NCSP
NUCLEAR CRITICALITY SAFETY PROGRAM

Five Year Execution Plan

for the

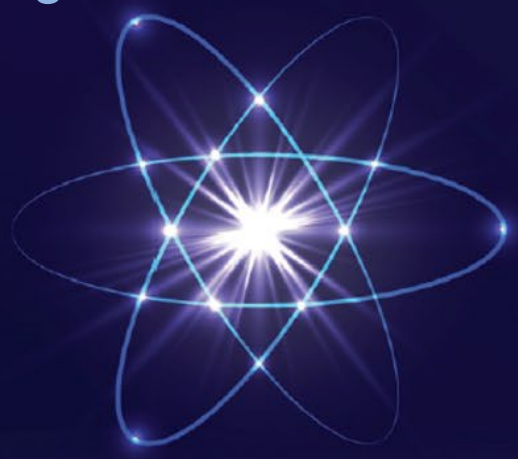
Mission and Vision

of the

United States Department of Energy Nuclear Criticality Safety Program

September 2020, Revision 4

FY 2020 through FY 2024



U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

Department of Energy Nuclear Criticality Safety Program Five-Year Execution Plan for Fiscal Years 2020 through 2024, dated July 2020.

Approved:

Dr. Angela Chambers
Manager
Nuclear Criticality Safety Program

Revision 4 Changes

Modification	**Section**
Transfer $50K from LLNL IPD1 to LLNL ND3	Main Plan, ND Section, IPD Section
Transfer $50K from LLNL IPD2 to LLNL ND5	Main Plan, ND Section, IPD Section
Transfer $100K from LLNL IPD5 to LLNL ND7	Main Plan, ND Section, IPD Section

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ACRONYMS AND DEFINITIONS

ACE	"A Compact ENDF" file
ADVANCE	Automated Data Verification and Assurance for Nuclear Calculations Enhancement (ADVANCE)
AM	Analytical Methods
AMPX	Nuclear cross-section processing code
ANL	Argonne National Laboratory
APRF	Army Pulse Reactor Facility
ARH	Atlantic Richfield Hanford
AWE	Atomic Weapons Establishment
BNL	Brookhaven National Laboratory
CAAS	Criticality Accident Alarm System
CALIBAN	Fast burst metal assembly in Valduc, France
CEA	Commissariat à l'Énergie Atomique
CIELO	Collaborative International Evaluated Library Organization
COG[1]	Lawrence Livermore National Laboratory Monte Carlo Computer Code
COMET	General Purpose Platform Lift Machine at NCERC
CritView	A plotting and interpolation software program designed to display criticality data from the ARH-600 Criticality Handbook
CRP	Coordinated Research Projects
CSCT	Criticality Safety Coordinating Team
CSEWG	Cross Section Evaluation Working Group
CSSG	Criticality Safety Support Group
DAF	Device Assembly Facility
DOE	Department of Energy
ENDF	Evaluated Nuclear Data File
EOC	Explanation of Change (for out-year peaks and dips in budget plots)
FFTF	Fast Flux Test Facility
FLATTOP	Highly-Reflected Spherical Benchmark Assembly
FMP	Fluor Marine Propulsion
FUDGE	Lawrence Livermore National Laboratory nuclear data management infrastructure
FY	Fiscal Year
GELINA	Linear Accelerator in Geel, Belgium
GForge	Web-based collaborative development environment
GODIVA	Unreflected Fast-Burst Assembly

IAEA	International Atomic Energy Agency
ICSBEP	International Criticality Safety Benchmark Evaluation Project
IE	Integral Experiments
IER	Integral Experiment Request
INL	Idaho National Laboratory
IP&D	Information Preservation and Dissemination
IRMM	Institute for Reference Materials and Measurements
IRSN	Institut De Radioprotection et De Sûreté Nucléaire
KENO[2]	Monte Carlo Criticality Computer Code
KRUSTY	Kilopower Reactor Using Stirling TechnologY
LA	Los Alamos (report)
LANL	Los Alamos National Laboratory
LINAC	Linear Accelerator
LLNL	Lawrence Livermore National Laboratory
MCNP®[3]	Monte Carlo N Particle Computer Code
MSTS	Mission Support and Test Services
NA00-10	Office of Environment, Safety and Health
NCERC	National Criticality Experiments Research Center
NCS	Nuclear Criticality Safety
NCSET	Nuclear Criticality Safety Engineer Training
NCSP	Nuclear Criticality Safety Program
NCSU	North Carolina State University
ND	Nuclear Data
NDA	non-destructive assay
NDAG	Nuclear Data Advisory Group
NJOY	Nuclear cross-section processing code
NNDC	National Nuclear Data Center
NNL	Naval Nuclear Laboratory
NNSA	National Nuclear Security Administration
NNSS	Nevada Nuclear Security Site
OECD/NEA	Organization for Economic Cooperation and Development/Nuclear Energy Agency
ORNL	Oak Ridge National Laboratory
PNNL	Pacific Northwest National Laboratory
POC	Point of Contact

PREPRO	Nuclear cross-section processing code
RPI	Renssalaer Polytechnic Institute
RSICC	Radiation Safety Information Computational Center
SAMMY[4]	R-matrix nuclear data evaluation computer code
SCALE[5]	A modular modeling and simulation system for nuclear safety analysis and design
SNL	Sandia National Laboratories
SQA	Software Quality Assurance
SRS	Savannah River Site
S/U	Sensitivity/Uncertainty
TACS	Training Assembly for Criticality Safety
T&E	Training and Education
TID	Technical Information Document (Los Alamos National Laboratory report)
TRG	Technical Review Group
TSUNAMI	Tool for Sensitivity and Uncertainty Analysis Methodology Implementation
US	United States of America
UT	University of Tennessee
V&V	Verification and Validation
WPEC	Working Party on International Nuclear Data Evaluation Corporation
WPNCS	Working Party on Nuclear Criticality Safety
Y-12	Y-12 National Security Complex

[1]COG was originally developed to solve deep penetration problems in support of underground nuclear testing. Variance reduction techniques are very important to these problems and hence the name COG was chosen as in "to cog the dice" or cheat by weighting.

[2]KENO is a family of Monte Carlo criticality codes whose name came from an observation of the KENO game in which small spheres, under air levitation, arbitrarily move about in a fixed geometry.

[3]MCNP® and Monte Carlo N-Particle® are registered trademarks owned by Los Alamos National Security, LLC, manager and operator of Los Alamos National Laboratory. Any third party use of such registered marks should be properly attributed to Los Alamos National Security, LLC, including the use of the '®' designation as appropriate. Any questions regarding licensing, proper use, and/or proper attribution of Los Alamos National Security, LLC marks should be directed to trademarks@lanl.gov.

[4]SAMMY is a nuclear model code, which applies R-Matrix theory to measured data and produces resolved and un-resolved resonance parameters in Reich-Moore and other formalisms.

[5]SCALE is a system of well-established codes and data for performing nuclear safety (criticality, shielding, reactor physics and fuel irradiation) analyses.

United States Department of Energy

Nuclear Criticality Safety Program
Five-Year Execution Plan

1.0 Nuclear Criticality Safety Program Mission and Vision

The Nuclear Criticality Safety Program (NCSP) Mission and Vision, as stated in The Mission and Vision of the United States Department of Energy Nuclear Criticality Safety Program for the Fiscal Years 2014-2023 (https://ncsp.llnl.gov/docs/NCSP_MISSION_VISION.pdf), are:

The NCSP mission is to provide sustainable expert leadership, direction, and the technical infrastructure necessary to develop, maintain, and disseminate essential technical tools, training, and data required to support safe, efficient fissionable material operations within the United States (U.S.) Department of Energy (DOE).

The NCSP will be a continually improving, adaptable, and transparent program that communicates and collaborates globally to incorporate technology, practices, and programs to be responsive to the essential technical needs of those responsible for developing, implementing, and maintaining nuclear criticality safety.

The NCSP is funded by the National Nuclear Security Administration (NNSA). Dr. Angela Chambers (NA-511) is the NCSP Manager. She is supported by the Criticality Safety Support Group (CSSG) and the Nuclear Data Advisory Group (NDAG), regarding technical matters, and by the Criticality Safety Coordinating Team (CSCT), consisting of Federal Criticality Safety Practitioners at the sites regarding DOE field criticality safety issues. Charters for the CSCT, CSSG, and the NDAG can be found on the NCSP website at: (http://ncsp.llnl.gov/). The NCSP Planning Calendar can also be found on the NCSP website at: (http://ncsp.llnl.gov/).

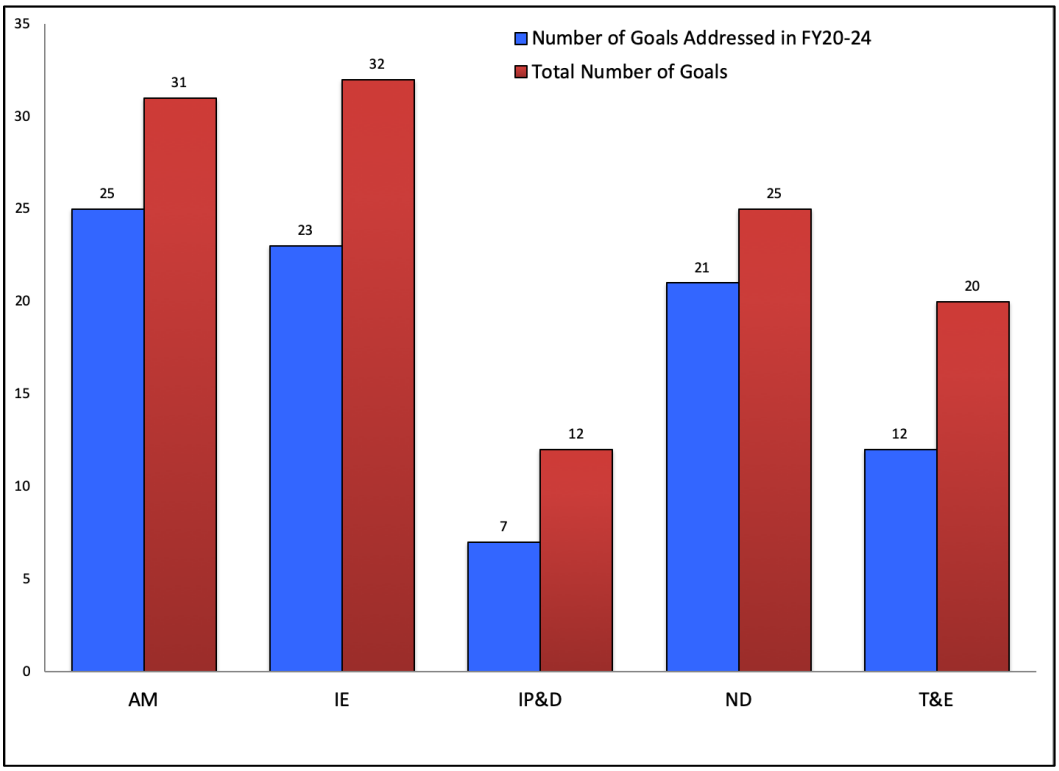
The NCSP Mission and Vision is achieved by identifying and accomplishing a set of five-year programmatic goals in five broad technical program elements that support identified ten-year goals. The NCSP Five-Year Plan defines tasks that are designed to accomplish specific goals identified in the NCSP Mission and Vision. The current Five-Year Plan has been developed to accomplish these Mission and Vision goals with the advice and assistance of experts appointed by the NCSP manager or working under charters approved by the NCSP manager. The five technical program elements are:

- Analytical Methods (AM)
- Information Preservation and Dissemination (IP&D)
- Integral Experiments (IE)
- Nuclear Data (ND)
- Training and Education (T&E)

The NCSP Mission and Vision provides specific goals for each program element. Each task in the current Five-Year Plan aligns with a specific NCSP Mission and Vision goal. The number of goals addressed by the current Five-Year Plan is provided in Figure 1.1. As shown in Figure 1.1, the FY20 work tasks will help address a number of NCSP Mission and Vision Goals, and additional goals will be addressed in FY20-FY24. Overall, the NCSP is on track to accomplish a significant number of Mission and Vision goals during the next five years. Also, the installation of the measurement laboratory at NNSS has been completed. These IE goals are completed and no further

work is required. The subsequent discussion provides a summary of the projected task accomplishments and technical gaps for each program element.

Figure 1.1 Number of NCSP Mission and Vision Program Element Goals Addressed by the NCSP Five-Year Plan



The AM program element provides for the development and maintenance of state-of-the-art analytical capabilities for the processing of nuclear data from the Evaluated Nuclear Data File (ENDF) and the radiation transport analysis capabilities needed to perform nuclear criticality safety analyses. The Five-Year Plan tasks specifically support 25 of 31 AM goals required to develop and sustain state-of-the-art cross-section processing and radiation transport modeling capabilities and expertise needed for criticality safety analyses. With regard to the overall AM technical gap over the next 5 years, the NCSP is continuing to make a modest investment toward the development and deployment of time-dependent multi-physics analysis capabilities to support excursion analyses; develop and maintenance of time-dependent geometry modeling capabilities; however, additional budget allocation would be needed to achieve these target AM goals during the next five years. Currently, the NCSP is not able to invest in coupling of modern NCS radiation transport software with CAD/CAE packages. Task proposals have been submitted for all of these goals, and these proposals will be considered pending increased NCSP AM budget targets.

The IE program element maintains a fundamental capability for the DOE NCSP to be able to perform critical, subcritical, and fundamental physics measurements, to address specific-site needs on a prioritized basis, and this program element also supports maintaining a fundamental nuclear materials handling capability, which enables hands-on NCS training programs and various other programs for the DOE NCSP and other Government Agencies. The Five-Year Plan tasks specifically support 23 of 32 IE goals to assess, design, perform, and document integral experiments. Examples of goals not addressed in FY20 but are addressed in the out years include: design a neptunium critical experiment capability; design a Jezebel-like critical assembly. The NCERC small sample Rabbit Transfer System task has been approved in FY20 and will address

fabrication, installation, and implementation of this important capability. However, there are some IE goals that cannot be addressed within the current five-year budget targets. Examples of goals not addressed include: expansion of the radiochemistry laboratory capabilities at NNSS; standup "hot"/"cold" machine shops at NCERC; design and deploy low scatter capabilities at NCERC; acquisition of Np metal at NCERC; and the construction of new critical assemblies (solution reactor and Np burst reactor). Task proposals have been submitted for these goals, and these proposals will be considered pending increased NCSP IE budget targets.

The Information Preservation & Dissemination program element preserves primary documentation supporting criticality safety [e.g., benchmark critical experiments from the International Criticality Safety Benchmark Evaluation Project (ICSBEP)] and makes this information available for the benefit of the technical community including international partners (e.g., IRSN, AWE, CEA and OECD) through the NCSP website. The Five-Year Plan tasks specifically support 7 of 12 IP&D goals for preserving and disseminating technical, programmatic, and operational information important for nuclear criticality safety. In particular, benchmark evaluations for experiments at the LLNL pulsed spheres and at the ORNL Health Physics Research Reactor are funded in FY20. The goal to provide a long-term hardcopy archive of critical experiment logbooks will not be addressed in FY20. Overall, there are some IP&D goals that cannot be addressed based on current budget targets. Examples of goals not addressed include: maintaining and publishing (as an electronic newsletter) a U.S./international database of near misses, operational issues and lessons learned (historical/future); implementing a process to rapidly disseminate information (e.g., operational upsets, emergency response) to criticality safety professionals ("Crit spam").

The Nuclear Data program element includes the measurement, evaluation, testing, and publication of neutron cross-section data for nuclides of high importance to nuclear criticality safety analyses. The Five-Year Plan tasks specifically support 21 of 25 ND goals to improve and disseminate measured and evaluated differential cross-section and covariance data needed by the AM element to support NCS analyses. Examples of goals not addressed in FY20 but are addressed in the out years include: identify and prioritize differential measurements beyond the next five years; identify and prioritize differential evaluations beyond the next five years. Overall, a large number of goals are addressed within the current ND budget targets; however, technical gaps do exist, and some ND goals cannot be addressed. Examples of goals not addressed include; develop new analysis tools to fully utilize new experimental capabilities such as the time project chamber (TPC), Chi-nu, and correlated data. Task proposals have been submitted for these goals, and these proposals will be considered pending increased NCSP ND budget targets.

The Training and Education program element identifies, develops, and facilitates training needs and educational resources (including hands-on training with fissionable material systems) in areas where no suitable alternative exists. The primary purpose of the T&E element is to maintain and enhance the technical abilities and knowledge of those who impact or are impacted directly by the practice of criticality safety. The Five-Year Plan tasks specifically support 12 of 20 T&E goals during the next five years. The tasks primarily support the development and maintenance of the classroom and "hands-on" training courses at the Nevada Field Office, SNL and NNSS. The NCSP Manager's Course will be modified as a result of CSSG tasking report 2018-01 to include content for Criticality Safety Officers. The new content will be piloted in FY20. In FY20, LLNL will address the feasibility to develop a mobile CAT III or IV material near-critical hands-on capability and develop a criticality simulator to demonstrate criticality physics fundamentals to process operators. FY20 work tasks will not address the Mission and Vision goal to provide a gap analysis of training needs based on an assessment of available training and education resources in the national and international community. Likewise, the T&E goal to cultivate and maintain university

partnerships will not be addressed in the FY20 T&E work tasks. NCSP work to partner with universities is being performed under the AM and ND program elements; however, these NCSP-university work tasks are not focused on NCS T&E activities. Overall, there are number of Mission and Vision goals that extend beyond the current scope of hands-on T&E classes. Examples of goals not addressed include: develop an integrated compendium of training and education resources that is coordinated for consistency across US agencies and institutions and accessible to the criticality safety community; develop an integrated compendium of training and education resources that is coordinated with international partners to foster consistency on material and maximize use of unique resources; establish a sustainable program (internship, rotational assignments, etc.) to facilitate collaborative training and education opportunities (national and international); and develop a mobile CAT 1 criticality hands-on critical or near critical demonstration capability. These goals will be considered pending increased NCSP T&E budget targets.

Although some technical gaps exist in each program element, execution of the NCSP Five-Year Plan will accomplish a significant number of Mission and Vision goals during the next five years. As a result, the NCSP will be able to accomplish the overall mission to provide sustainable expert leadership, direction, and technical infrastructure needed to support safe, efficient fissionable material operations within the DOE. A new Mission and Vision document is currently in development that will provide a new baseline for all NCSP technical program elements starting in FY20.

2.0 Technical Program Elements

As mentioned above, the NCSP includes the following five technical program elements:

- Analytical Methods
- Integral Experiments
- Information Preservation and Dissemination
- Nuclear Data
- Training and Education

A description of how each of these elements contributes to the enhancement of criticality safety is contained in the NCSP Mission and Vision document. This Five-Year Execution Plan contains the road map for each of the five technical program elements, including a budget, tasks, and milestones for completing the work and achieving the NCSP Vision. All tasks are approved based on their contribution to the achievement of the five- and ten-year goals in the Mission and Vision document. Funding figures are provided for each program element section. The status of all milestones will be reported to the NCSP Manager in quarterly reports that are due no later than three weeks from the last day of the month following the end of the quarter.

