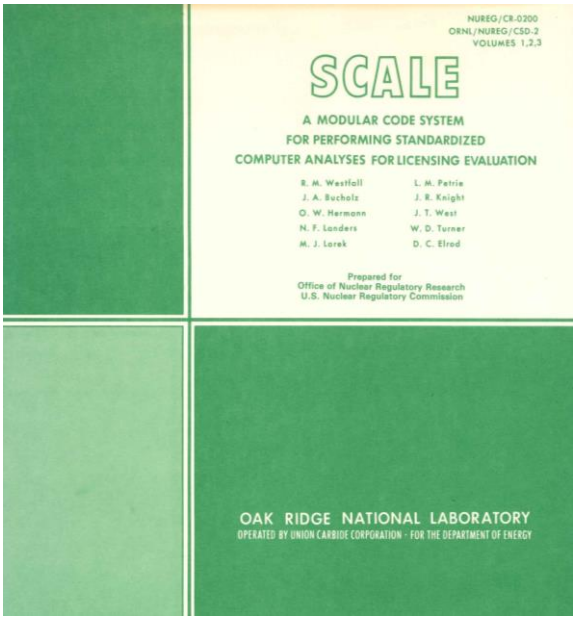

Fig. 1. Cover of Original SCALE-0 Documentation from 1980.

Subsequent additions and modifications resulted in the following releases:

CCC-424/SCALE 1 in 1981	SCALE 4.4 in 1998
CCC-450/SCALE 2 in 1983	SCALE 4.4a in 2000
CCC-466/SCALE 3 in 1985	CCC-725/SCALE 5 in 2004
CCC-545/SCALE 4.0 in 1990	CCC-732/SCALE 5.1 in 2006
SCALE 4.1 in 1992	CCC-750/SCALE 6.0 in 2009
SCALE 4.2 in 1994	CCC-785/SCALE 6.1 in 2011
SCALE 4.3 in 1995	CCC-834/SCALE 6.2 in 2016

The SCALE team is thankful for 40 years of sustaining support from NRC NMSS/SFM, as well as decades of support from NRC Office of Nuclear Regulatory Research, National Nuclear Security Administration's Nuclear Criticality Safety Program, US Department of Energy (DOE) Office of Nuclear Energy, and DOE Office of Environmental Management.

SCALE 6.2.1 Update

The SCALE 6.2.1 update is available for SCALE 6.2 to provide enhanced performance and resolve issues in the areas detailed below. This update is recommended for all SCALE 6.2 users.

Since SCALE 6.2 was released on April 28, 2016, end users and the SCALE development team have identified a few issues that impact the performance of the code package in some cases. The most important of these issues are addressed in the SCALE 6.2.1 Update. The issues not resolved by this update will be addressed in a patch to the current release or in the next release of SCALE.

Please contact your distribution center (RSICC, NEA Data Bank, or RIST) to obtain this update.

Summary of updates and enhancements

CRAWDAD

A restriction that limited CRAWDAD to treating only up to 100 temperature values has been removed. A memory defect was resolved that could cause a 'glibc' crash for some cases.

Fulcrum

New features available in 6.2.1:

- Text block column operations are now supported. By using the *Alt+Left* mouse button drag, a block of text is selected and can then be deleted, pasted, edited, etc.
- The file name is no longer incorporated into the file's specific action items (*Save*, *Save as*, etc.). When using *Save as*, the file name is prepopulated with the current file name.
- Text panels now display the line number in the same font as selected for text viewing.
- Geometry view now has a *Show view origin* button allowing users to place a crosshair at the origin of the view plane, which can be helpful for zooming to a certain region of the geometry.
- Data files that include reaction names now also include the reaction identifier (MT) number; this MT is also shown in the plot legend. This applies to many data formats, including multigroup and continuous-energy cross sections, sensitivity data files, covariance data, etc.
- The ability to highlight all instances of selected text within the editor is now provided to help users recognize patterns of use. This highlighting appears as a shadow box surrounding additional occurrences.
- In-line mathematical expression evaluation is now supported within any text file. Selected functions and expressions can be evaluated by clicking *Edit* → *Evaluate* or by using the *CTRL+E* key (*CMD+E* on Macintosh systems) combination. In addition to basic arithmetic operators (+, -, *, /, ^), the following functions are available for evaluation: sqrt, cos, sin, root, abs, min, max, avg, sum, mul, floor, ceil, exp, log, logn, log10, hyp, ifFunction, clamp, inrange, sign, deg2rad, tan, equal, acos, asin, atan, cosh, tanh, sec, csc, cot, sinh, round, roundn.

Several issues in the previous version of Fulcrum were addressed in SCALE 6.2.1.

- Sensitivity data file (.sdf) for the energy-integrated k_{eff} sensitivity can be now displayed.
- With multiple documents open, file actions (*Find*, *Autocomplete*, *Save As*, etc.) now operate on the expected file.
- Fulcrum's geometry XZ and YZ MeshView 2D plot creation has been updated to correctly set the voxel index at the point needed to create the 2D plot. The results of previous calculations are not affected, but visualization of results may result in minor offsets of data that use the Z-plane. Mouse hover operation now incorporates the mesh voxel index in the info label, along with the absolute (x,y,z) Cartesian coordinates, unit, and material.
- A warning message is now provided to the user when closing a message or editor view with a running job attached to it.
- An empty CELLDATA block no longer produces a validation error.
- SCALE input parsing (the form of the input) and validation (correctness of input parameters) errors have been disambiguated. Calculations cannot be started for inputs with parse errors, but they can be started for inputs with validation errors to obtain additional diagnostic data from the computational codes.
- A TRITON timetable density specification with 0 nuclides (indicating all nuclides) no longer produces a validation error in Fulcrum.
- Syntax highlighting, originally only available for inputs with all lower case keywords, is now case-insensitive.
- Correct validation is now performed for MCDancoff inputs that start particles in holes, geometry ring regions, and it also supports FIDO statements.
- Mixing table generation capability (*Run/Mixing* table) now supports material aliases.

KENO

Several issues in SCALE 6.2 were addressed by the update.

- Temperature output edits for multigroup calculations now correctly list nuclides' temperatures. Calculation results are not affected.
- The KENO plot file (.png) is now created on Windows systems.
- The PNU parameter (prompt or total neutrons from fission for continuous-energy calculations) now properly functions when requested. Previously, only total neutron emissions (prompt+delayed) were used, regardless of the parameter setting.
- The mean free path edit previously provided the mean distance travelled before a collision or a boundary crossing. Therefore, the mean free path depended in part on how the user modeled the geometry. The mean free path has been updated to correctly represent the mean distance between collisions.

Monaco
An issue with generating secondary gamma production was resolved in continuous-energy calculations. Fission gammas or gammas from other particle productions (e.g., proton, alpha, and tritium) might have been disabled, depending on the problem. Results for the Monaco regression problems used for SCALE testing show an insignificant change in the magnitudes of flux and response values.

NEWT
In addition to input keywords *fluxplane, fluxplan,* and *flux,* which are supported in SCALE 6.2, *fluxplanes* is also supported in SCALE 6.2.1.

ORIGAMI
One of the first setup operations ORIGAMI performs is to interpolate an ORIGEN library (with ARP) to the desired enrichment, moderator density, and burnups. For decay calculations, ORIGAMI uses the most recently loaded data set with flux=0. For a **restart** decay calculation, values for the interpolation parameters do not need to be defined. The previous logic was to assume the default enrichment of 3.2% and moderator density and zero burnup. However, this caused an error when a reactor library could not be interpolated to 3.2%. The updated logic for restart decay calculations considers the data set with the lowest enrichment and moderator density.

The "total" row in the neutron and gamma emission summary table of an ORIGAMI output is now suppressed since it is a misnomer.

ORIGEN
Additional backwards compatibility was added for reading SCALE 6.1 and earlier FIDO style input.

The default cutoff criteria for (alpha,n) sources has been changed from 1e-5 to 0 (no cutoff) based on the recommendation of Rick Migliore of AREVA, who noticed that there can be 15% error in some cases in the (alpha,n) component of the total neutron source with the previous default cutoff of 1e-5. With the current implementation, the runtime increase incurred by using a zero cutoff instead of 1e-5 is negligible.

Issues resolved in SCALE 6.2.1:

- Crashes have sometimes occurred due to formatting of the beta principal emitter summary in the output, when trying to access an out-of-bounds array element.
- An issue was resolved in calculating the time step when (1) isotopics where loaded from an f71 file and (2) the user specified a start time of zero in the time block. The output file shows the actual time steps used in the calculation. The bug was fixed, and additional inputs were added to control the material timeline and time specification.

Polaris
The use of size=2 for large water holes could sometimes cause the calculation to terminate. The issue has been resolved in this update.

The Polaris MOC transport solver has been enhanced. PN calculations are supported, with P2 designated as the new default scattering treatment. The accuracy of light water reactor (LWR) reflector calculations has been significantly improved with the addition of anisotropic scattering. Transport cross section edits have been improved, with hydrogen transport cross sections being computed using the neutron-leakage-correction method. The MOC calculation was modified to use less memory and provide improved runtime performance through updates to the Coarse Mesh Finite Difference (CMFD) acceleration calculation.

PUFF (AMPX)
The AMPX code PUFF for generating multigroup cross section covariance data has been modernized and enhanced. PUFF has been rewritten in C++ to take advantage of the new C++ reading routines for (1) ENDF (which will also support the new GND format), (2) the new in-memory input/output resource for the COVERX file format, and (3) the new resonance processing application program interface (API). In addition, the new PUFF version adds covariance matrices for redundant reaction if not given by the evaluator (e.g., absorption reaction when fission and capture are provided). Processing for fission spectrum (chi) covariance matrices previously available in a different module has been incorporated into PUFF.

Errors found in the old version of PUFF that affected some test libraries not distributed with SCALE have been corrected. Results from previous and updated codes have been compared and found to be in good agreement, except for cases in which erroneous covariance matrices were previously computed.

A new keyword-based input with more options has been added, but the old FIDO-style input is still supported.