Funding for NCSP activities are shown in Figures 2.1, 2.2, 2.3 (rounded to the nearest $K) and Figure 2.4.

Finally, the goal of the NCSP is to provide "transparent responsiveness" for the DOE and Stakeholders. Therefore, this Plan and all accomplishments achieved under the auspices of the NCSP are posted in a timely manner on the NCSP website at: http://ncsp.llnl.gov/.

Figure 2.1 NCSP Funding Overview FY2020-FY2024

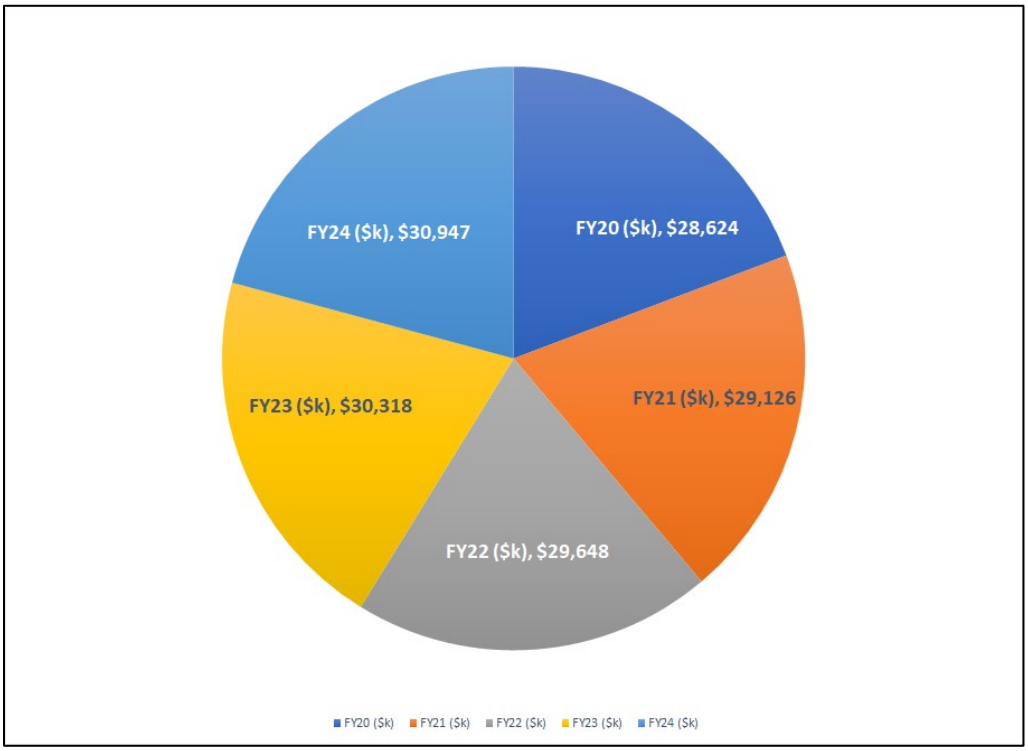


Figure 2.2 NCSP Funding Overview – By Element

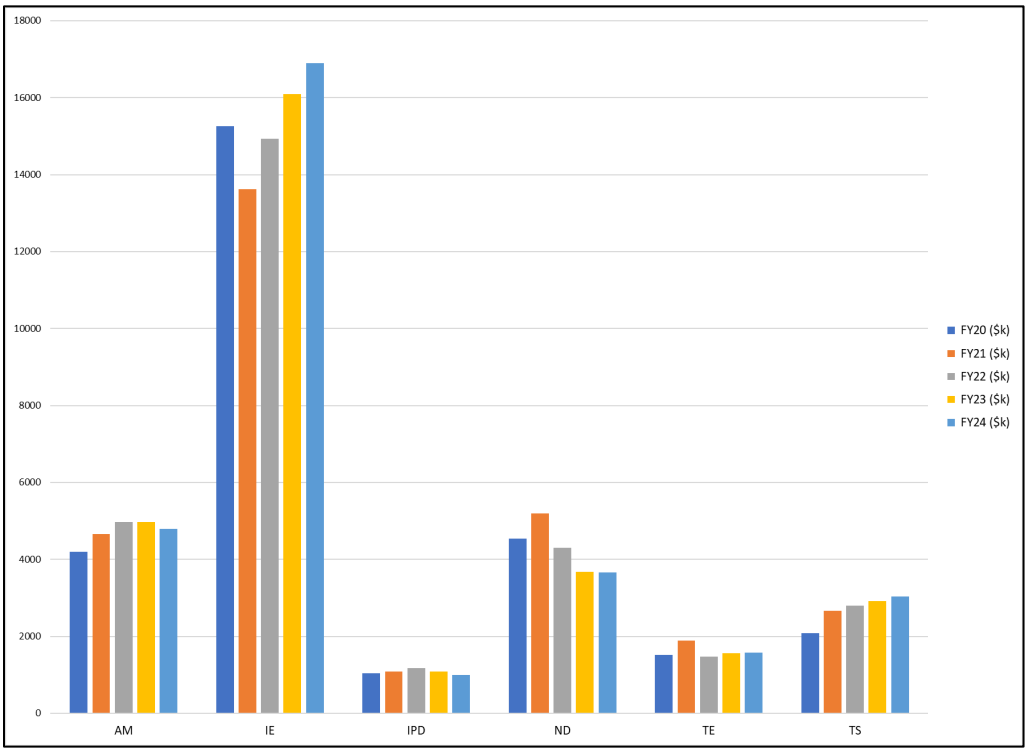


Figure 2.3 NCSP Funding Overview – By Laboratory (FY2020 – FY2024)

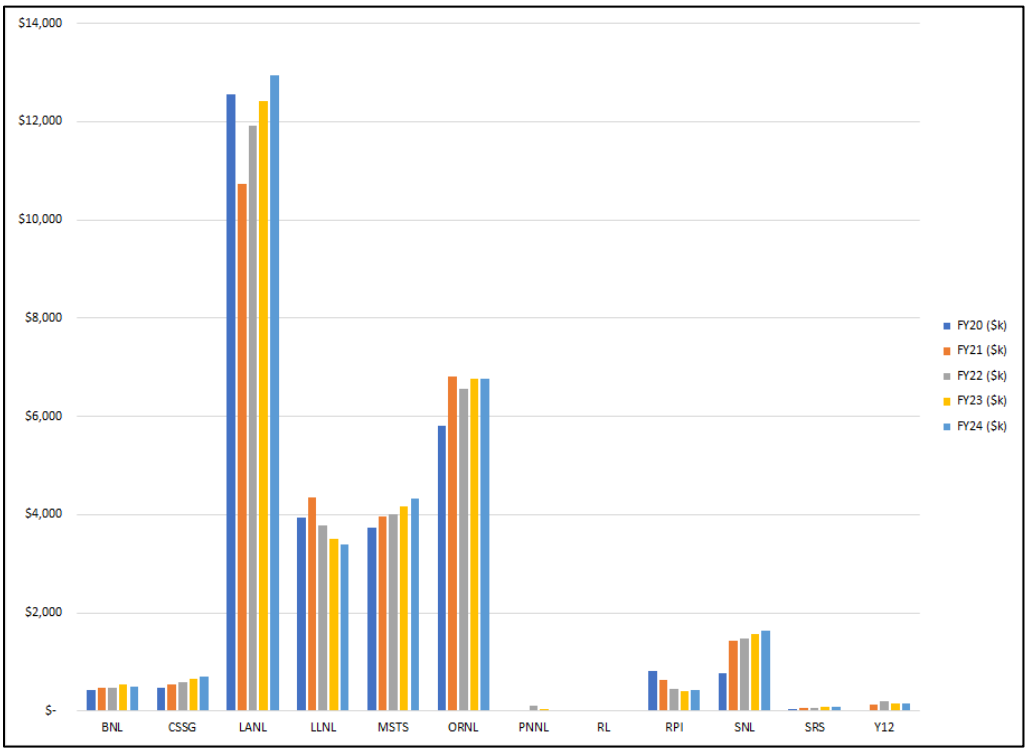
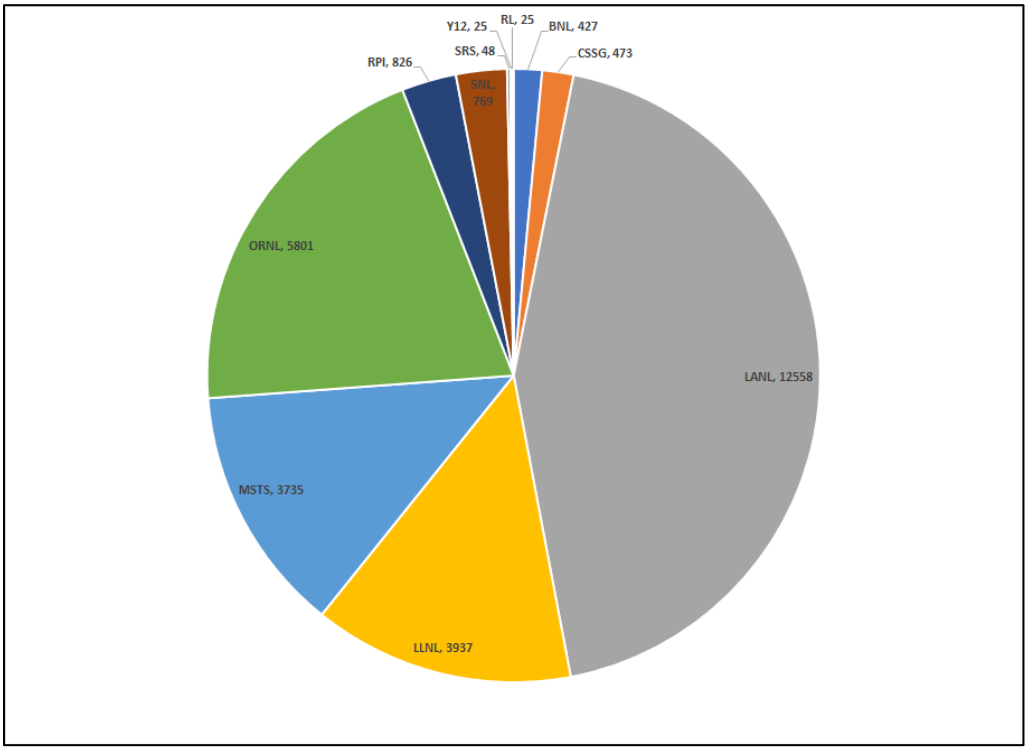


Figure 2.4 NCSP Funding Overview – By Laboratory (FY2020)



2.1 Analytical Methods (AM)

2.1.1 Program Element Description

The Analytical Methods program element provides development and maintenance of state-of-the-art analytical capabilities for the processing of nuclear data from the Evaluated Nuclear Data File (ENDF) and the radiation transport analysis needed to support Nuclear Criticality Safety (NCS) evaluations for subcriticality and shielding. An essential aspect of the AM capabilities is the human expertise required to develop the analytical software, provide software configuration control, and train and assist the user community. A figure precedes each task description and provides information about the Task Name, Task Title, Task Budget, and collaborators. The list of collaborators may include IRSN or AWE. These international collaborators have provided a list of tasks of interest to each organization (see Appendix E for IRSN and Appendix F for AWE).

Figure 2.1-1 AM Budget (FY2020-FY2024)

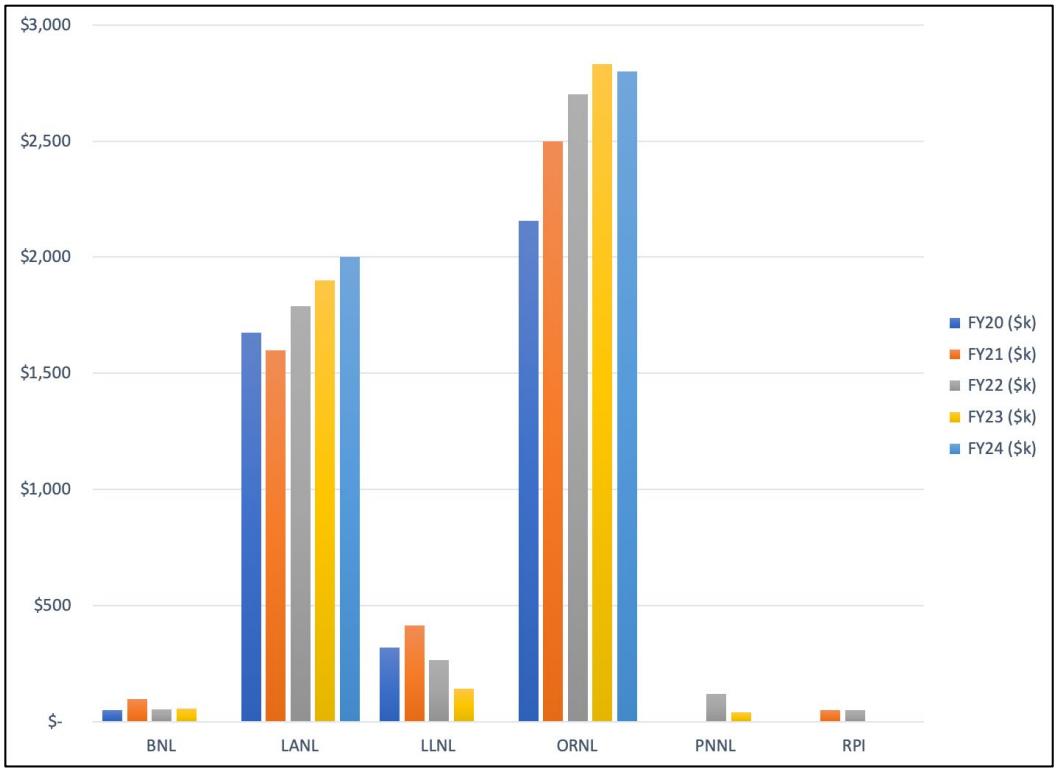
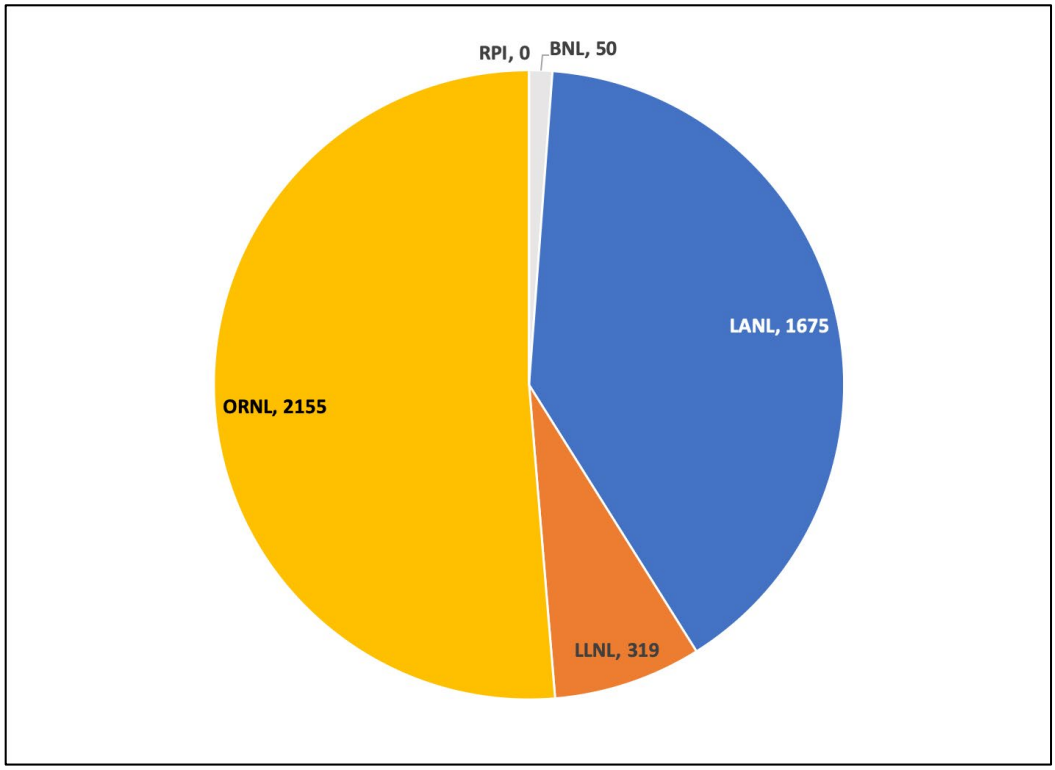


Figure 2.1-2 AM Budget (FY2020)



Explanation of Change (EOC) – for out-year peaks and dips in budget plots:
Modest increases in the LANL and ORNL budgets are due to increased projected budgets for MCNP and SCALE and for the initiation of specific AM tasks in the outyears. The reduction in LLNL tasks in the outyears indicates the completion of their AM tasks with no projected tasks to replace them. PNNL starts a project with ORNL in FY22 (PNNL-AM1) for the analysis of sum-of-fractions for nuclide mixtures.