Sampler
Sampler was updated to enable multi-dimensional parametric analyses for studying the effects of combinations of varying parameters on various calculated responses. Using the READ PARAMETRIC block, a user may enter one or more variables that have been defined with uniform distributions, along with the number of samples for each variable. Each variable is sampled uniformly over the domain defined by its minimum and maximum values.

Sampler generates a summary table of the parametric study, including values for which the minimum and maximum of each response occurs. PTP plot files showing the dependency of each response on each variable are generated.

SCALE Runtime Environment
An issue was resolved where the HTML icon graphics were not properly copied to the htmd directory.

Standard Composition Processing
Improved warning messages are provided for nuclides not present on the user-specified cross section data library. Several warnings can be observed for models with multiple

compositions containing oxygen. Oxygen contains 0.2 atoms % of O-18, for which cross section data are not available in ENDF/B-VII.0 or ENDF/B-VII.1. The user can now export the environment variable MISSING_NUCLIDE_MSG_LEVEL=QUIET to reduce the amount of information printed for nuclides missing from the cross section library. The calculation is performed with the nuclide removed from the model, using a zero cross section for each of the missing nuclide(s); the impact on radiation transport results and activation/depletion results has been assessed as negligible for most tested cases.

The material processor now supports the legacy SOLN formatted solution composition input that was supported in SCALE 6.1.

TRITON

An error that impacts depletion analyses using the ASSIGN function was present in SCALE 6.2. The error led to incorrect calculation of mass and volume for some of the depleted materials, and consequently, incorrect calculation of the specific power for these materials. This issue was corrected in SCALE 6.2.1. All SCALE 6.2 T-DEPL calculations using ASSIGN should be reanalyzed with SCALE 6.2.1.

The T-DEPL sequence in SCALE 6.2 contains a new capability to swap materials in the timetable block. This capability is designed to allow users to swap in and out control rods and burnable absorber materials during depletion simulations. A bug was discovered in the swap implementation that caused an incorrect power normalization. Power is incorrectly applied to materials that are swapped out, resulting in an incorrect power normalization for all materials. This bug may not be apparent to users because the materials associated with the swap function are correctly placed in the geometry and the calculated k_{eff} behavior may appear to be correct; however, the power assigned to those materials is incorrectly calculated. The magnitude of the impact increases with increasing fuel burnup. The error can be seen by inspecting the power summary table in the TRITON output file (search for "Material powers" or "Transport k"). In the "Total Power" column of this table, users will notice that materials swapped out at a certain time still have power applied to them. This issue was resolved in the SCALE 6.2.1 update. All SCALE 6.2 T-DEPL calculations using SWAP should be reanalyzed with SCALE 6.2.1.

Output edits in multigroup depletion calculations had ADDNUX nuclides with missing titles. The results of calculations were not affected. The issue was resolved in SCALE 6.2.1.

In KENO-based TRITON calculations, the geometry volume was being recalculated for each depletion step. The results were not affected. The issue was resolved in SCALE 6.2.1, and the calculation efficiency was improved.

ALIAS expansion is now available in KENO-based TRITON calculations.

TSUNAMI

The job information data imbedded in sensitivity data files (.sdf) from TSUNAMI-3D continuous-energy calculations has been updated to provide the expected data.

SAMS mixture numbers longer than 4 digits are now printed in various sensitivity edits. This issue was a holdover from previous SCALE releases where mixture numbers could not exceed 2147.

Total sensitivity coefficients by nuclide and total sensitivity coefficients by mixture are now displayed for all mixtures.

XSProc

Issues occurring in cross-section processing affect all SCALE modules or sequences where XSproc is used.

For multigroup data, temperature interpolation for threshold reactions could sometimes generate a negative cross section, such as for ^{232}Th. This issue was resolved.

In the cell data block, changing the origin of the zone definition in a multiregion model caused the calculation to fail. This issue was resolved.

Using upper-case continuous-energy library names caused the problem to stop. This issue was resolved.

Calculations using DOUBLEHET failed when CELLMIX was used. This issue was resolved.

Calculations when CENTRM used npxs=0 and nfst=6 failed. This issue was resolved.

In some depletion calculations when CENTRM was used with a user-provided Dancoff factor, memory grew per depletion step. This issue was resolved.

An issue was resolved with the thermal calculation routine using the CENTRM 2D MOC solver option (npxs=6). The impact on criticality calculations for SCALE sample input problems was very small. Calculations with other npxs values are not affected.

The CENTRM "iterp" temperature interpolation message is now correctly identified as a warning (not an error) and is limited to one occurrence per calculation.

Multigroup calculations involving multiregion cells with invalid zone radii (equal radii for more than one zone) produced a misleading *lbar is zero* error. This message has been updated to indicate the line and column of both offending cell radii.

The default settings for legacy standalone (FIDO input) CENTRM calculations have been updated for consistency with XSProc-based CENTRM.

The MOC solver was updated to use equal-volume radial mesh for discretizing each material zone. Previous versions of the MOC solver used equal-radii radial mesh. Although the equal-volume radial mesh is more appropriate, this code change has little impact on the accuracy of self-shielded calculations.

Y12 (AMPX)

A memory defect was resolved in the AMPX Y12 module, which would sometimes cause calculations to fail.

SCALE 6.2 Open Issues

The issues described below have not been resolved in the SCALE 6.2.1 update and are planned to be addressed in a later patch to the current release or in the next release of SCALE.

Units printed in the TRITON system mass summary output table

The TRITON depletion sequences produce a system mass summary output table (see SCALE 6.2 documentation Section 3.1.5.4.3). One column header of this table states "Fractional HM Mass (g)." The values of this column correspond to fractional heavy metal (HM) mass, which is a unitless quantity. Users should be aware that the units are not grams as the column header suggests. Moreover, the system mass summary table provides units for the HM mass of each material, as well as the units of the normalization factor required to normalize the mass to 1 metric ton of HM in the system. For example, for the 2D depletion (t-depl) sequence, the units of the HM mass should be *g/cm,* and the unit of the normalization should be *cm***,** For the 3D KENO sequences (t5-depl and t6-depl), the displayed units should be *g* and *no units*. However, the units displayed in the table are always *g/cm* and *cm*, regardless of the geometry's dimension. Users should be aware that for 3D depletion calculations (and 1D slab or sphere depletion), the output file displays incorrect units for the mass summary table. However, the data in the tables are correct and correspond to units based on the actual geometry's dimension.

Resonance self-shielding for unreferenced compositions in TRITON calculations

SCALE has historically treated unreferenced compositions (i.e., compositions not explicitly identified in the CELLDATA block) as infinite homogeneous media for multigroup resonance self-shielding calculations. Unreferenced compositions undergo BONAMI and CENTRM self-shielding calculations based on the infinite homogeneous treatment (if parm=bonami, only BONAMI is called). To reduce runtime for depletion calculations, TRITON has historically performed only BONAMI infinite homogeneous media self-shielding calculations for the unreferenced compositions, regardless of the *parm* specification.

TRITON in SCALE 6.2 further reduces runtime by treating the compositions as infinitely dilute instead of as an infinite homogeneous media, meaning that resonance self-shielding calculations are not performed unless the composition is explicitly identified in the CELLDATA block. In most cases, this update has a minor effect on results, as most compositions require self-shielding definitions. However, several compositions (e.g., structural materials) may be unreferenced, and the infinitely dilute treatment can lead to some noticeable effects. To test for consistency, infinite homogeneous media self-shielding can be explicitly added to the cell block for any unreferenced composition (e.g., *inf 10 end* to specify infinite homogeneous medium treatment for mixture 10 or *inf 10 20 30 end* to treat mixtures 10, 20, and 30 using only one line of input). Users can test for consistency by comparing eigenvalue differences between TRITON and CSAS calculations, as CSAS continues to provide the traditional approach of treating unreferenced compositions as infinite homogeneous media.

SCALE Quality Assurance Program

The SCALE quality assurance (QA) program was updated in 2013 to provide improved high-quality software and data to the user community. The new QA program is compliant with international standards in ISO 9001-2008, US Department of Energy Order 414.1D, and the ORNL Standards-Based Management System, and it is consistent with US NRC guidelines in NUREG/BR-0167, as well as ASME NQA-1. The SCALE QA program implements a streamlined Kanban process with continuous integration of new features and an automated test system that performs approximately 100,000 tests per day on Linux, Macintosh, and Windows operating systems. This QA program provides for rapid introduction of new features for deployment to end users. However, the SCALE team makes no guarantees regarding the performance of SCALE for any specific purpose, and users should independently submit the software to their own site- or program-specific testing and validation prior to use.

See http://scale.ornl.gov/moreinfo.shtml to download a copy of the SCALE QA plan.

SCALE Publications

The SCALE team produces numerous publications on development and application activities, including peer-reviewed journals, technical reports, and conference publications. Publications are often jointly created with users and developers throughout the community. A summary of publications released to date in 2016 is provided here.

Peer-Reviewed Journal Articles

I. C. Gauld, J. M. Giaquinto, J. S. Delashmitt, J. Hu, G. Ilas, T. J. Keever, and C. Romano, "Re-evaluation of Spent Nuclear Fuel Assay Data for the Three Mile Island Unit 1 Reactor and Application to Code Validation," *Annals of Nuclear Energy* **87**, 267–281 (2016). http://dx.doi.org/10.1016/j.anucene.2015.08.026

A. E. Isotalo, G. G. Davidson, T. M. Pandya, W. A. Wieselquist, and S. R. Johnson, "Flux Renormalization in Constant Power Burnup Calculations," *Annals of Nuclear Energy* **96**, 148–157 (2016). http://dx.doi.org/10.1016/j.anucene.2016.05.031

S. W. D. Hart, C. Celik, G. I. Maldonado, and L. Leal, "Creation of Problem-dependent Doppler-broadened Cross Sections in the KENO Monte Carlo Code," Annals of Nuclear Energy **88**, 49–56 (2016). http://dx.doi.org/10.1016/j.anucene.2015.10.011