2.1.2 Approved Tasks

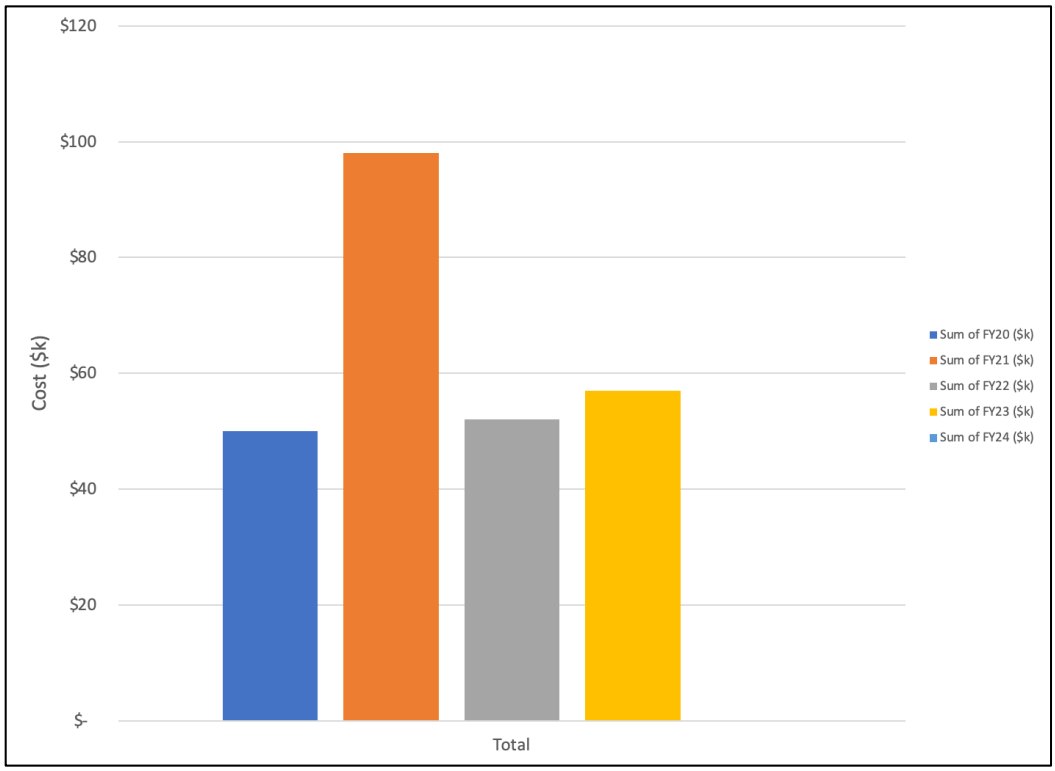
2.1.2.1 Brookhaven National Laboratory (BNL)

Task Name	Task Title
BNL AM5	FUDGE Generation of a Complete ENDF/B-VIII.0 Library for Testing in Production Codes
Budget	**Collaborators**
$50K	LLNL (LLNL-AM8)

This new task is to for LLNL and BNL to collaborate the following:

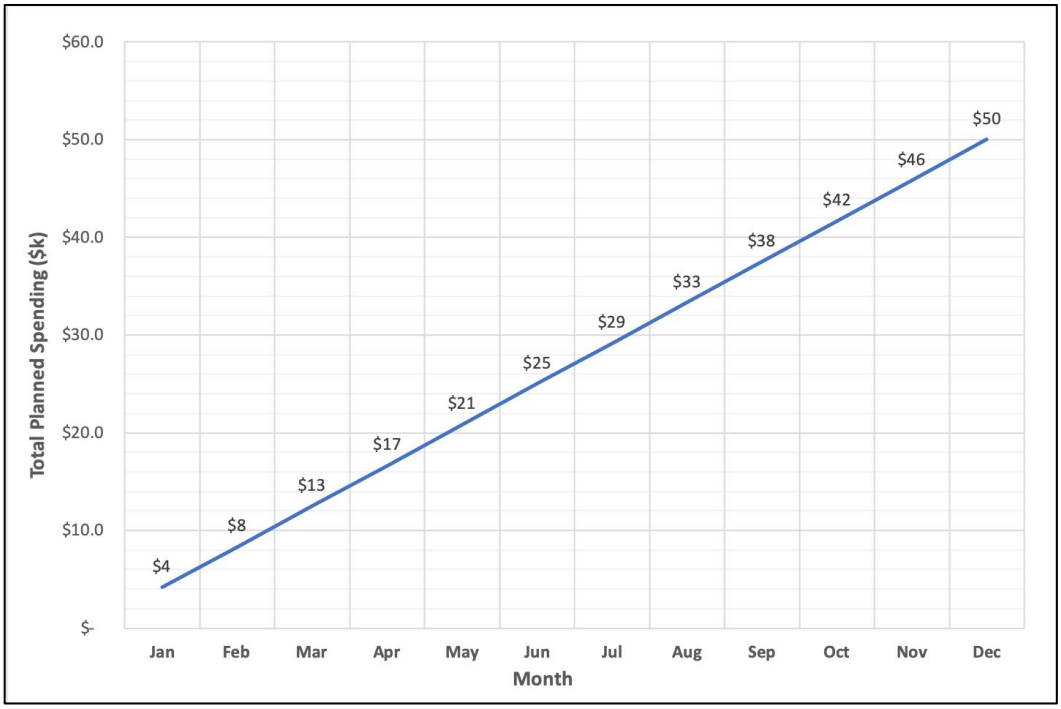
- LLNL and BNL to provide the double differential cross-sections (DDXS) for thermal scattering and probability density functions (PDF) data for the unresolved resonance region in GNDS containers
- LLNL to test the FUDGE/GNDS data including the new DDXS and PDF data and compare the results to those using legacy codes
- In the event of discrepancies, BNL and LLNL to use these results to identify issues and inform further development of the DDXS and PDF algorithm as required
- Upon completion of the project, LLNL and BNL to provide the final ENDF/BVIII.0 DDXS and PDF data in GNDS containers
- LLNL to provide the full test suite to BNL for inclusion in ADVANCE

Figure 2.1-3 BNL AM Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
The drop in funding in FY2022 is due to the completion of the BNL-AM5 task in FY2021. There are no planned AM funds at BNL after FY2023.

Figure 2.1-4 BNL AM Planned Spending (FY2020)



BNL AM Milestones:

Occurs all 4 Quarters

- Provide a status report on completing an ENDF/B-VII.0 library with FUDGE. (AM5)

2.1.2.2 Los Alamos National Laboratory (LANL)

Task Name	Task Title
LANL-AM1	MCNP Maintenance and Support, Uncertainty Analysis Development, and Modernization
Budget	**Collaborators**
$1,200K	IRSN (IRSN-AM15)

This is a continuing task for the maintenance of the basic capabilities for performing Nuclear Criticality Safety calculations with the Monte Carlo N Particle (MCNP®) computer code, including general code maintenance, user support, improved nuclear data libraries, Verification and Validation (V&V), documentation, user training, and implementation of limited new capabilities; focus on modernizing MCNP for next-generation computing hardware; continue to develop MCNP-Whisper for continuous-energy sensitivity-uncertainty analysis, and contribute to the Organization for Economic Cooperation and Development/Nuclear Energy Agency (OECD/NEA) Working Party on Criticality Safety. For all tasks, LANL reports will be issued and posted on the MCNP website.

Task Name	Task Title
LANL-AM2	NJOY Development and Maintenance, Uncertainty Analysis Development, and Modernization
Budget	**Collaborators**
$300K	IRSN (IRSN-AM7)

This is a continuing task to support development and maintenance of the NJOY nuclear data processing code system, implement capabilities as needed to process new general purpose nuclear data files in the continuously evolving ENDF-6 format, provide support to NJOY users, modernize NJOY to adapt to modern code practices, new data formats, and next-generation computing hardware, and contribute to the NDAG, the Cross Section Evaluation Working Group (CSEWG), CIELO, the Working Party on International Nuclear Data Evaluation Corporation (WPEC) and the International Atomic Energy Agency (IAEA) Coordinated Research Projects (CRP) as approved by the NCSP Manager. All NJOY updates will be distributed to users through a LANL maintained website.

Task Name	Task Title
LANL-AM4	Sensitivity/Uncertainty Comparison Study with a Focus on Upper Subcritical Limits
Budget	**Collaborators**
$50K	IRSN (IRSN-AM14), ORNL (ORNL-AM9)

Various methods have been developed recently to assist the Criticality Safety Analyst (CSA) determine a safe Upper Subcritical Limit (USL) for an application of interest. IRSN has developed the MACSENS tool which relies on Monte Carlo results from the MORET code. ORNL has developed the TSUNAMI package, which relies on Monte Carlo results from KENO (among various transport options), and LANL has developed the Whisper package which relies on Monte Carlo results from MCNP6.® This proposal is to have the three Laboratories compare results from the various methods on a small set of benchmark problems. Differences in results will be understood, and one or more of the methods may be improved as a result. Two relevant problems will be chosen each FY, and results such as sensitivity profiles and individual components of the USL will be compared. Each year, the two problems to be compared will be chosen. Nuclear data choices will also be made. For example, year one might study a fast Pu system and a solution system from ICSBEP. For some comparisons we might all employ the same nuclear data; for others a range of evaluated data might be used. We anticipate choosing real-world application problems of interest as well as historical benchmark problems during the lifetime of the project. The NCSP AM Working Group will provide a forum for presenting and discussing results to ensure timely

completion of the milestones. LANL will be responsible for one summary report for two of the test cases while the other labs will provide summary reports for their test case work. IRSN will lead the development in the final year of a summary report for the project.

Task Name	Task Title
LANL AM5	Proposed Benchmark Intercomparison Study
Budget	**Collaborators**
$50K	IRSN (IRSN-AM13), ORNL (ORNL-AM10), LLNL (LLNL-AM5)

CEA and IRSN published a summary of the results of an extensive benchmark intercomparison study of French analytic methods using JEFF-3.1.1 nuclear data in the proceedings of the International Conference on Nuclear Criticality Safety (ICNC 2015). While JEFF data is available in many NCSP codes (e.g., COG, MCNP), due to resource limitations it has not been tested as rigorously as the US national database ENDF/B. The proposal is for IRSN to lead a new intercomparison based on the MORET code with the latest JEFF-3.2 data and ENDF/B-VIII.0 data, when available, using their existing comprehensive selection of 2,714 benchmarks and collate their results together with those from LLNL (COG), LANL (MCNP) and ORNL (SCALE). Due to the large number of benchmarks involved, this effort is envisioned to take three years with an additional year for IRSN to complete a summary report. The benchmark development will be performed independently to minimize modeling errors through discovery and resolution of discrepant results. A summary report will be generated (led by IRSN) to document the results of this study.

Task Name	Task Title
LANL-AM6	Technical Data for the Pitzer Formulation of Solution Compositions to Include Uranium/Plutonium Solutions with Selected Admixed Absorbers
Budget	**Collaborators**
$0 (FY19 funds to be used)	ORNL (ORNL-AM16), LLNL (LLNL-AM7), IRSN (IRSN-AM17)

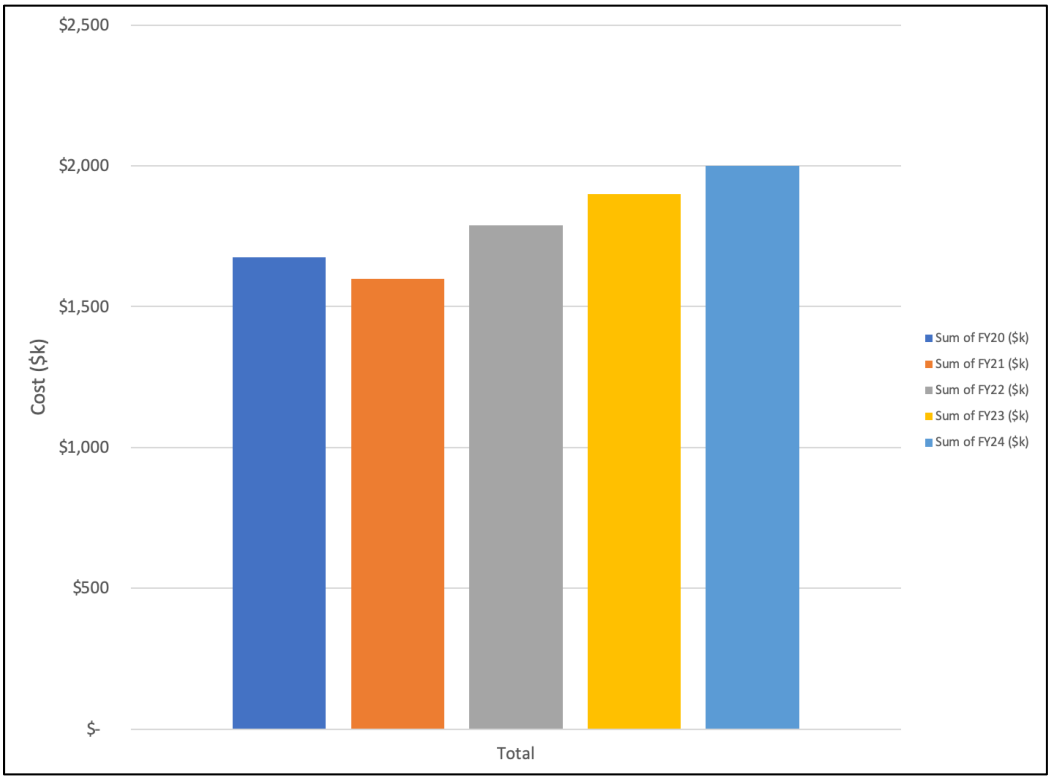
This is an ongoing task (FY19) to support development of Pitzer formulations for uranium and plutonium solutions for inclusion into the SCALE system and MCNP material input processor. ORNL is the lead on this task. This task is to perform a literature review regarding gaps in experimental data for solution compositions to generate a follow-up proposal for experimental measurements in the outyears. Funds carried over from FY19 will be used to complete this task.

Task Name	Task Title
LANL-AM7	Incorporation of Benchmark Experiment Correlations into the Whisper Nuclear Criticality Safety Software
Budget	**Collaborators**
$75K	University of Michigan

The Whisper computer code and methodology was developed at LANL in 2014 for criticality safety code validation, including determining baseline USLs. This methodology was used to assist the LANL Nuclear Criticality Safety Division in upgrading their analysis software, validating that software, and applying it to the determination of baseline USLs for the LANL plutonium facility. Whisper makes use of the most reliable features of MCNP6 - criticality calculations and sensitivity/uncertainty methods. B.C. Kiedrowski (Univ. Michigan) has submitted an NCSP University proposal for extending the MCNP6-Whisper sensitivity-uncertainty methodology to include reaction rate ratios and kinetics parameters, and to extend the treatment of correlations among measurements. We fully support the proposed Michigan work. This proposal encompasses the LANL work to fully integrate the MCNP6-Whisper improvements into the full MCNP6 production code repository, perform confirmatory testing and verification, and make the new capabilities available to the NCSP user community. Code work, testing, distribution, and user training are necessary to follow through in providing the new capabilities to the end-users (NCS

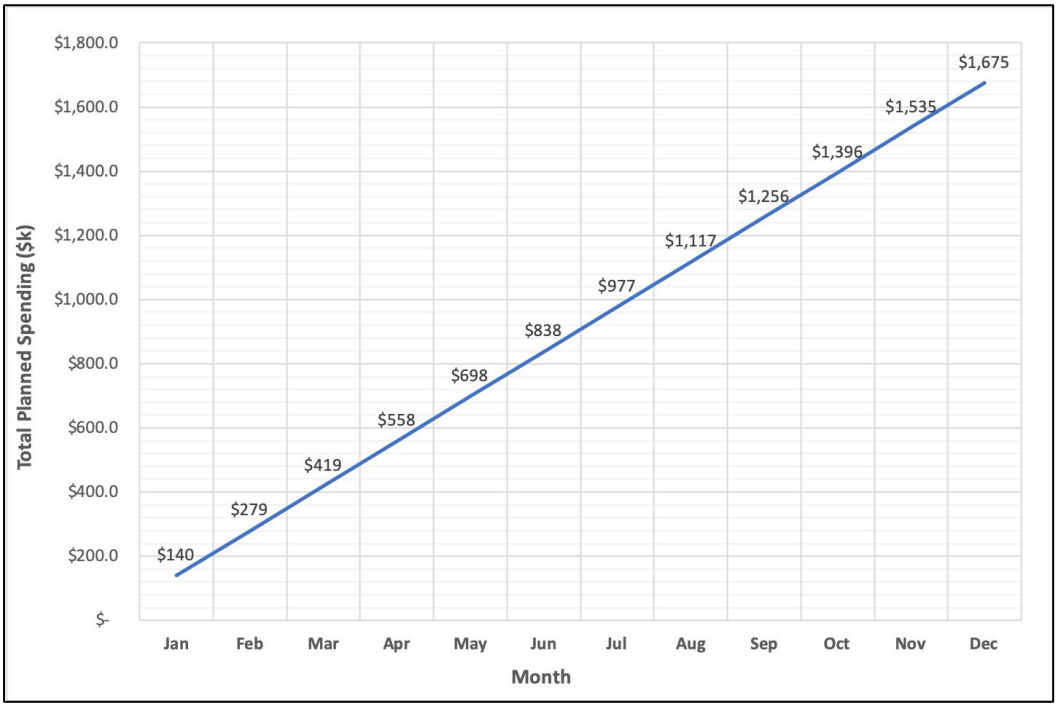
analysts at the DOE sites). The first year (2019) will primarily involve collaboration with the Michigan efforts to ensure that they use the latest versions of MCNP6, Whisper, and the associated nuclear data. Some initial testing of the Michigan work will be performed. A thorough review and assessment of the Michigan work will be conducted. The second year (2020) will focus on integrating the Michigan work with the full MCNP production line and making the new capabilities available to the end-users, NCS analysts. A training module will be developed and integrated into existing MCNP classes on code usage, criticality calculations, and sensitivity uncertainty methods.

Figure 2.1-5 LANL AM Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
The modest increases in FY22-FY24 are for increased budgets in the outyears for production code development and modernization for MCNP and NJOY. The slight dip in FY21 is due to the completion of the S/U intercomparison and benchmark study tasks, LANL-AM4 and LANL-AM5, respectively.

Figure 2.1-6 LANL AM Planned Spending (FY2020)



LANL AM Milestones:

Occurs all 4 Quarters

- Support MCNP6 users (AM1)
- Support NJOY users (AM2)
- Provide status reports on LANL participation in US and International analytical methods collaborations (AM1, AM2, AM4, AM5, and AM6)

Quarter 1

- Provide reports on summer intern work accomplished (AM1)
- Provide MCNP6 Criticality training course (AM1)
- Continue to distribute MCNP6 with automated acceleration and convergence testing to NCSP early-adopters and collect feedback (AM1)
- Obtain (University of Michigan) Whisper and explore various approaches for the effective sample size (AM7)

Quarter 2

- Report on LANL XCP-3, LANL NCS, & IRSN collaboration on detailed differences found in ICSBEP Benchmark Comparison Study (AM5)
- Provide status of all MCNP6 and Whisper progress at the NCSP Technical Program Review (AM1)
- Implement the selected effective sample size method into Whisper (AM7)

Quarter 3

- Provide training module on the use of MCNP6 unstructured mesh for CAAS analysis (AM1)
- Issue an MCNP V&V report, including MCNP6 automated acceleration and convergence (AM1)
- Perform Whisper calculations demonstrating the impact of benchmark experiment correlations on results. (AM7)

Quarter 4

- Modernize and integrate RECONR capabilities in NJOY21 (AM2)
- Complete modernization of LEAPR capabilities (AM2)
- Issue report on detailed review, comparisons, and updates to the Sensitivity-Uncertainty Comparison Study (AM4)
- Provide MCNP6 Criticality training course (AM1)
- Document and release beta versions of ENDF/B-VIII.1 evaluations in ACE format on LANL website (AM1)
- Deliver final modified version of Whisper to LANL with an ANS conference paper to disseminate the work (AM7)
- Document and release updated S(a,b) tables for MCNP based on ENDF/B-VIII.0 (AM1)

2.1.2.3 Lawrence Livermore National Laboratory (LLNL)

Task Name	Task Title
LLNL-AM2	Multi-Physics Methods for Simulation of Criticality Excursions
Budget	**Collaborators**
$139K	IRSN (IRSN-AM16)

This is an ongoing approved task to support and build upon existing LLNL state-of-the-art 3-D analytical and multi-physics methods including participation in international collaboration efforts (e.g., CSEWG, IAEA, OECD). This task was broken into four subtasks that will be funded through FY22: Subtask 1: Simulate the response of Godiva or Caliban to a fast reactivity insertion of various magnitudes. Simulate the Godiva accidents including quantification of mechanical damage to support structures and surface oxidation, Subtask 2: Simulate other reactor systems or criticality accidents as approved by the NCSP manager, Subtask 3: Add delayed neutron and photon emission physics and Subtask 4: Add physics to enable simulation of solution systems.