U. Mertyurek and I. C. Gauld, "ORIGEN Libraries for MOX Fuel Assembly Designs," *Nuclear Engineering and Design* **297**, 220–230 (2016). http://dx.doi.org/10.1016/j.nucengdes.2015.11.027

T. M. Pandya, S. R. Johnson, T. M. Evans, G. G. Davidson, S. P. Hamilton, and A. T. Godfrey, "Implementation, Capabilities, and Benchmarking of Shift, a Massively Parallel Monte Carlo Radiation Transport Code," *Journal of Computational Physics* **308**, 239–272 (2016). http://dx.doi.org/10.1016/j.jcp.2015.12.037

V. Sobes, L. Leal, G. Arbanas, and B. Forget, "Resonance Parameter Adjustment Based on Integral Experiments," *Nuclear Science and Engineering* **183(**3), 347–355 (2016).

http://dx.doi.org/10.13182/NSE15-50

C. M. Perfetti, B. T. Rearden, and W. R. Martin, "SCALE Continuous-Energy Eigenvalue Sensitivity Coefficient Calculations," *Nuclear Science and Engineering* **182**(3), 332–353 (2016). http://dx.doi.org/10.13182/NSE15-12

B. Ade, A. Worrall, J. Powers, and S. Bowman, "Analysis of Key Safety Metrics of Thorium Utilization in LWRs," *Nuclear Technology* **194**, 162–177 (2016). http://dx.doi.org/10.13182%2fNT15-100

M. T. Pigni, S. Croft and I. C. Gauld, "Uncertainty Quantification in (α,n) Neutron Source Calculations for an Oxide Matrix," *Progress in Nuclear Energy* **9**, 147–152 (2016). http://dx.doi.org/10.1016/j.pnucene.2016.04.006

Technical Reports

J. Hu, I. C. Gauld, J. L. Peterson, and S. M. Bowman, "U.S. Commercial Spent Nuclear Assembly Characteristics: 1968–2013," NUREG/CR-7227 (2016). http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr7227/

W. J. Marshall, B. J. Ade, S. M. Bowman, and J. S. Martinez-Gonzalez, "Axial Moderator Density Distributions, Control Blade Usage, and Axial Burnup Distributions for Extended BWR Burnup Credit," NUREG/CR-7224 (2016). http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr7224/

Conference Proceedings

T. A. Eckleberry, W. J. Marshall, E. L. Jones, and G. I. Maldonado, "Validation of KENO Thermal Moderator Doppler Broadening Method in SCALE 6.2 Beta5 Using Continuous-Energy B-VII.1 Library," *ANS Transactions* **114**, 484–487 (2016).

S. P. Hamilton, G. G. Davidson, T. M. Evans, and K. Banerjee, "Accelerated Monte Carlo Fission Source Convergence with Fission Matrix and Kernel Density Estimators," *ANS Transactions* **114**, 385–387 (2016).

W. J. Marshall, B. J. Ade, and S. M. Bowman, "Apparent Monte Carlo Source Convergence Problem with BWR Fuel Depleted with Partial Control Blade Insertion," *ANS Transactions* 114, 475–478 (2016).

C. M. Perfetti and B. T. Rearden, "CE TSUNAMI-3D Algorithm Improvements in SCALE 6.2.," *ANS Transactions* **114**, 385–387 (2016).

C. M. Perfetti and B. T. Rearden, "A New TSUNAMI-3D Capability for Calculating Undersampling Metrics and Biases," *ANS Transactions* **114**, 385–387 (2016).

G. Ilas, B. Betzler, B. Ade, "Impact of Reactor Operating Parameters on Cask Reactivity in BWR Burnup Credit," CD Proceedings, PATRAM 2016, Kobe, Japan (2016).

W. J. Marshall, B. J. Ade, and S. M. Bowman, "Study of Axial Burnup Profile Effects on BWR Burnup Credit," CD Proceedings, PATRAM 2016, Kobe, Japan (2016).

D. Chandler and R.J. Ellis, "Development of an Efficient Approach to Perform Neutronics Simulations for Plutonium-238 Production," CD Proceedings, PHYSOR 2016, Sun Valley, ID, USA (2016).

G. G. Davidson, T. M. Pandya, A. E. Isotalo, S.R. Johnson, T. M. Evans, W. A. Wieselquist, "Nuclide Depletion Capabilities in the Shift Monte Carlo Code," CD Proceedings, PHYSOR 2016, Sun Valley, ID, USA (2016).

G. Radulescu and K. J. Connolly, "A Parametric Analysis of Factors Affecting Calculations of Estimated Dose Rates from Spent Nuclear Fuel Shipments," CD Proceedings, WM2016 Symposium, Phoenix, AZ, USA (2016).

Do you have a publication documenting the application of SCALE to a challenging analysis scenario? Submit your publication to scalehelp@ornl.gov and it may appear in a future edition of the SCALE Newsletter!

SCALE Team

The SCALE team consists of 40+ talented and diverse staff members from ORNL's Reactor and Nuclear Systems Division. Most of our team members hold advanced degrees in nuclear engineering, physics, and/or computer science. SCALE development, testing, deployment, and training are organized into task-oriented teams as shown below in Fig. 2 Many other internal and external collaborators and students also contribute to SCALE on an ongoing basis.

A photo of the team members present for the release of SCALE 6.2 is shown in Fig. 3 below.

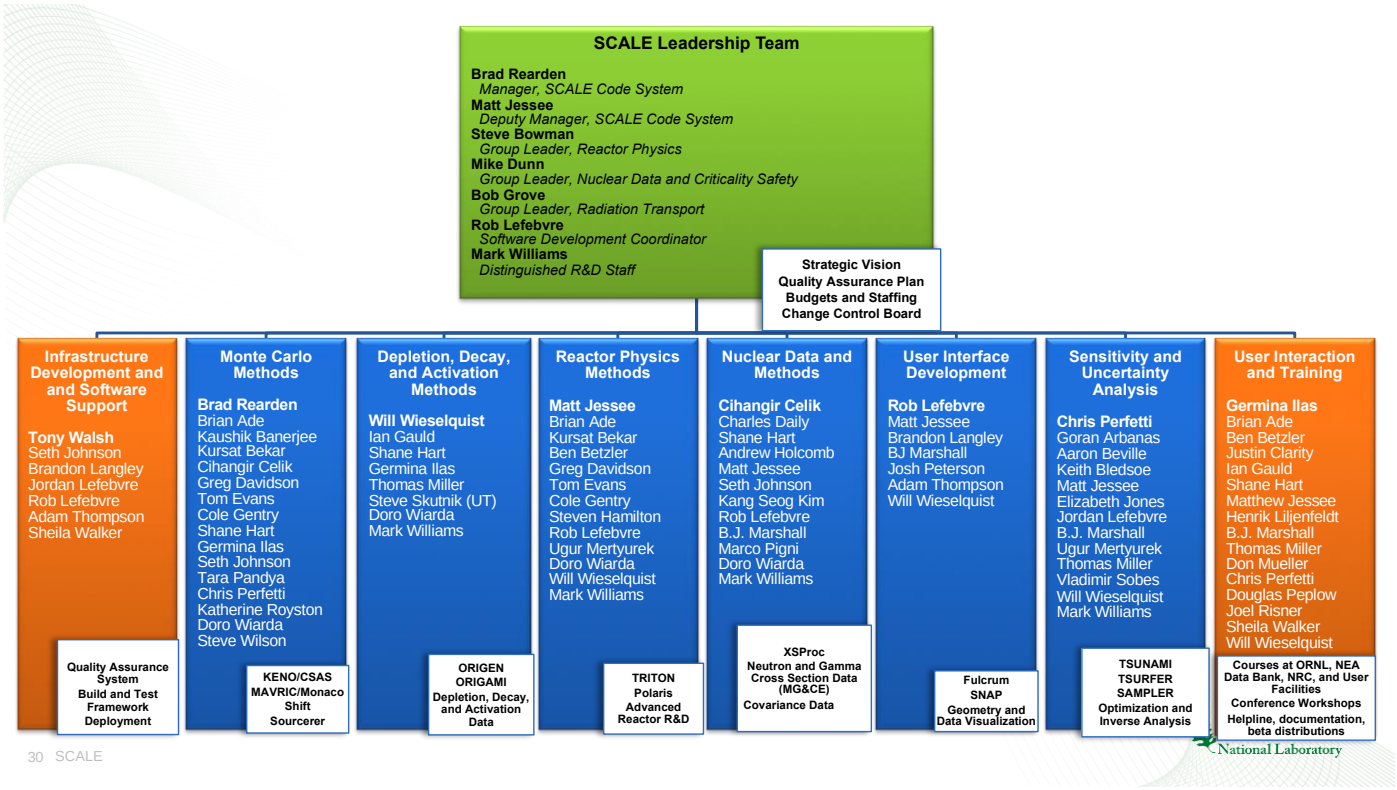

Fig. 2. SCALE Team Structure

Fig. 3. SCALE 6.2 Team Photo - April 2016 (Left to right. First Row: Jianwei Hu, Germina Ilas, Tara Pandya, Shane Hart, Lester Petrie, Brad Rearden, Bob Grove, Mike Dunn, Mark Williams, Georgeta Radulescu, Elizabeth Jones, Ian Gauld; Second Row: Matt Jessee, Steve Skutnik, Kevin Clarno, Tony Walsh, Cihangir Celik, Ron Ellis, Kursat Bekar, Doro Wiarda, Mark Baird; Back Row: Jordan Lefebvre, Rob Lefebvre, Adam Thompson, Andrew Holcomb, Rose Raney, Ugur Mertyurek, B. J. Marshall, Steve Bowman, Don Mueller, Ahmad Ibrahim, Brandon Langley, Douglas Peplow, Greg Davidson, Dan Ilas, Justin Clarity, Josh Peterson, and Will Wieselquist)

Recent SCALE Photos

SCALE Sensitivity and Uncertainty Calculations Course
ORNL, August 2016

SCALE 6.2/ORIGEN Standalone Fuel Depletion, Activation, and Source Term Analysis Course
ORNL, August 2016

SCALE 6.2/ORIGEN Standalone Fuel Depletion, Activation, and Source Term Analysis Course
Moscow Engineering Physics Institute (MEPhI), Russia
October 2016

SCALE Spotlight

This issue's featured team member is Dr. Cihangir Celik.