Task Name	Task Title
LLNL-AM3	Slide Rule Application
Budget	**Collaborators**
$30K	IRSN (IRSN-AM5), (AWE-AM1), ORNL (ORNL-AM6)

This is an ongoing task to support work to generate and update a criticality slide rule, including for plutonium systems. IRSN is the lead on this task.

Task Name	Task Title
LLNL-AM5	Proposed Benchmark Intercomparison Study
Budget	**Collaborators**
$50K	IRSN (IRSN-AM13), ORNL (ORNL-AM10), LANL (LANL-AM5)

CEA and IRSN published a summary of the results of an extensive benchmark intercomparison study of French analytic methods using JEFF-3.1.1 nuclear data in the proceedings of the International Conference on Nuclear Criticality Safety (ICNC 2015). While JEFF data is available in many NCSP codes (e.g., COG, MCNP), due to resource limitations it has not been tested as rigorously as the US national database ENDF/B. The proposal is for IRSN to lead a new intercomparison based on the MORET code with the latest JEFF-3.2 data and ENDF/B-VIII.0 data, when available, using their existing comprehensive selection of 2,714 benchmarks and collate their results together with those from LLNL (COG), LANL (MCNP) and ORNL (SCALE). Due to the large number of benchmarks involved, this effort is envisioned to take three years with an additional year for IRSN to complete a summary report. The benchmark development will be performed independently to minimize modeling errors through discovery and resolution of discrepant results. A summary report will be generated (led by IRSN) to document the results of this study.

Task Name	Task Title
LLNL-AM6	Proposed 1-D Multipoint Analytical Benchmark Comparison
Budget	**Collaborators**
$0K (FY18/FY19 funds to be used)	ORNL (ORNL-AM11), University of Arizona

This task involves the completion of a comparison of several computational features of both NCSP Monte Carlo and U. of Arizona deterministic codes in the diffusion approximation. Since the analytical solution accommodates upwards of 500 energy points, a meaningful criticality comparison of codes and libraries becomes possible including resonance treatments. With a full heterogeneous solution, we can also study 1D assemblies as to their composition and including

control rods and various fuel designs. With an overall comparison to a true analytical solution as a baseline, one can document biases, if any, in Monte Carlo codes. The University of Arizona will establish the 1-D analytical benchmarks, ORNL will provide COG Monte Carlo results, and ORNL will provide SCALE Monte Carlo results for this task. The work progress on this task will be monitored by the NCSP Analytical Methods Working Group. The deliverable will summarize a comparison of LLNL COG, ORNL SCALE and 1-D Analytical benchmark calculations. This task was not initiated on time due to the availability of the staff from the University of Arizona.

Task Name	Task Title
LLNL-AM7	Technical Data for the Pitzer Formulation of Solution Compositions to Include Uranium/Plutonium Solutions with Selected Admixed Absorbers
Budget	**Collaborators**
$0 (FY19 funds to be used)	ORNL (ORNL-AM16), LANL (LANL-AM6), IRSN (IRSN-AM17)

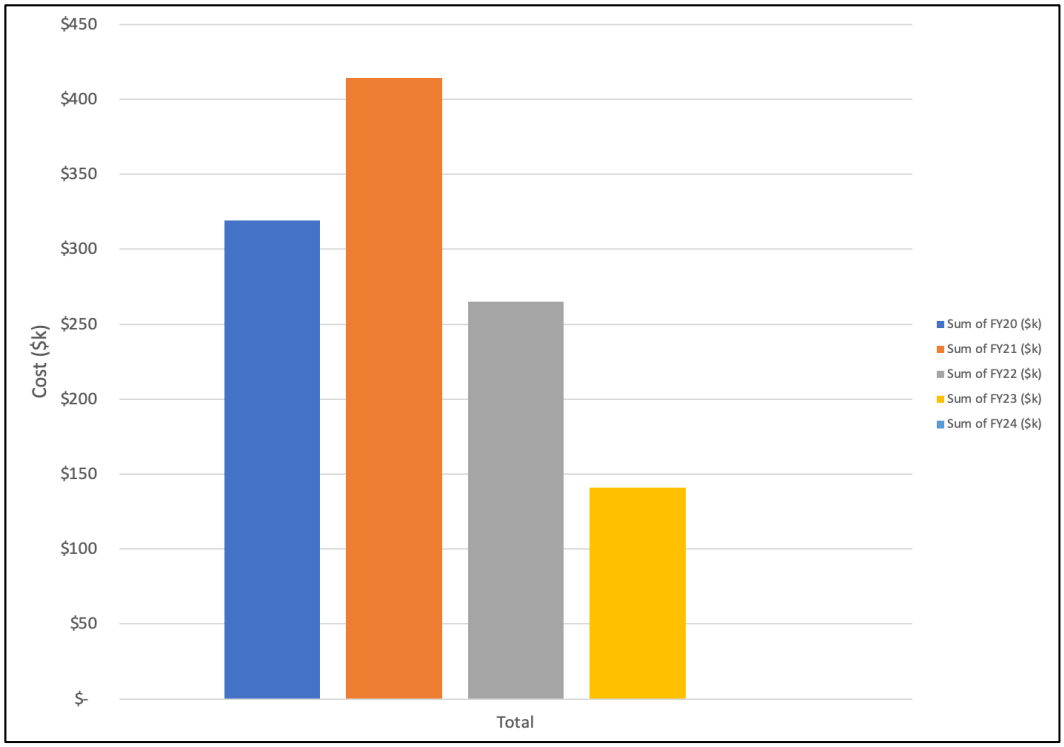
This is an ongoing task (FY19) to support development of Pitzer formulations for uranium and plutonium solutions for inclusion into the SCALE system and MCNP material input processor. ORNL is the lead on this task. This task is to perform a literature review regarding gaps in experimental data for solution compositions to generate a follow-up proposal for experimental measurements in the outyears. Funds carried over from FY19 will be used to complete this task.

Task Name	Task Title
LLNL-AM8	FUDGE Generation of a Complete ENDF/B-VIII.0 Library for Testing in Production Codes
Budget	**Collaborators**
$100K	(BNL) BNL-AM5

This new task is to for LLNL and BNL to collaborate the following:

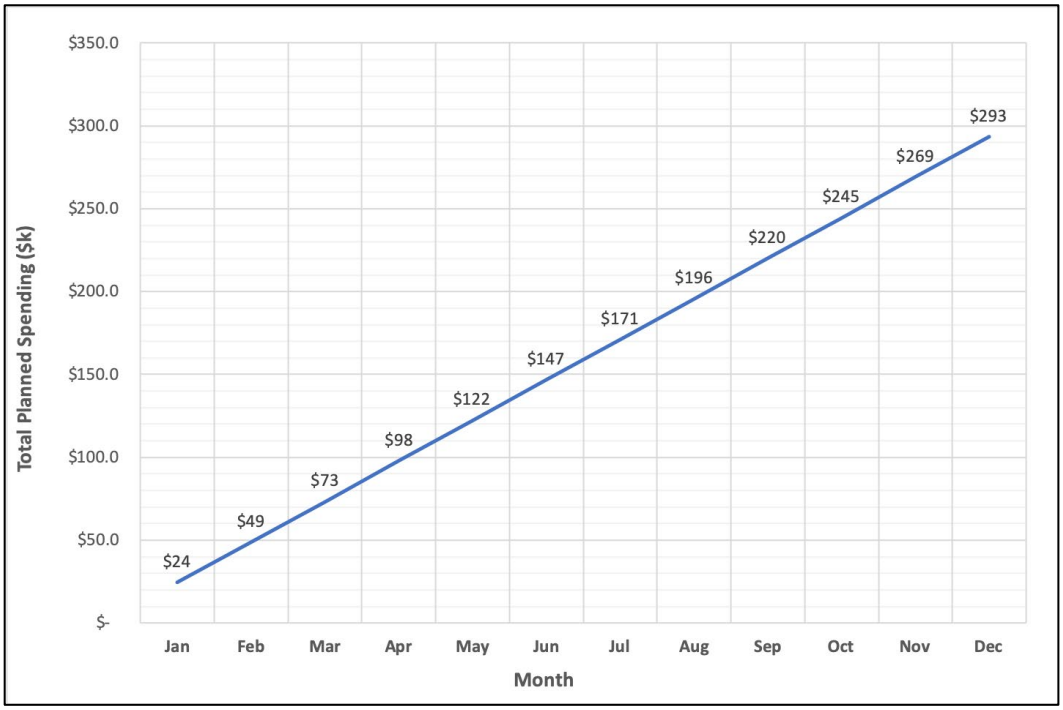
- LLNL and BNL to provide the double differential cross-sections (DDXS) for thermal scattering and probability density functions (PDF) data for the unresolved resonance region in GNDS containers
- LLNL to test the FUDGE/GNDS data including the new DDXS and PDF data and compare the results to those using legacy codes
- In the event of discrepancies, BNL and LLNL to use these results to identify issues and inform further development of the DDXS and PDF algorithm as required
- Upon completion of the project, LLNL and BNL to provide the final ENDF/BVIII.0 DDXS and PDF data in GNDS containers
- LLNL to provide the full test suite to BNL for inclusion in ADVANCE

Figure 2.1-7 LLNL AM Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
The increase in LLNL AM funding in FY21 is due to the start of LLNL-AM4 (Thermal Scattering and Self-Shielding in GND/FUDGE). After FY21, budget reductions are due to the completion of LLNL-AM3 (SlideRule) and LLNL-AM4 completion. There are no projected LLNL AM tasks for FY24.

Figure 2.1-8 LLNL AM Planned Spending (FY2020)*



* LLNL Planned Spending reduced by approximately 8% to account for required laboratory hold-back during FY continuing resolution (CR) funding uncertainty.

LLNL AM Milestones:

Occurs all 4 Quarters

- Provide status on LLNL AM activities in NCSP Quarterly Progress Reports (AM2, AM3, AM5, AM6, AM7, and AM8).

2.1.2.4 Oak Ridge National Laboratory (ORNL)

Task Name	Task Title
ORNL-AM1	Radiation Safety Information Computational Center (RSICC)
Budget	**Collaborators**
$325K	None

RSICC ongoing approved task to collect, update, package, and distribute software and associated nuclear data libraries (i.e., SCALE, MCNP, VIM, and COG and nuclear data processing (i.e., NJOY, AMPX and SAMMY) to the NCS community. The NCS community includes: DOE and NNSA M&O NCS staff, e.g., LANL, LLNL, SNL, SRNS, etc., DOE-EM M&O NCS staff, e.g., PGDP, PORTS, SRNL, etc. This does not include NRC-regulated NCS staff, M&O subcontractors, and independent consultants. University students in Nuclear Engineering programs performing NCS analysis is also included. Also, test and disseminate processed nuclear data associated with the software.

Task Name	Task Title
ORNL-AM2	SCALE/KENO/TSUNAMI Maintenance and Support/Cross-Section and Generation/Modernization
Budget	**Collaborators**
$1,200K	IRSN (IRSN-AM1, IRSN-AM3)

Ongoing, approved task to provide SCALE/KENO/TSUNAMI maintenance and user support for performing Nuclear Criticality Safety (NCS) calculations with the SCALE package. Work tasks include: sustaining and continually improving SCALE NCS features through user-driven enhancements, software quality assurance (SQA) and V&V; assuring adaptability to various computing platforms and compilers; providing improved user interfaces and user documentation consistent with modern engineering software; supporting responsive communication to SCALE criticality safety users through SCALE Newsletters, email notices, and updates on the SCALE website, and training. The task also includes support for modernizing the software infrastructure and capabilities to improve quality and reliability and to ensure long-term sustainability of the NCS capabilities.

Task Name	Task Title
ORNL-AM3	AMPX Maintenance and Modernization
Budget	**Collaborators**
$300K	IRSN (IRSN-AM9)

Ongoing, approved task to develop and maintain the AMPX nuclear data processing code system to provide cross-section and covariance data libraries for NCS radiation transport software such as SCALE. In addition, the task includes additional effort to implement new software enhancements needed to improve the quality and reliability of the nuclear data libraries that are produced by AMPX. The overall development and maintenance work effort will ensure the AMPX software is up-to-date and in conformance with ENDF/B formats and procedures. Moreover, the development and enhancements to the AMPX software will enable improved nuclear data processing capabilities needed to provide reliable nuclear data libraries to support radiation transport methods development and analyses.

Task Name	Task Title
ORNL-AM6	Slide Rule Application
Budget	**Collaborators**
$30K	IRSN (IRSN-AM5), AWE (AWE-AM1), LLNL (LLNL-AM3)

This is a continuing task with IRSN, ORNL, and LLNL to modernize the existing SlideRule accident response tool. ORNL developed the initial SlideRule, and under this task, IRSN will update the SlideRule using modern radiation transport tools (e.g., SCALE, MCNP, COG, etc.) and expand the SlideRule capabilities. IRSN, ORNL, and LLNL on the SlideRule modernization effort and perform review tasks as needed to assess the performance of the updated SlideRule capability.

Task Name	Task Title
ORNL-AM9	Sensitivity/Uncertainty Comparison Study with a Focus on Upper Subcritical Limits
Budget	**Collaborators**
$50K	IRSN (IRSN-AM14), LANL (LANL-AM4)

Various methods have been developed recently to assist the Criticality Safety Analyst (CSA) determine a safe Upper Subcritical Limit (USL) for an application of interest. IRSN has developed the MACSENS tool which relies on Monte Carlo results from the MORET code. ORNL has developed the TSUNAMI package, which relies on Monte Carlo results from KENO (among various transport options), and LANL has developed the Whisper package which relies on Monte Carlo results from MCNP6.® This proposal is to have the three Laboratories compare results from the various methods on a small set of benchmark problems. Differences in results will be understood, and one or more of the methods may be improved as a result. Two relevant problems will be chosen each FY, and results such as sensitivity profiles and individual components of the USL will be compared. Each year, the two problems to be compared will be chosen. Nuclear data choices will also be made. For example, year one might study a fast Pu system and a solution system from ICSBEP. For some comparisons we might all employ the same nuclear data; for others a range of evaluated data might be used. We anticipate choosing real-world application problems of interest as well as historical benchmark problems during the lifetime of the project. The NCSP AM Working Group will provide a forum for presenting and discussing results to ensure timely completion of the milestones. LANL will be responsible for one summary report for two of the test cases while the other labs will provide summary reports for their test case work. IRSN will lead the development in the final year of a summary report for the project.

Task Name	Task Title
ORNL-AM10	Proposed Benchmark Intercomparison Study
Budget	**Collaborators**
$50K	IRSN (IRSN-AM13), LLNL (LLNL-AM5), LANL (LANL-AM5)

CEA and IRSN published a summary of the results of an extensive benchmark intercomparison study of French analytic methods using JEFF-3.1.1 nuclear data in the proceedings of the International Conference on Nuclear Criticality Safety (ICNC 2015). While JEFF data is available in many NCSP codes (e.g., COG, MCNP), due to resource limitations it has not been tested as rigorously as the US national database ENDF/B. The proposal is for IRSN to lead a new intercomparison based on the MORET code with the latest JEFF-3.2 data and ENDF/B-VIII.0 data, when available, using their existing comprehensive selection of 2,714 benchmarks and collate their results together with those from LLNL (COG), LANL (MCNP) and ORNL (SCALE). Due to the large number of benchmarks involved, this effort is envisioned to take three years with an additional year for IRSN to complete a summary report. The benchmark development will be performed independently to minimize modeling errors through discovery and resolution of discrepant results. A summary report will be generated (led by IRSN) to document the results of this study.

Task Name	Task Title
ORNL-AM11	Proposed 1-D Multipoint Analytical Benchmark Intercomparison
Budget	**Collaborators**
$0K (FY18/FY19 funds to be used)	LLNL (LLNL-AM6), University of Arizona

This task involves the completion of a comparison of several computational features of both NCSP Monte Carlo and U. of Arizona deterministic codes in the diffusion approximation. Since the analytical solution accommodates upwards of 500 energy points, a meaningful criticality comparison of codes and libraries becomes possible including resonance treatments. With a full heterogeneous solution, we can also study 1D assemblies as to their composition and including control rods and various fuel designs. With an overall comparison to a true analytical solution as a baseline, one can document biases, if any, in Monte Carlo codes. The University of Arizona will establish the 1-D analytical benchmarks, ORNL will provide COG Monte Carlo results (ORNL-AM6), and ORNL will provide SCALE Monte Carlo results for this task. The work progress on this task will be monitored by the NCSP Analytical Methods Working Group. The deliverable will summarize a comparison of LLNL COG, ORNL SCALE and 1-D Analytical benchmark calculations. This task was not initiated on time due to the availability of the staff from the University of Arizona.

Task Name	Task Title
ORNL-AM15	The Effects of Temperature on the Propagation of Nuclear Data Uncertainty in Nuclear Criticality Safety Calculations
Budget	**Collaborators**
$100K	Massachusetts Institute of Technology

This is a new task to develop an analytic methodology and implement it in a module of the AMPX nuclear data processing code to allow the nuclear data covariance to accurately reflect the degree of knowledge of the cross section at different temperatures. This new capability will allow for investigating and demonstrating the effects of temperature on the propagation of nuclear data uncertainty in nuclear criticality safety applications.

Task Name	Task Title
ORNL-AM16	Technical Data for the Pitzer Formulation of Solution Compositions to Include Uranium/Plutonium Solutions with Selected Admixed Absorbers
Budget	**Collaborators**
$0 (FY19 funds to be used)	LLNL (LLNL-AM7), LANL (LANL-AM6), IRSN (IRSN-AM17)

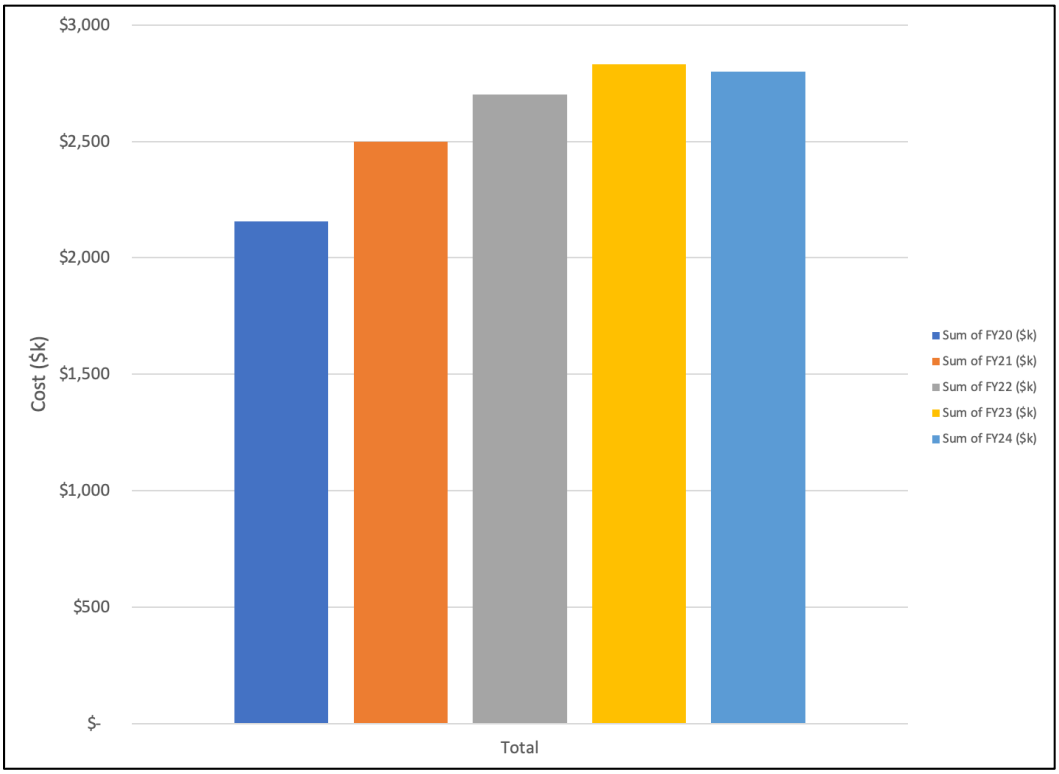
This is an ongoing task (FY19) to support development of Pitzer formulations for uranium and plutonium solutions for inclusion into the SCALE system and MCNP material input processor. ORNL is the lead on this task. This task is to perform a literature review regarding gaps in experimental data for solution compositions to generate a follow-up proposal for experimental measurements in the outyears. Funds carried over from FY19 will be used to complete this task.

Task Name	Task Title
ORNL-AM20	Nuclear Data and Cross Section Testing Using ENDF/B-VIII.0
Budget	**Collaborators**
$100K	None

This task will validate the AMPX processed ENDF/B-VIII.0-based cross section libraries for use in the latest SCALE code system. Using the ENDF/B-VIII.0-based cross section libraries, we will perform validation studies using ORNL's Verified, Archived Library of Inputs and Data (VALID) system. We will rerun all existing VALID cases (more than 400) using the newly generated

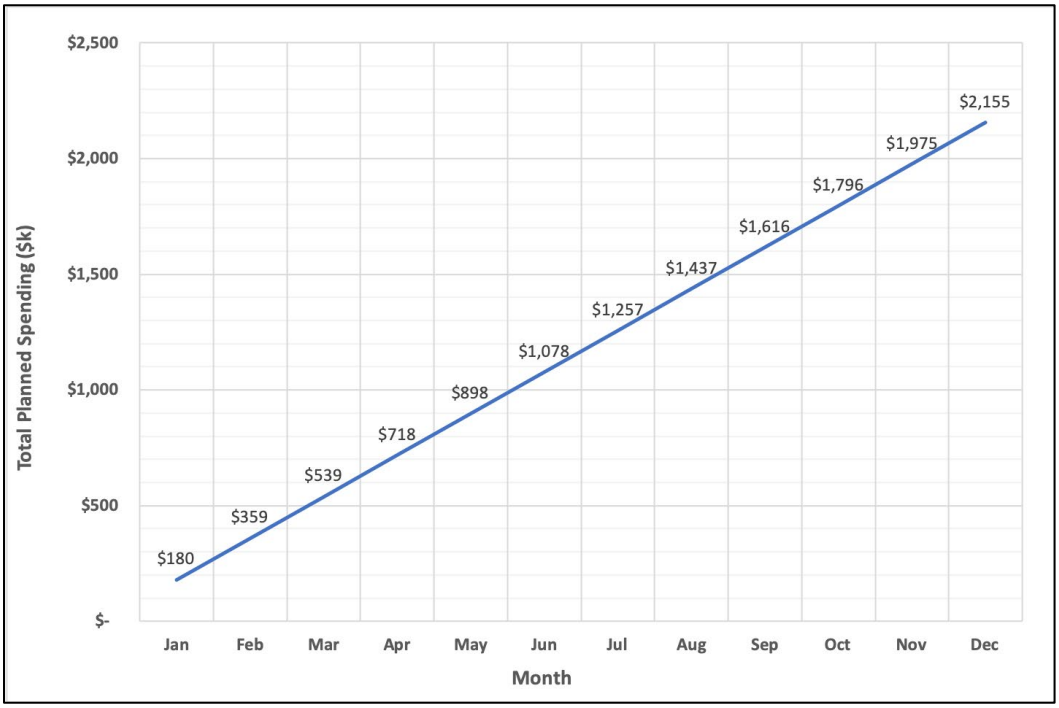
libraries and perform rigorous detailed analyses to compare the results against previous ENDF/B-VII.1-based results with both continuous energy and multigroup modes. In this proposed new work, we will primarily focus on the sensitivity data differences for all cases in the VALID library of inputs and data (in addition to the keff values). Recent work at ORNL identified the temperature-dependent validation as one of the problematic areas as well as the intermediate spectrum systems. The effect of new evaluations and improvements in ENDF/B-VIII.0 on especially these problematic areas will also be assessed. Finally, the validation test results will be documented and published as appropriate.

Figure 2.1-9 ORNL AM Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
The ORNL AM budget increases from FY20-FY23 due to AM tasks being started in the outyears (ORNL-AM15, AM17, AM18, and AM19). The other budget increases are due to modest increases in SCALE and AMPX budgets in the outyears, ORNL-AM2 and ORNL-AM3, respectively.

Figure 2.1-10 ORNL AM Planned Spending (FY2020)



ORNL AM Milestones:

Occurs all 4 Quarters

- Continue distribution of available and newly packaged software to the NCS community requesters (at no direct cost to them) and provide distribution totals quarterly. (AM1)
- Provide status reports on ORNL participation in US and International Analytical Methods collaborations and provide brief trip summary report to NCSP Manager on items of NCSP interest. (AM2, AM3)
- Provide status on ORNL AM activities in NCSP Quarterly Progress Reports. (AM1, AM2, AM3, AM6, AM9, AM10, AM11, AM13, AM14, AM15, AM16, AM17, AM18, AM19, AM20)

Quarter 2

- Issue an annual SCALE maintenance report to the NCSP Manager. (AM2)

Quarter 4

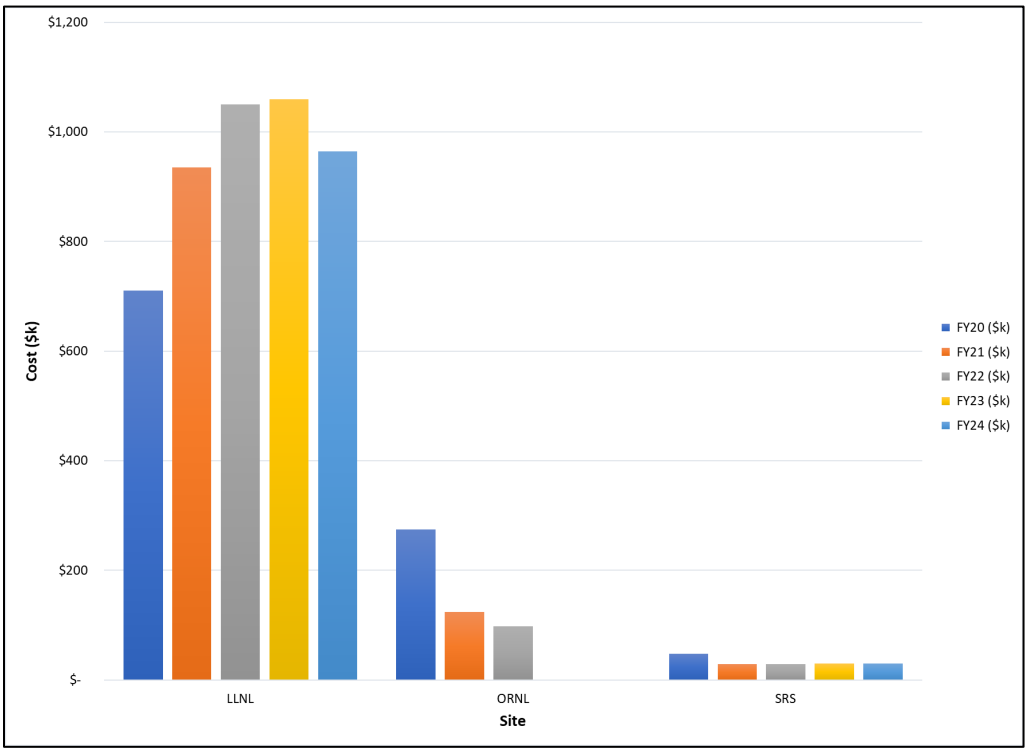
- Publish annual newsletter to users to communicate software updates, user notices, generic technical advice, and training course announcements. (AM2)
- Document AMPX modernization and technical support for SCALE CE, multigroup, and covariance libraries and report status annually to the NCSP Manager. (AM3)

2.2 Information Preservation and Dissemination (IP&D)

2.2.1 Program Element Description

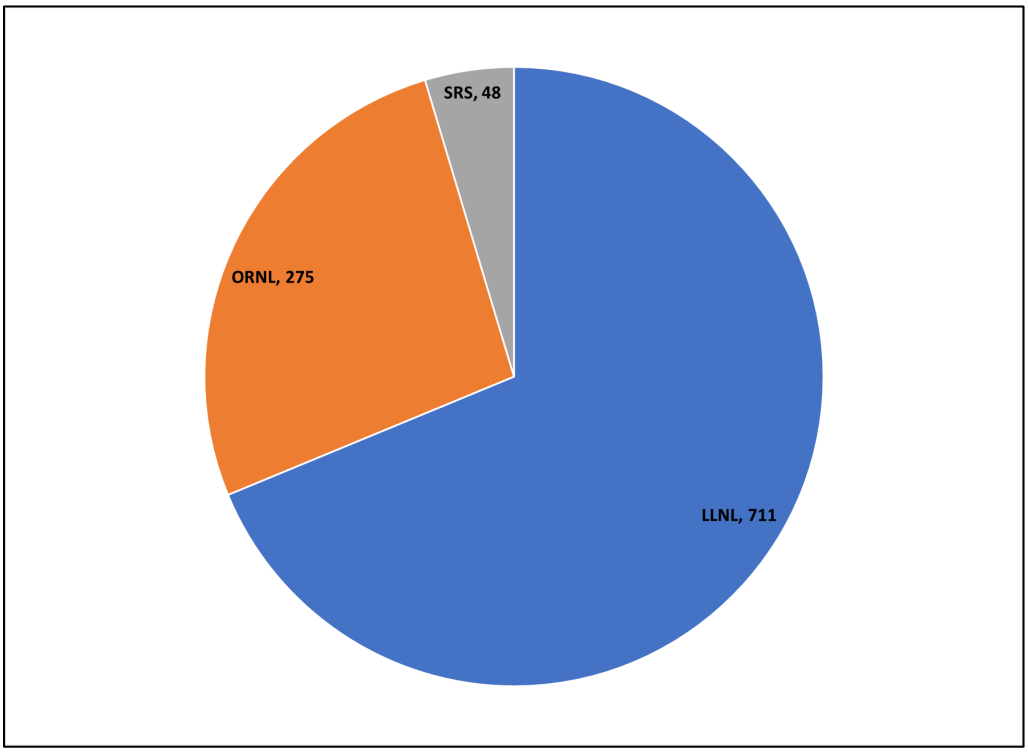
The Information Preservation and Dissemination program element preserves primary documentation supporting criticality safety and makes this information available for the benefit of the technical community. The NCSP website (http://ncsp.llnl.gov) is the central focal point for access to criticality safety information collected under the NCSP, and the gateway to a comprehensive set of hyperlinks to other sites containing criticality safety information resources.

Figure 2.2-1 IP&D Budget (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
LLNL budgets in FY20-22 increase somewhat due to growing budgets for some ongoing tasks then go down in FY24 as LLNL-IPD3 (NCSP website search capabilities) and LLNL-IPD6 (LLNL Pulsed Spheres) tasks are completed. The overall budget trend from FY22 to FY24 is reduced in part as ORNL completes ORNL-IPD4 (Development of Experimental Uncertainty Correlation Evaluation) and ORNL-IPD5 (ORNL Health Physics Research Reactor CAAS Benchmark Evaluation) tasks.

Figure 2.2-2 IP&D Budget (FY2020)



2.2.2 Approved Tasks

2.2.2.1 Lawrence Livermore National Laboratory (LLNL)

Task Name	Task Title
LLNL IPD1	Conduct ICSBEP for Benchmarks listed in Appendix C of the 5-Year Plan and publish annual revision to the Handbook
Budget	**Collaborators**
$236K	IRSN (IRSN-IPD1), AWE (AWE-IPD1)

This is an ongoing approved task that provides independent and Technical Review Group (TRG) reviews for newly completed integral experiments for publication as NCSP contributions to the International Criticality Safety Benchmark Evaluation Project (ICSBEP). Priority historical experiments may also be evaluated and reviewed (internal, independent, and TRG) as resources allow. All NCSP funded experiments will be finalized and published on the NCSP website within two quarters of receipt of an Experiment Design Team reviewed and approved draft report (CED-4a). LLNL IP&D1 will also provide leadership, coordination, and publication support for the OECD/NEA ICSBEP. **(LLNL IPD1 was modified from $286K to $236K (moved to LLNL ND3) in FY20 5-year plan, Rev. 4)**

Task Name	Task Title
LLNL IPD2	Maintain the NCSP Website and Systems
Budget	**Collaborators**
$150K	None

This is an ongoing approved task for operation, maintenance and modernization of the NCSP website. The NCSP website is the central focal point for access to criticality safety information collected under the NCSP and is the gateway to a comprehensive set of hyperlinks to other sites containing criticality safety information resources. **(LLNL IPD2 was modified from $200K to $150K (moved to LLNL ND5) in FY20 5-year plan, Rev. 4)**

Task Name	Task Title
LLNL IPD4	Benchmark Evaluation of Hot Box, LLNL Historical Critical Configurations at High Temperature
Budget	**Collaborators**
$25K	None

This is a new approved task for evaluation of the LLNL "Hot Box" for inclusion in the ICSBEP Handbook.

Task Name	Task Title
LLNL IPD5	IT Support at NNSS
Budget	**Collaborators**
$200K	None

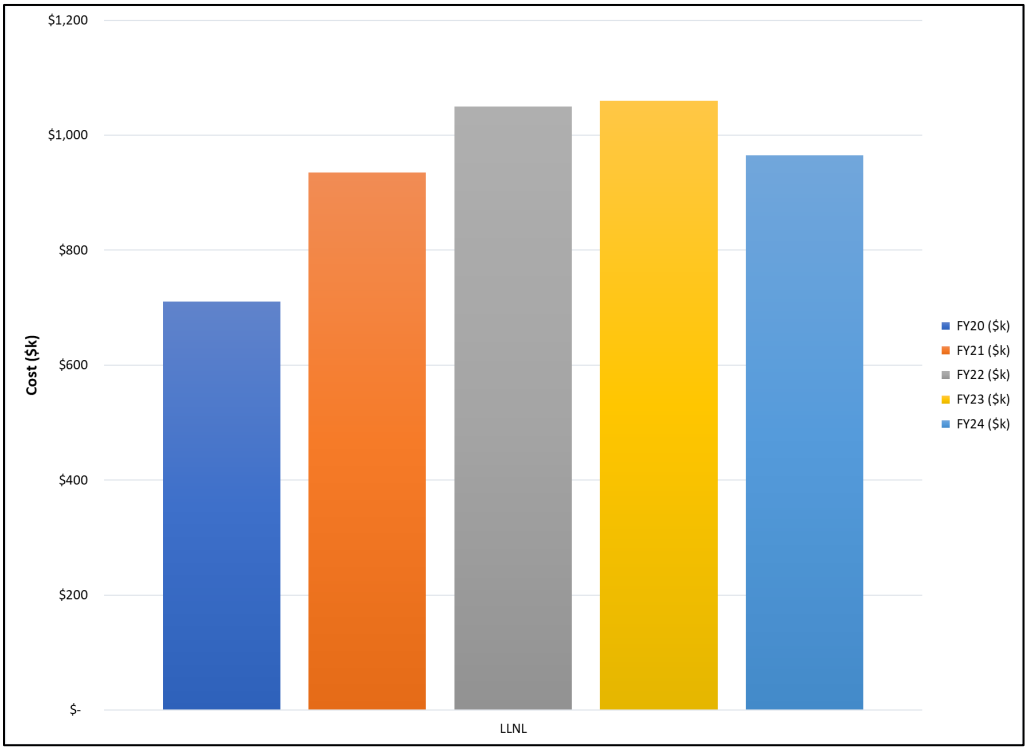
This task is to provide IT support at the NNSS, e.g., Classified computing, etc. **(LLNL IPD5 was modified from $300K to $200K (moved to LLNL ND7) in FY20 5-year plan, Rev. 4)**

Task Name	Task Title
LLNL IPD6	Benchmark Evaluation of LLNL 'Pulsed Spheres'
Budget	**Collaborators**
$100K	None

This task for LLNL will involve formally evaluating the LLNL 'Pulse Sphere' experimental campaign for inclusion into the ICSBEP Handbook and/or SINBAD compendium. Dr. Luisa Hansen, the Principal Investigator (PI), is still available and willing to assist in this effort as the internal reviewer. LLNL is thus uniquely qualified to perform this task as we have access to the PI, data, drawings, interim reports, etc., and have state-of-the-art 'open' and 'closed' analytical

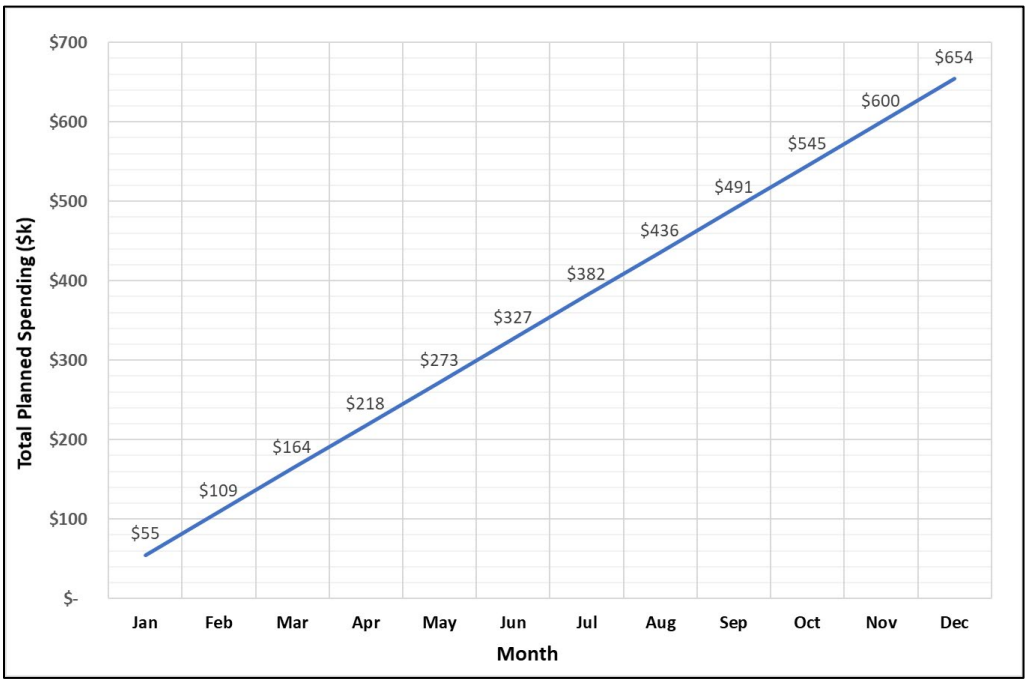
methods capable of performing simulations from first principles starting with the charged particle deuteron beam. This is particularly important because the beam is not fully stopped in the tritiated target, and so must be more realistically Nuclear Criticality Safety Program Proposal Template for FY2020 – FY2024 simulated, which it appears has not been done prior to 2012 due to limitations in popular codes. Lastly, it should be noted that these experiments are unique and important in that they are especially sensitive to elastic and inelastic scattering whereas critical assembly experiments of all types are dominated by fission and capture.