Cihangir Celik

Positions:

- Research and Development Staff Member
- Nuclear Data and Criticality Safety Group Member
- Nuclear Data and Methods Team Lead

Focus areas:

Nuclear data, criticality safety, radiation shielding, reactor physics.

Most significant projects:

Dr. Celik joined ORNL in 2010 as a postdoctoral student working on continuous energy Monaco implementations. He became an R&D staff member in 2013. With a mindset to pursue every possible opportunity to understand and to represent actual systems as accurately as possible, even if it requires sacrifice of some sleep, Dr. Celik has been involved with a variety of projects, including nuclear data generation and testing with AMPX, Monte Carlo methods and codes (MONACO, KENO, SOURCERER, and Shift), continuous energy and multigroup physics packages for SCALE and Shift, integral experiment benchmark evaluations and sensitivity calculations, and method development for Doppler broadening of nuclear cross sections.

Dr. Celik considers himself fortunate that he has overcome challenges by always having an expert next door. He is grateful for his colleagues at ORNL, who "are always welcoming me whenever I show up at their doors without any notice in advance. This is a priceless resource." Looking ahead, Dr. Celik plans to continue his work on identifying research needs and developing methods and applications for an accurate, efficient, feasible solution.

Fig. 4. Cihangir and his children preparing for Halloween

Life outside of work:

Dr. Celik and his wife are originally from Turkey, and children always take the central part of their daily life. He writes, "being a descendant of nomadic culture, I enjoy outdoors and wildlife as much as possible. My family is always taking care of my safety, by reminding me not to take on a bull or climb down from a cliff by jumping on a close-by tree."

Technical Support and Training

The SCALE team is dedicated to supporting all SCALE users, but the team can only provide limited complimentary technical support for inquiries submitted to scalehelp@ornl.gov. For basic help in getting started with SCALE, new users are encouraged to attend the public training courses where the capabilities of SCALE are presented in detail.

To facilitate interaction among SCALE users and with developers, the SCALE Users Group forum hosted by Google is available at the following link: https://groups.google.com/forum/#!forum/scale-users-group.

SCALE primers for KENO V.a, KENO-VI, TSUNAMI, and TRITON provide detailed, step-by-step instructions to assist new users in learning how to use these modules for criticality safety, sensitivity/uncertainty, lattice physics, and source term calculations. Direct links to the SCALE primers are available at http://scale.ornl.gov/training_primers.shtml.

If your team could benefit from customized technical support or training, additional options are available. The SCALE team can provide direct support or a visit to your site to present customized, hands-on courses to provide the expertise needed to solve challenging application scenarios. Please contact scalehelp@ornl.gov for more information.

SCALE Leadership Team

The SCALE Leadership Team consists of the SCALE manager, line managers, program managers, and developers. The Leadership Team meets regularly to discuss status and make programmatic and managerial decisions regarding SCALE.

Members of the SCALE Leadership Team are as follows:

Brad Rearden, Manager, SCALE Code System

Matt Jessee, Deputy Manager, SCALE Code System

Steve Bowman, Group Leader, Reactor Physics

Mike Dunn, Group Leader, Nuclear Data and Criticality Safety

Bob Grove, Group Leader, Radiation Transport

Rob Lefebvre, SCALE Software Development Coordinator

Mark Williams, Distinguished Developer, Nuclear Data and Reactor Physics

Upcoming SCALE Training Courses

Training courses are provided by developers and expert users from the SCALE team. These courses provide a review of theory, descriptions of capabilities and limitations of the software, and hands-on expertise running problems of varying levels of complexity. Please see http://scale.ornl.gov/training_2017_feb-mar.shtml for more information.

Dates	Course	Registration Fee
February 13–17, 2017	**SCALE Lattice Physics and Depletion** *Oak Ridge National Laboratory, Oak Ridge, TN, USA* Reactor physics analysis capabilities in SCALE: TRITON, modular reactor physics sequence for a wide variety of system types, and Polaris, LWR lattice physics sequence.	$2,000*
February 20–24, 2017	**SCALE/ORIGEN Fuel Depletion, Activation, and Source Term Analysis** *Oak Ridge National Laboratory, Oak Ridge, TN, USA* Isotopic depletion, activation analysis, and source term characterization with ORIGEN, featuring the new keyword-based input with the new Fulcrum graphical user interface (GUI) and the new ORIGAMI tool for convenient spent fuel characterization with ORIGEN.	$2,000*
February 27–March 3, 2017	**SCALE Criticality Safety and Radiation Shielding** *Oak Ridge National Laboratory, Oak Ridge, TN, USA* KENO-VI Monte Carlo code for criticality safety calculations. MAVRIC shielding sequence with 3D automated variance reduction for deep-penetration problems. Integrated criticality accident alarm analysis (CAAS) with KENO-VI and MAVRIC.	$2,000*
March 6–10, 2017	**SCALE Computational Methods for Burnup Credit** *Oak Ridge National Laboratory, Oak Ridge, TN, USA* Use of SCALE tools to meet the requirements of NRC Interim Staff Guidance 8 Rev. 3 for the use of actinide and fission product burnup credit. Previous experience with SCALE is recommended.	$2,000*
March 13–17, 2017	**SCALE Sensitivity/Uncertainty Analysis (SA) and Uncertainty Quantification (UQ) in Reactor Physics Analyses** *OECD/NEA Data Bank, Boulogne -Billancourt, Paris, France* Note: this class differs from previous classes that focused on criticality safety. Multigroup and continuous energy TSUNAMI sequences to perform nuclear data SA and UQ for eigenvalue and reaction rates. Stochastic sampling-based UQ with the new Sampler super-sequence to perform UQ for any computed response due to uncertainty in nuclear data and model input parameters.	€2,000
March 20–24, 2017	**SCALE Criticality Safety Calculations** *OECD/NEA Data Bank, Boulogne -Billancourt, Paris, France* KENO-V.a and KENO-VI Monte Carlo codes for criticality safety calculations. Use of the new Fulcrum GUI for interactive model setup, visualization, computation, and output review.	€2,000

**Full-time university students can register at a reduced rate. Professional and student registration fees are discounted $200 for each additional course.*

All attendees must be licensed users of SCALE 6.2.1, which is available from ORNL/RSICC in the USA, the OECD/NEA Data Bank in France, and the RIST/NUCIS in Japan.

Class size is limited, and a course may be canceled if minimum enrollment is not obtained one month prior to the start of the course. Course fees are refundable up to one month before each class.

NON US CITIZENS VISITORS TO ORNL - Payment MUST be received at least one week prior to attending the training course. All non US citizens must register 40 days before the start date of the training course that they plan to attend.

Welcome New SCALE Users

SCALE 6.2 was released through the Radiation Safety Informational Computational Center (RSICC) in April 2016 and subsequently distributed through the Nuclear Energy Agency (NEA) Data Bank in France and the Research Organization for Information Science and Technology (RIST) in Japan. A recent update, SCALE 6.2.1, was made available in September 2016. Through September 2016, there have been 906 distributions of SCALE 6.2, including 267 distributions to individuals who had not previously used any version of SCALE. There are currently 7,500 SCALE users in 56 different nations, as shown in Fig. 5. If you are one of the new users of SCALE, we welcome you to our community and hope you find SCALE useful in your work.

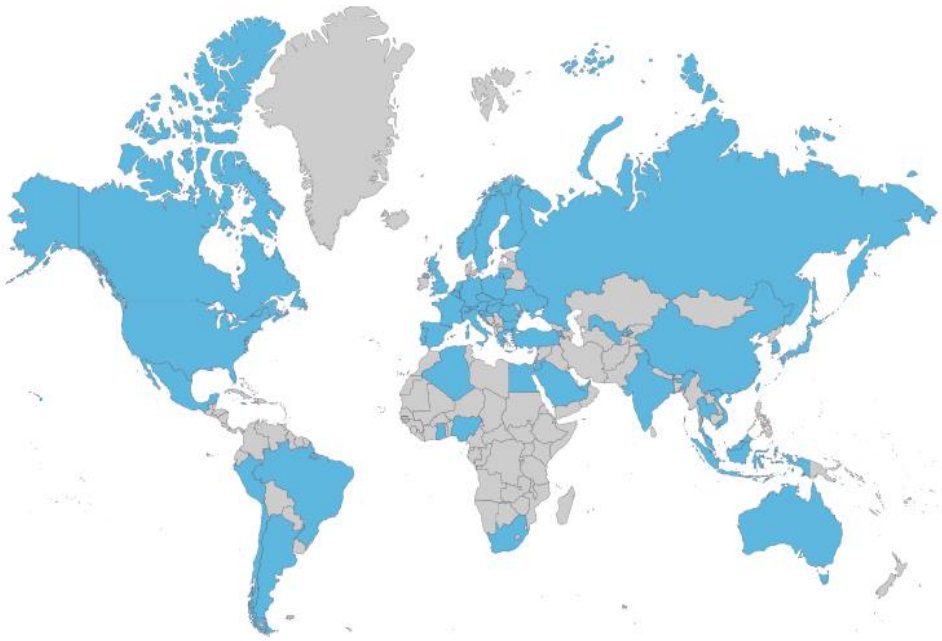

Fig. 5. Nations where SCALE is licensed.

There are many resources for new and current users, including:
- How-to primers on many topics: (http://scale.ornl.gov/training_primers.shtml),
- Validation reports: (http://scale.ornl.gov/validation.shtml),
- Training courses: (http://scale.ornl.gov/training.shtml).
- User discussion forum on Google Groups: (https://groups.google.com/forum/?hl=en&fromgroups#!forum/scale-usersgroup),
- E-mail helpline: (scalehelp@ornl.gov).

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