Figure 2.2-3 LLNL IPD Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots: LLNL budgets in FY20-22 increase somewhat due to growing budgets for some ongoing tasks then go down in FY24 as LLNL-IPD3 (NCSP website search capabilities) and LLNL-IPD6 (LLNL Pulsed Spheres) tasks are completed.

Figure 2.2-4 LLNL IP&D Planned Spending (FY2020)*



* LLNL Planned Spending reduced by approximately 8% to account for required laboratory hold-back during FY CR funding uncertainty.

LLNL IPD Milestones:

Occurs all 4 Quarters

- Manage all aspects of the DOE NCSP participation in the ICSBEP as required to ensure the finalizing and publishing ICSBEP evaluations per IE schedule. (IPD1)
- Provide status reports on LLNL participation in US and International IPD collaborations (including ICSBEP) and provide brief summary report to NCSP Manager on items of NCSP interest. (IPD1)
- Maintain, operate and modernize he NCSP website, databases, and provide user assistance as required. (IPD2)
- Provide a status report for the evaluation of the LLNL "Hot Box" for inclusion in the ICSBEP Handbook. (IPD4)
- Provide status report on progress on IT support at NNSS, the benchmark evaluation of LLNL 'Pulsed Spheres,' and the ICSBEP quality assessment project (IPD5, IPD6, IPD7).

2.2.2.2 Oak Ridge National Laboratory (ORNL)

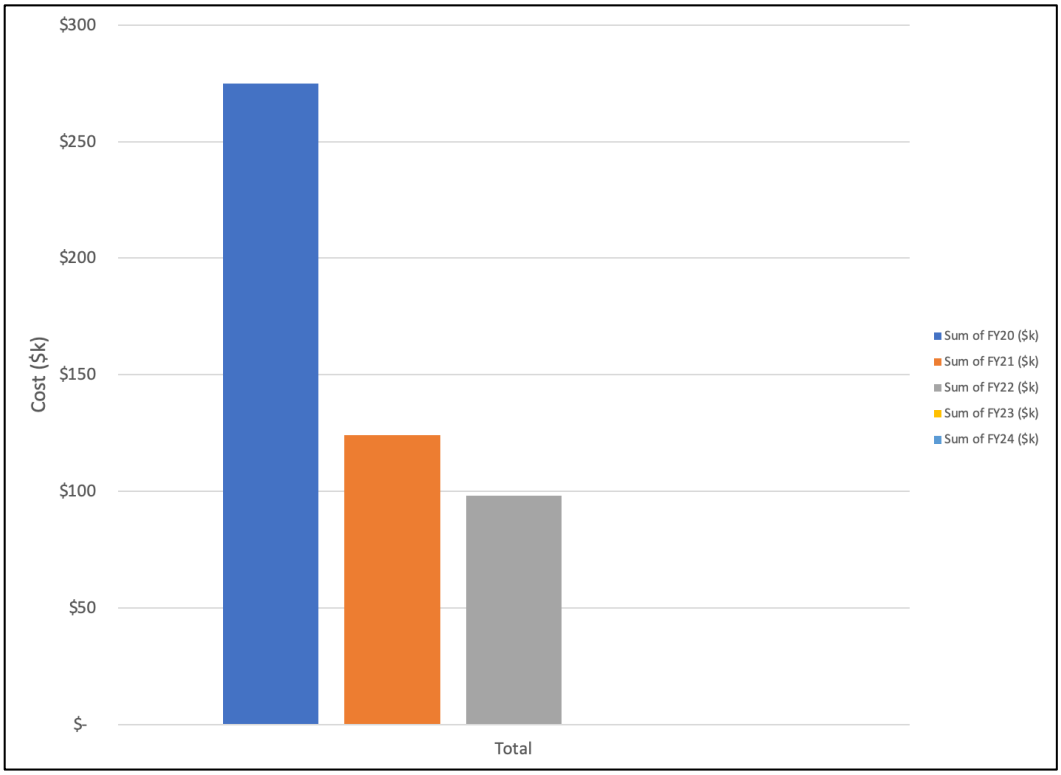
Task Name	Task Title
ORNL IPD5	Oak Ridge Health Physics Research Reactor CAAS Benchmark Evaluation
Budget	**Collaborators**
$220K	None

Generate a CAAS benchmark for the ICSBEP using measurement data from the Oak Ridge Health Physics Research Reactor (HPRR). The first subtask involves a search of the ORNL archives to determine if the information needed to create an ICSBEP CAAS benchmark based on the HPRR is available. All the relevant information will be documented in a fashion like CED-3b of the CEdT process. At the end of the first year, the data collected during the first subtask will be evaluated, and if it is deemed possible to create a new CAAS benchmark then the second subtask will begin in FY20.

Task Name	Task Title
ORNL IPD7	Preserving the "Howard Dyer" Library at ORNL
Budget	**Collaborators**
$55K	None

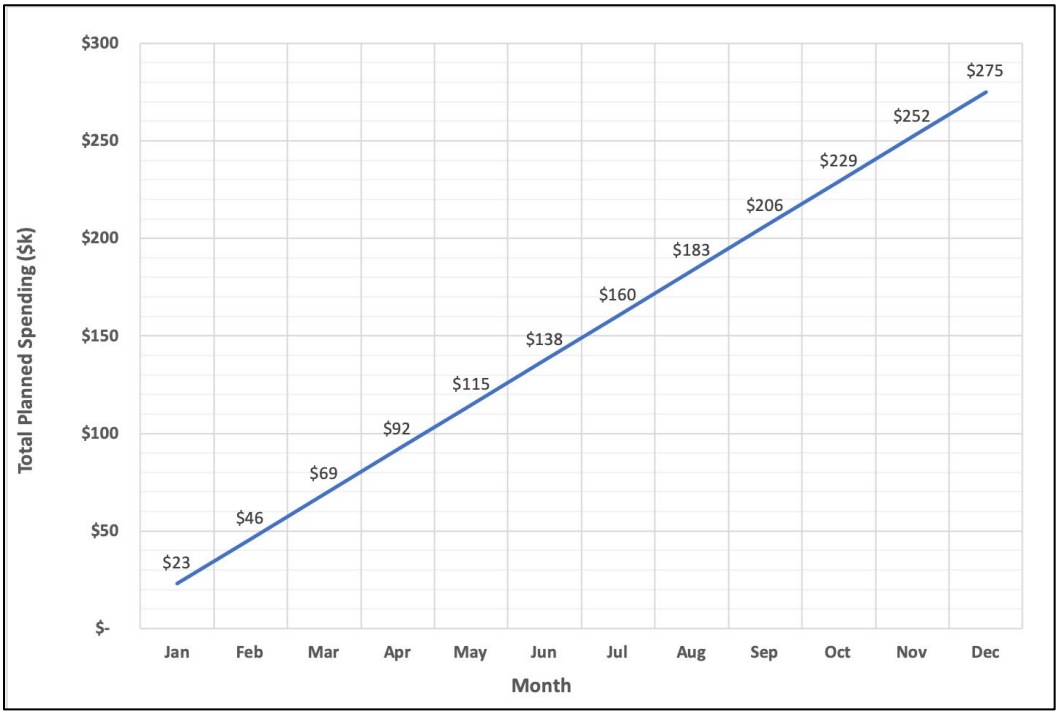
The purpose of this proposal is to convert the "Howard Dyer" library at ORNL from hard copy format to electronic format to share with the NCS community. The PDF files will be provided to LLNL for inclusion on the NCSP website.

Figure 2.2-5 ORNL IPD Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
The ORNL budget trend decreases after FY21 as ORNL completes ORNL-IPD4 (Development of Experimental Uncertainty Correlation Evaluation) and ORNL-IPD5 (ORNL Health Physics Research Reactor CAAS Benchmark Evaluation) tasks.

Figure 2.2-6 ORNL IPD Planned Spending (FY2020)



ORNL IPD MILESTONES:

All Quarters

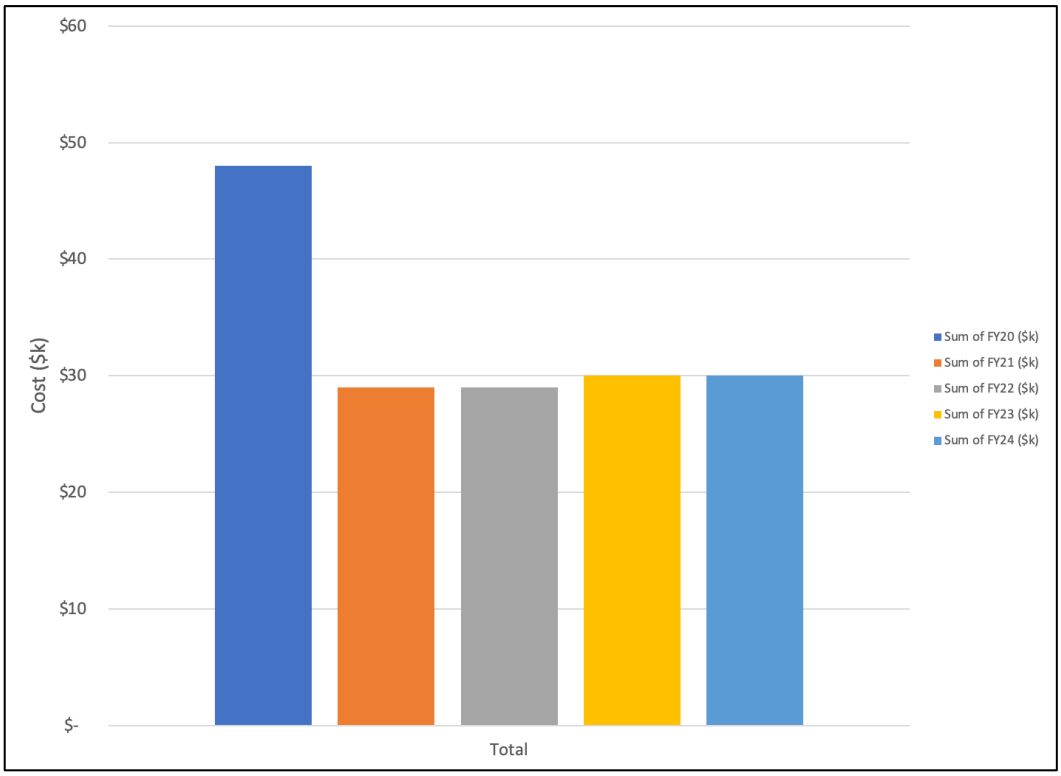
- Provide a status report on progress made on IPD tasks. (IPD5, IPD7)

2.2.2.3 Savannah River Site (SRS)

Task Name	Task Title
SRS IPD1	ARH-600 Reissue (CritView)
Budget	**Collaborators**
$48K	None

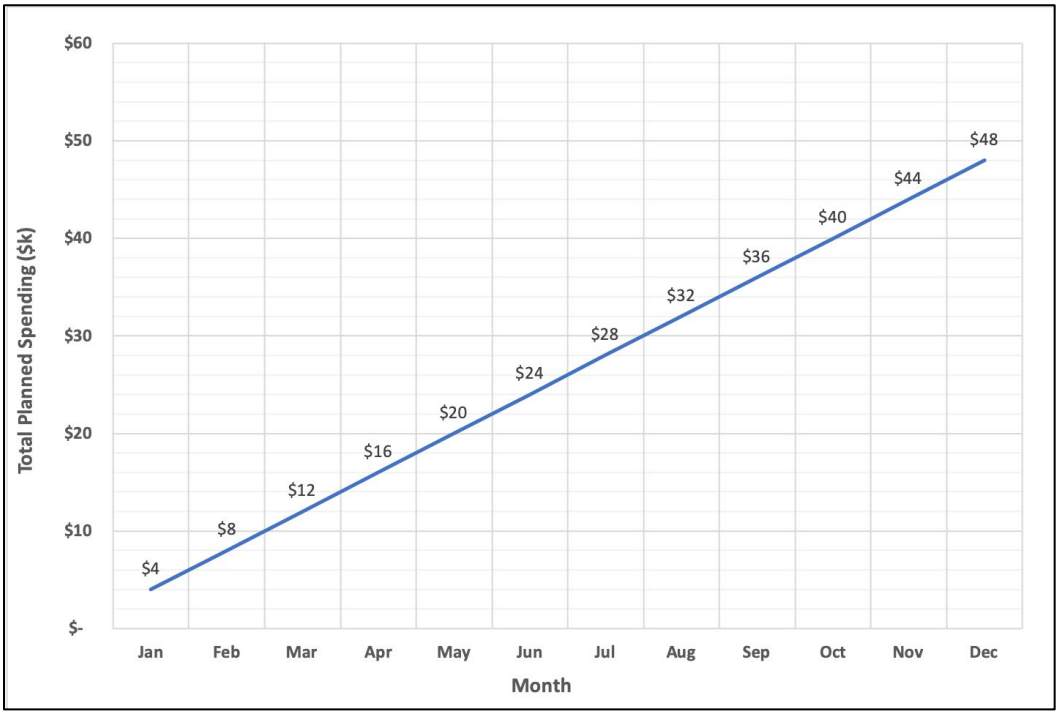
The updated CritView software and libraries will be a reliable tool for criticality safety analysts that can supplement computer calculations and other handbook values. This effort maintains capabilities and provides improved efficiencies in accessing criticality data to reduce safety risk. ARH-600, and other criticality safety handbook data, are being evaluated with MCNP and SCALE, will be peer reviewed and will be issued as an electronic handbook with unique search and visualization features. The current focus is to update CritView to 1) better handle large databases to support improved functionality and significantly more data, and 2) upgrade the user interface to provide a more efficient and user-friendly program. Also provide limited response to user queries, any error identification, and database management.

Figure 2.2-7 SRS IP&D Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
The reduction in funding in FY20 is due to completion of the development phase of the SRS-IPD1 task. The steady budget after FY20 allows for maintenance of the CritView package for the long-term.

Figure 2.2-8 SRS IP&D Planned Spending (FY2020)



SRS IP&D Milestones

Occurs all 4 Quarters

- Provide status reports on SRS progress with CritView. (IPD1)
- Provide status report on progress on the ICSBEP quality assessment project. (IPD2)

Quarter 2

- Develop QA documents for current version to meet current SRS/DOE requirements. (IPD1)

Quarter 4

- Issue Preliminary (updated) CritView version for internal testing. (IPD1)
- Issue Preliminary User Guide to support internal testing. (IPD1

2.3 Integral Experiments (IE)

2.3.1 Program Element Description

The Integral Experiments program element maintains a fundamental capability for the DOE NCSP to be able to perform critical, subcritical, and fundamental physics measurements, within the limits of its resources, to address criticality physics needs, emerging data improvement needs by DOE programs, and specific-site needs on a prioritized basis. This program element supports the entire cost of the LANL NCERC permanent party staff and also supports maintaining a fundamental nuclear material handling capability, which enables hands-on NCS training programs and various other programs for the DOE NCSP and other government agencies.

Figure 2.3-1 IE Budget (FY2020-FY2024)

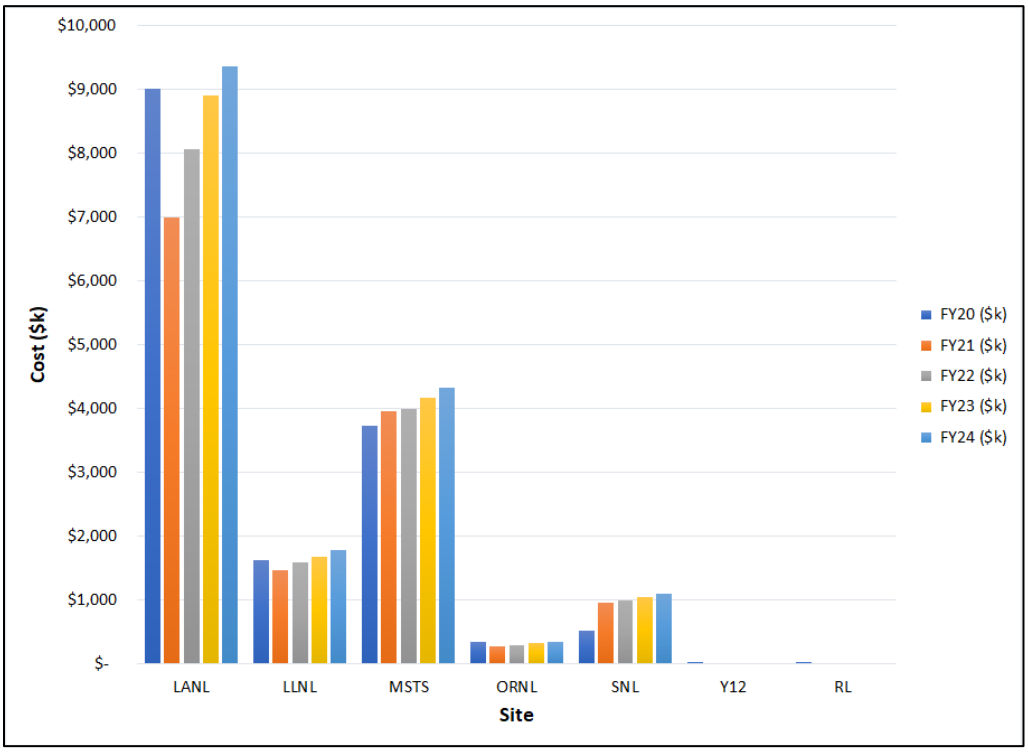
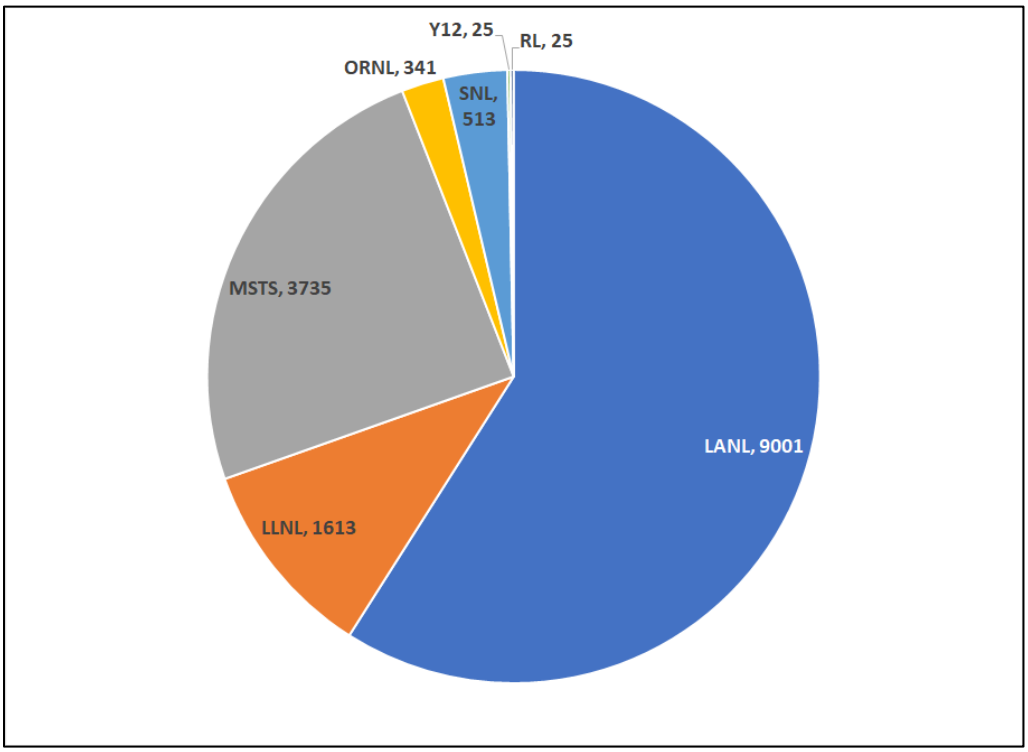


Figure 2.3-2 IE Budget (FY2020)



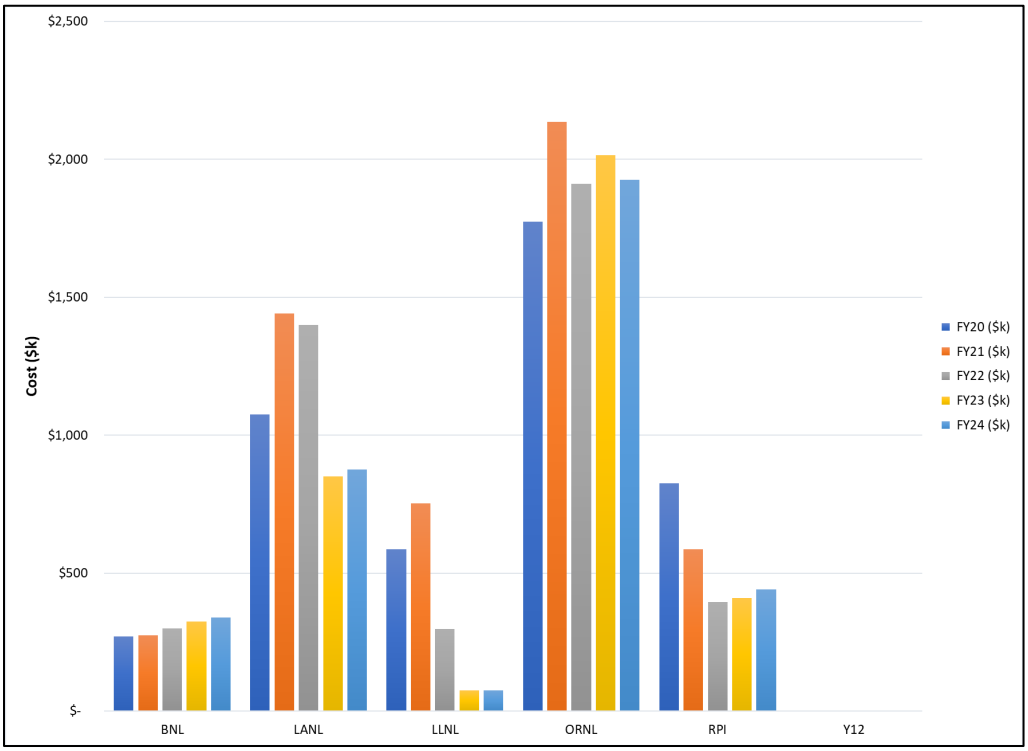
All Integral Experiment tasks and milestones are published as a standalone document. Contact the NCSP Program Manager, Dr. Angela Chambers, if you have a 'Need-to-Know.'

2.4 Nuclear Data (ND)

2.4.1 Program Element Description

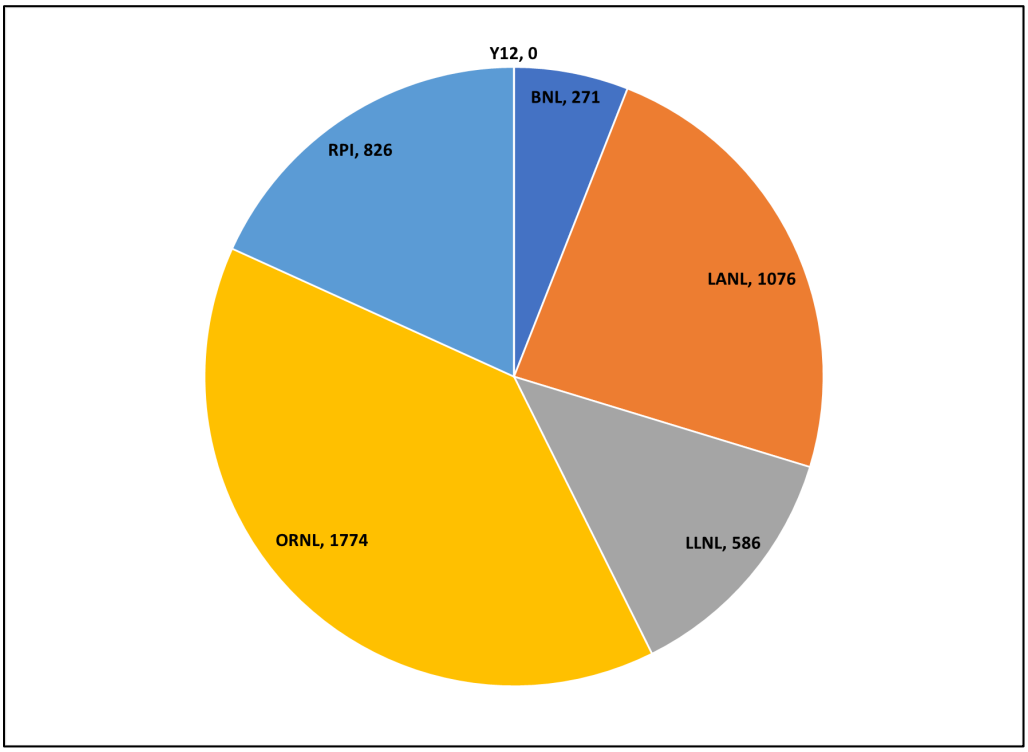
The Nuclear Data program element includes the measurement, evaluation, testing, and publication of neutron cross-section data for nuclides of high importance to NCS analyses. The NCSP continues to improve coordination of ND activities by fostering a strong collaborative effort among all of the national and international resources in this highly technical area. The objective is to solve the highest priority ND problems relevant to criticality safety in a timely manner. This program element is essential for the NCSP because it provides the nuclear cross-section data required by the AM program element. Refer to Appendix B for the FY2020 through FY2024 schedule, milestones, and deliverables associated with specific nuclear data measurement, evaluation, and publication. Milestones not contained in Appendix B are delineated below.

Figure 2.4-1 ND Budget (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
The NCSP ND budget varies significantly from FY20 to FY24 due to the time of start-up and completion of ND tasks at LNL, LLNL, and RPI. A series of LANL measurements, LANL-ND1 "Prompt Fission Neutron Spectra Measurement of ^{240}Pu" and LANL-ND2, "Unresolved and Fast Measurements of ^{233}U," begin in FY20 and end in FY22 (more than $1.6M in funding). The LANL ND budget drops significantly starting in FY23 once the measurements are completed. At LLNL, there are seven ND tasks that will be completed by the end of FY22 (total of $874K of funding) that results in a significant reduction in LLNL funding in by FY23. Also, the completion of the RPI ND3 task for upgrading the RPI LINAC results in sharp reduction in the budget trend from FY20 to FY22 (more than $500K in funding). The budgets at BNL and ORNL are much more stable over the 5-year period than the other sites. Y-12 is still listed in the chart because they continue to have a ND task to generate a depleted uranium neutron production target for IRMM but will be using FY19 funding to complete the task.

Figure 2.4-2 ND Budget (FY2020)



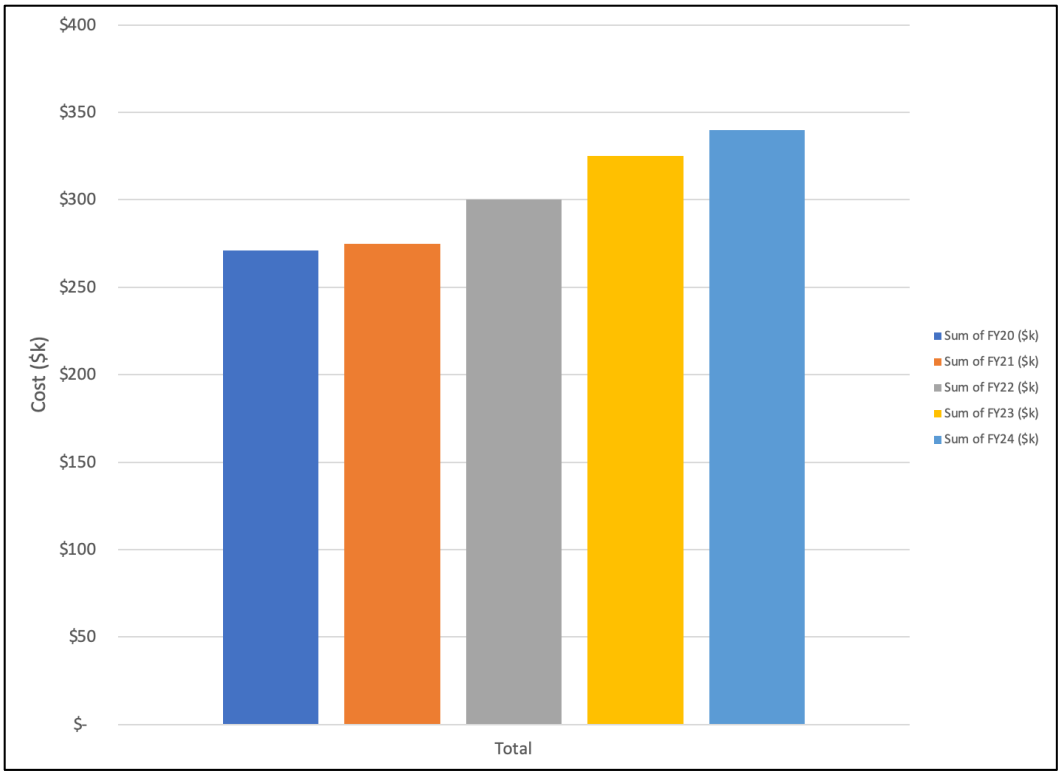
2.4.2 Approved Tasks

2.4.2.1 Brookhaven National Laboratory (BNL)

Task Name	Task Title
BNL ND1	National Nuclear Data Center (NNDC) Support to the NCSP
Budget	**Collaborators**
$271K	None

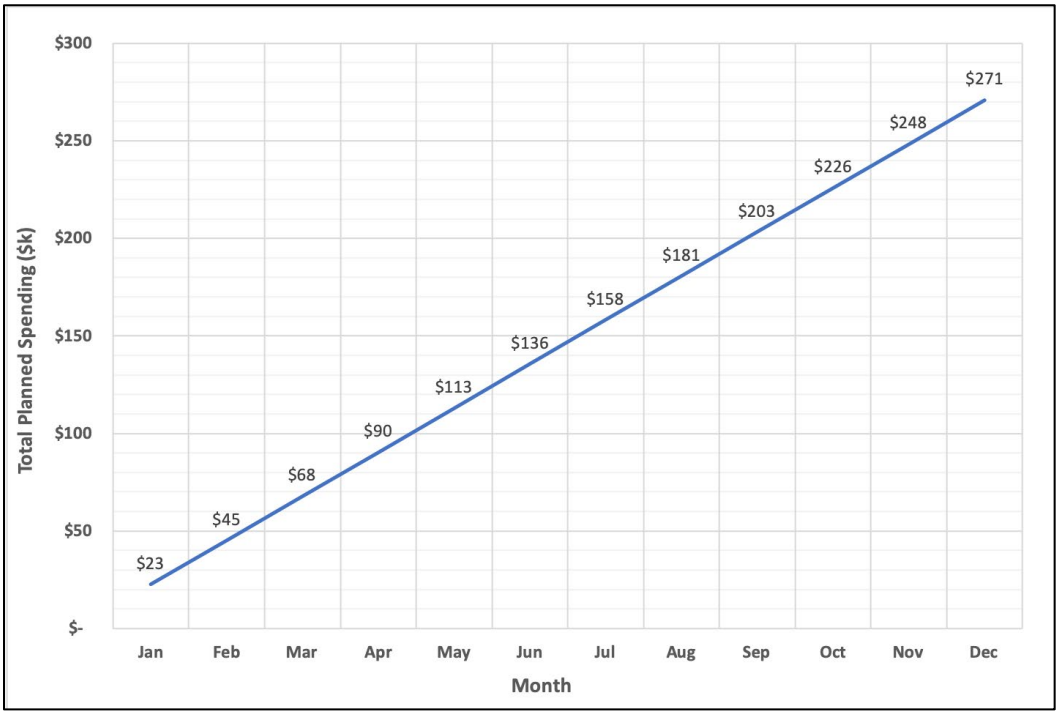
This is an ongoing approved task to provide technical support to the NCSP to ensure that NCSP cross-section evaluations are checked, processed, visualized, reviewed, archived, and made available through the National Nuclear Data Center (NNDC) GForge system as candidate evaluations for the future versions of the ENDF/B library. Maintain Atlas of Neutron Resonances as a unique resource of thermal and resonance data and their uncertainties.

Figure 2.4-3 BNL ND Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
The modest BNL budget increases from FY20 through FY24 for the BNL-ND1, "NNDC Support to the NCSP" task are due to increased costs for doing business.

Figure 2.4-4 BNL ND Planned Spending (FY2020)



BNL ND Milestones:

Occurs all 4 Quarters

- Maintain and upgrade ADVANCE code system by performing data verification of new NCSP evaluations and performing quality assurance on the data as required and provide status reports on all nuclear data support activities to the NCSP Manager. (ND1)

Quarter 3

- If mandated by CSEWG, release new ENDF library. (ND1)

2.4.2.2 Los Alamos National Laboratory (LANL)

Task Name	Task Title
LANL ND1	Nuclear Data Evaluation and Testing
Budget	**Collaborators**
$726K	IRSN (IRSN-ND2)

This is an ongoing approved task to provide differential data evaluation and covariance development in the energy region above the resonance range for heavy elements (often in partnership with resonance-range work from ORNL), and over the entire ENDF energy range for light elements. Particular focus will be on neutron fission. Perform data testing analysis with new evaluated sets. Contribute to NDAG, CSEWG, CIELO, WPEC, and IAEA CRP. The LANL nuclear data measurements and evaluations are performed in accordance with the milestone schedule in Appendix B.

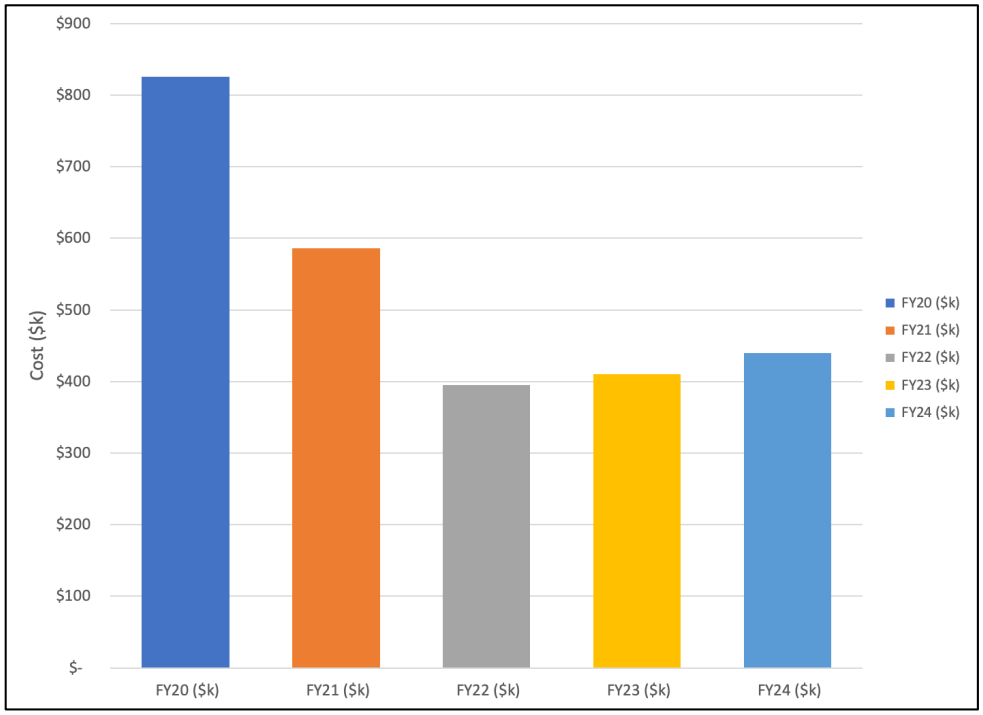
Task Name	Task Title
LANL ND2	Prompt Fission Neutron Spectra (PFNS) Measurement of Plutonium-240
Budget	**Collaborators**
$150K	None

Building upon recent improvements in measurements techniques for uranium-235, plutonium239 and uranium-238 (ongoing), this work is to measure the prompt fission neutron spectra (PFNS) for plutonium-240. This work has low technical risk, building upon previously established measurement and evaluation techniques. This work will be done using the Chi-Nu detectors at WNR, part of the LANSCE/LANL facility, with analysis carried out by a postdoc (to be hired) supervised by senior staff. Please note the Chi-Nu detectors include a liquid scintillator array for the high-energy (HE) tail and a lithium glass array for the low-energy (LE) tail with measurements performed separately.

Task Name	Task Title
LANL ND3	Unresolved and Fast Measurements of Uraunium-233 (n,gamma)
Budget	**Collaborators**
$200K	None

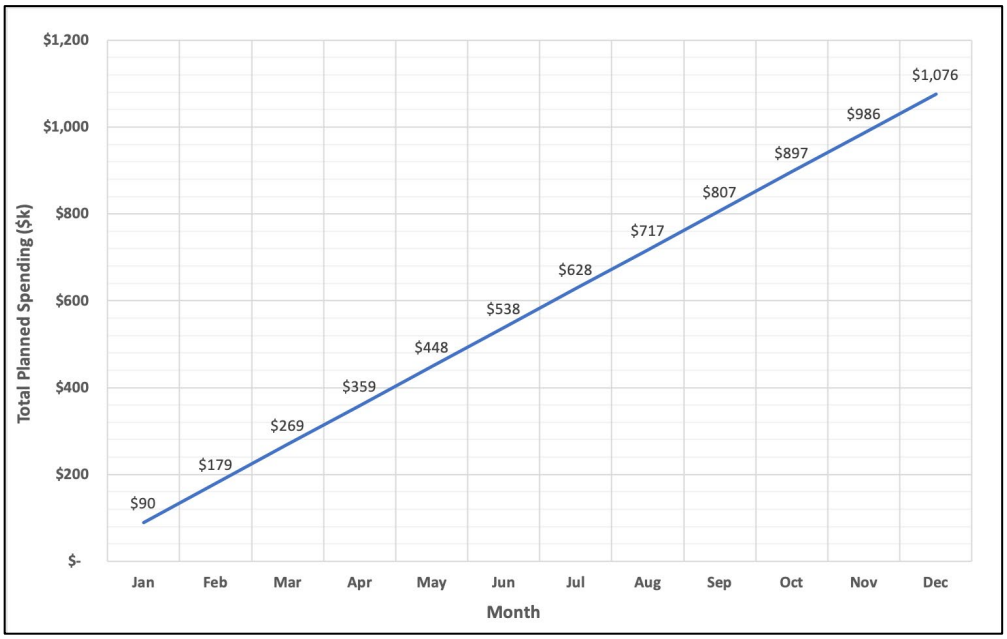
Building upon recent improvements in measurements techniques for capture cross section (and alpha, the capture to fission ratio) that have been successfully applied for U235 and Pu239, this work is to measure the uranium-233 capture cross section. This is a low-risk measurement based upon now well-established techniques that have yielded 2% uncertainties on alpha in the keV region to 10% uncertainties around 1 MeV. These measurements will complement and extend previous uranium-233 total and capture measurements at lower energies. This work will be done using the DANCE detector at the Lujan center, part of the LANSCE/LANL facility, with analysis carried out by a postdoc (to be hired) supervised by senior staff.

Figure 2.4-5 LANL ND Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
A series of LANL measurements, LANL-ND1 "Prompt Fission Neutron Spectra Measurement of ^{240}Pu" and LANL-ND2, "Unresolved and Fast Measurements of ^{233}U," begin in FY20 and end in FY22 (more than $1.6M in funding). The LANL ND budget drops significantly starting in FY23 once the measurements are completed.

Figure 2.4-6 LANL ND Planned Spending (FY2020)



LANL ND Milestones:

Occurs all 4 Quarters

- Provide status reports on LANL participation in US and International Nuclear Data collaborations. (ND1)

Quarter 1

- Conduct CSEWG Data Evaluation Committee session. (ND1)
- Report data testing results with ENDF/B-VIII.0 and additional beta release cross sections. (ND1)

Quarter 3

- Complete review of previous "thin" target U233 measurements and finalize specifications for new "thick" U233 target (ND3)

Quarter 4

- Deliver nuclear data evaluations as indicated in Appendix B of this document. (ND1)
- Acquire Pu240 PPAC target (ND2)

2.4.2.3 Lawrence Livermore National Laboratory (LLNL)

Task Name	Task Title
LLNL ND1a	Subtask 1 – Delayed Fission Gamma Multiplicity and Spectra
Budget	**Collaborators**
$43K	IRSN (IRSN-ND1)

This is an ongoing approved task (subtask 1 of 2) to work with IRSN to develop, test, and document a first principles analytic method to determine the equilibrium and time-dependent emission of delayed gammas based on event-by-event modeling of the fission process and subsequent fission product decay. This subtask supports continued data testing as new experimental data becomes available from foil activation measurements and dosimetry testing using GODIVA, FLATTOP, and other assemblies.

Task Name	Task Title
LLNL ND1b	Subtask 2 – Delayed Fission Gamma Multiplicity and Spectra
Budget	**Collaborators**
$53K	IRSN (IRSN-ND1)

This is an ongoing approved task (subtask 2 of 2) to work with IRSN to develop, test, and document a first principles analytic method to determine the equilibrium and time-dependent emission of delayed gammas based on event-by-event modeling of the fission process and subsequent fission product decay. This subtask involves issuing a report to document the technical basis of the method and data testing results.

Task Name	Task Title
LLNL ND2	Generation and Benchmarking of Thermal Neutron Scattering Cross Sections in Support of Advanced Nuclear Reactor Concepts
Budget	**Collaborators**
$72K	North Carolina State University and Naval Nuclear Laboratory

This is an ongoing approved task in collaboration with NCSU and NNL to refine and complete basic atomistic models for executing molecular dynamics simulations for the moderator materials specified in Appendix B. A potential function describing the atomistic interactions will be chosen and parameterized to reproduce its observed characteristics. Subsequently, the excitation spectrum (i.e., vibrations, rotations, etc.) will be calculated. This information will be used to develop modules in FLASHH and NJOY (if possible) to calculate the scattering law, S(α,β), and the thermal neutron scattering cross sections at temperatures of interest. The libraries produced will account for both inelastic and coherent elastic scattering, when applicable. With LLNL assistance, these S(α,β) libraries in both ENDF File 7 and ACE ("A Compact ENDF" file) formats will be tested in NCSP analytic methods using relevant criticality safety benchmarks selected from the ICSBEP Handbook. Finally, the S(α,β) libraries in ENDF File 7 will be provided to the National Nuclear Data Center at Brookhaven National Laboratory. The NR Program (NNL) will provide $75K in matching funding.

Task Name	Task Title
LLNL ND3	Development and Implementation of an Advanced and Rigorous Computational Platform for Thermal Neutron Scattering Analysis
Budget	**Collaborators**
$100K	North Carolina State University and Naval Nuclear Laboratory

This is an ongoing approved task in collaboration with NCSU and NNL to develop and refine a "next generation" computational platform for calculating thermal neutron scattering cross sections and to assist in interpreting and processing related measured data. This tool will be based on rigorous physics and will abandon all simplifications such as the incoherent, cubic and Gaussian approximations that are implemented in current computer codes. In addition, it will include the

option to accept as input phonon frequency spectra (as in the current practice), full dispersion relations (as needed to address strong coherent scattering materials such as carbon and beryllium), velocity autocorrelation functions (as the starting point for describing liquids and non-crystalline materials), and/or the van Hove correlation function (i.e., G(**r**,t)) for exact calculations of the full S(α,β) of a given material including the self and distinct components. Furthermore, advanced, physics-based S(α,β) interpolation free analysis methods will be investigated. For completeness, the code will include a generalized capability for calculating the coherent elastic scattering cross section for crystalline materials that addresses any material and structure as specified by the user. Finally, method specific formulations for estimating covariance information for the data will be explored and included. The NR Program (NNL) will provide $100K in matching funding. **(LLNL ND3 was modified from $100K to $50K (moved to LANL IE1 and LANL IE3) in FY20 5-year plan, Rev. 3) (LLNL ND3 was modified from $50K to $100K (moved from LLNL IPD1) in FY20 5-year plan, Rev. 4)**

Task Name	Task Title
LLNL ND5	Development and Implementation of a Modern Doppler Broadening Approach Including Atomic Binding Effects
Budget	**Collaborators**
$95K	North Carolina State University and Naval Nuclear Laboratory

This is an ongoing approved task in collaboration with NCSU and NNL to formulate, develop and implement a modern Doppler broadening of nuclear cross sections that abandons the free gas approximation and accounts for atomic binding effects. The NR Program (NNL) will provide $50K in matching funding. **(LLNL ND5 was modified from $95K to $45K (moved to LANL IE1 and LANL IE3) in FY20 5-year plan, Rev. 3) (LLNL ND5 was modified from $45K to $95K (moved from LLNL IPD2) in FY20 5-year plan, Rev. 4)**

Task Name	Task Title
LLNL ND6	Evaluate Neutron Radiative Capture Gamma Production in Cadmium
Budget	**Collaborators**
$48K	None

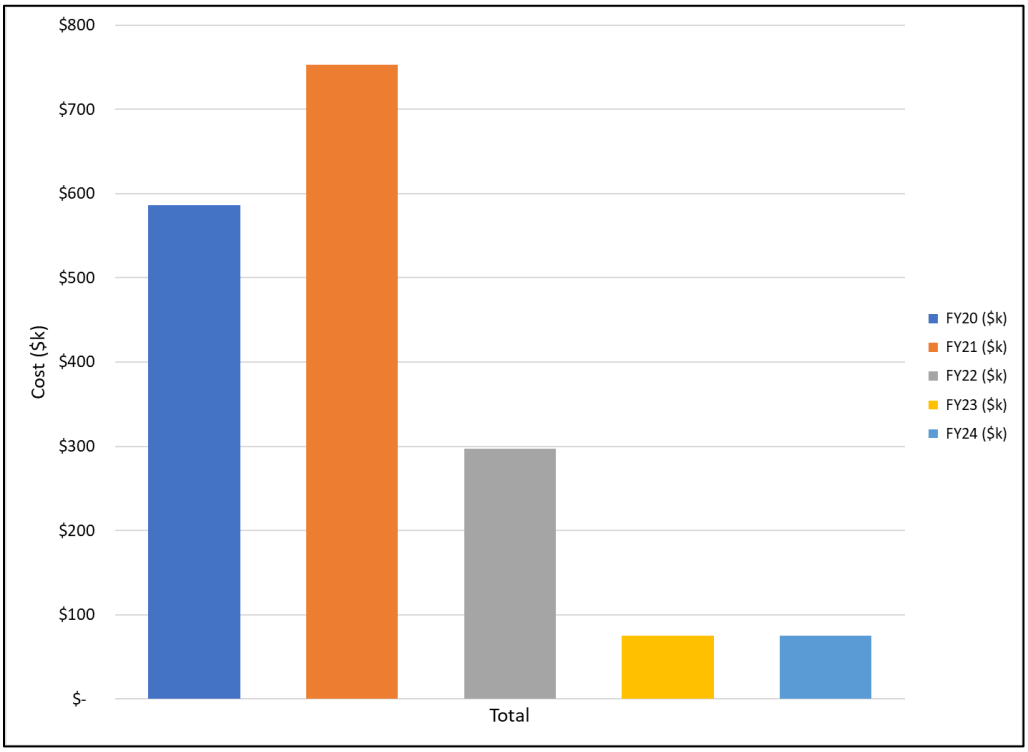
This is an ongoing approved task to evaluate available neutron radiative capture gamma production data for cadmium and revise the ENDF/B-VIII.0 evaluation to include the evaluated best values. This task also includes testing the revised evaluations for cadmium using the ICSBEP evaluation ALARM-TRAN-CH2-SHIELD-001 and providing the testing results and completed evaluation to BNL for inclusion in ENDF/B in ENDF-6 and GND formats.

Task Name	Task Title
LLNL ND7	'Alpha-N' Benchmark Measurements
Budget	**Collaborators**
$175K	None

The proposal is to utilize LLNL's hybrid neutron time-of-flight spectrometer to measure the neutron emission rate and spectrum for materials of interest. Note that this spectrometer has already been successfully used to measure the high-energy portion of the Godiva spectrum as part of IER-147. LLNL also has a number of MSA 'HEX' cans containing significant quantities of pure $^{239}PuO_2$. In FY-2019, the proposal is to modernize the data acquisition system and calibrate the spectrometer using reference mono-energetic neutron fields. In FY-2020, LLNL will deploy this instrument to measure the $^{239}PuO_2$ (α,n) and spontaneous fission neutron emission spectrum and compare the results to COG and MC21 calculated results. NNL has agreed to provide independent analysis of the proposed experiment free of charge to NCSP. If successful, a separate proposal will be developed in consultation with NNL and other laboratories to measure other materials of interest (e.g., UF_6, UF_4, PuF_4, Am-Be, Am-B, Am-Li). These are also candidates for

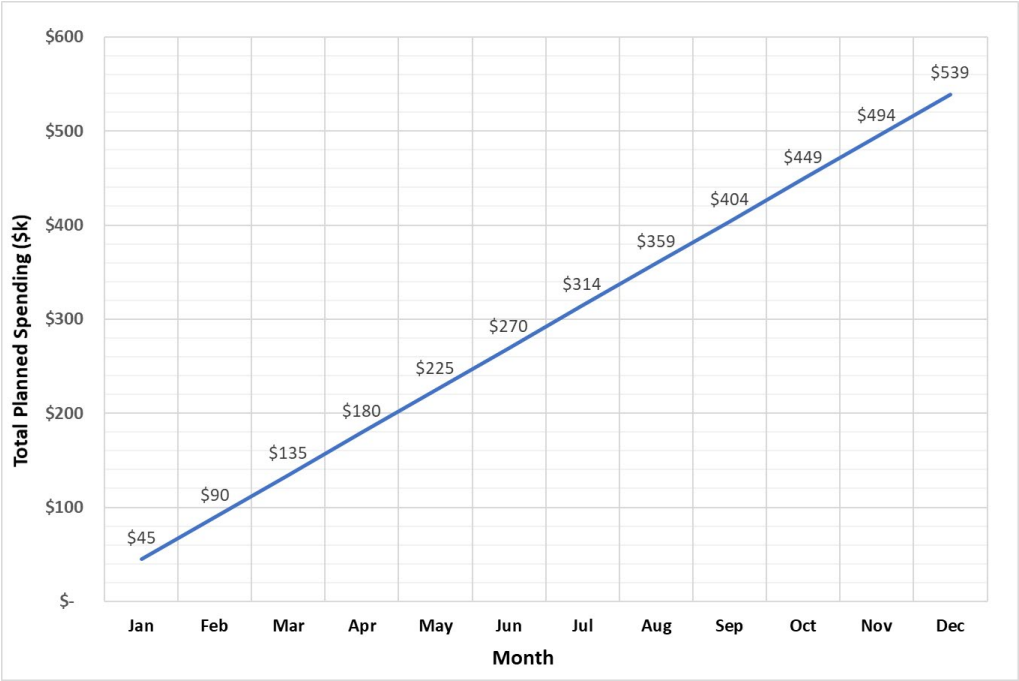
future NA-22/NP nuclear data proposals (FY-2020+) as there was considerable discussion at the recent NDREW meeting regarding the national need for such (α,n) nuclear data (measurements, evaluations, and validation benchmarks). NNL has also expressed interest in LLNL measuring a production Am-Be neutron test source as used in the fleet. This proposal furthers the ongoing collaboration between LLNL and NNL and provides fundamental nuclear reaction data needed for applications ranging from nuclear fuel burnup monitoring (NR) to probability of initiation (DP) and "alpha ratio" (NCSP, NCT). **(LLNL ND7 was modified from $175K to $75K (moved to LANL IE1 and LANL IE3) in FY20 5-year plan, Rev. 3) (LLNL ND7 was modified from $75K to $175K (moved from LLNL IPD5) in FY20 5-year plan, Rev. 4)**

Figure 2.4-7 LLNL ND Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
At LLNL, there are seven ND tasks (LLNL-ND1a/ND1b "Delayed Fission Gamma Multiplicity and Spectra," LLNL-ND3 "Development and Implementation of an Advanced and Rigorous Computational Platform for Thermal Neutron Scattering Analysis," LLNL-ND5 "Development and Implementation of a Modern Doppler Broadening Approach Including Atomic Binding Effects," LLNL-ND6 "Evaluate Neutron Radiative Capture Gamma Production in Cadmium," LLNL-ND7 "Alpha-N Benchmark Measurements," LLNL-ND8 "Study: Fission TPC Measurement of the $^{233}U/^{235}U$ (n,f) Cross Section Ratio," and LLNL-ND9 Scoping Study: Li-6 Doped Liquid Scintillator Array for Fission Correlations") that will be completed by the end of FY22 (total of $874K of funding) that results in a significant reduction in LLNL funding in by FY23.

Figure 2.4-8 LLNL ND Planned Spending (FY2020)*



* LLNL Planned Spending reduced by approximately 8% to account for required laboratory hold-back during FY CR funding uncertainty.

LLNL ND Milestones:

Occurs all 4 Quarters

- Provide status on LLNL/NCSU nuclear data activities to NCSP Manager (ND1 {subtask 1 and 2}, ND2, ND3, ND5, ND6, ND7).

Quarter 4

- Deliver thermal neutron scattering data evaluations as indicated in Appendix B of the 5-Year Plan. (ND2)

2.4.2.4 Oak Ridge National Laboratory (ORNL)

Task Name	Task Title
ORNL ND1	Nuclear Data Measurement and Evaluation
Budget	**Collaborators**
$1069K	IRSN (IRSN-ND1), JRC-Geel

Ongoing task to conduct nuclear data measurement and evaluation activities in support of the NCSP. This subtask continues to primarily focus on the resonance-region and includes cross-section measurements and the production of new cross-section evaluations with covariance data. The ORNL nuclear data measurements and evaluations are performed in accordance with the milestone schedule in Appendix B.

Task Name	Task Title
ORNL ND3	Isotopic Sample Leases to Support ND1 ND Measurements
Budget	**Collaborators**
$40K	JRC-Geel, RPI

This "task" is to separate out funding for natural and stable, isotopically enriched samples, for nuclear data measurements aligned with the priorities and schedule provided in Appendix B. The task also supports activation analysis to demonstrate the likely lease options to negotiate with DOE/SC-NP (DOE Office of Science- Nuclear Physics).

Task Name	Task Title
ORNL ND4	Thermal Neutron Total Cross Section Measurements for Improvement of Criticality Calculations and Propagation of Scattering Kernel Uncertainties
Budget	**Collaborators**
$150K	RPI (RPI-ND2)

This is an ongoing approved task in collaboration with ORNL to support the thermal Neutron Scattering Measurement for Improvement of Criticality Calculations and Propagation of Scattering Kernel Uncertainties. This task also supports the work to broaden and maintain the U.S. capabilities to support NCSP experimental nuclear data needs by providing priority NCSP thermal scattering law data. Aligns with RPI-ND2.

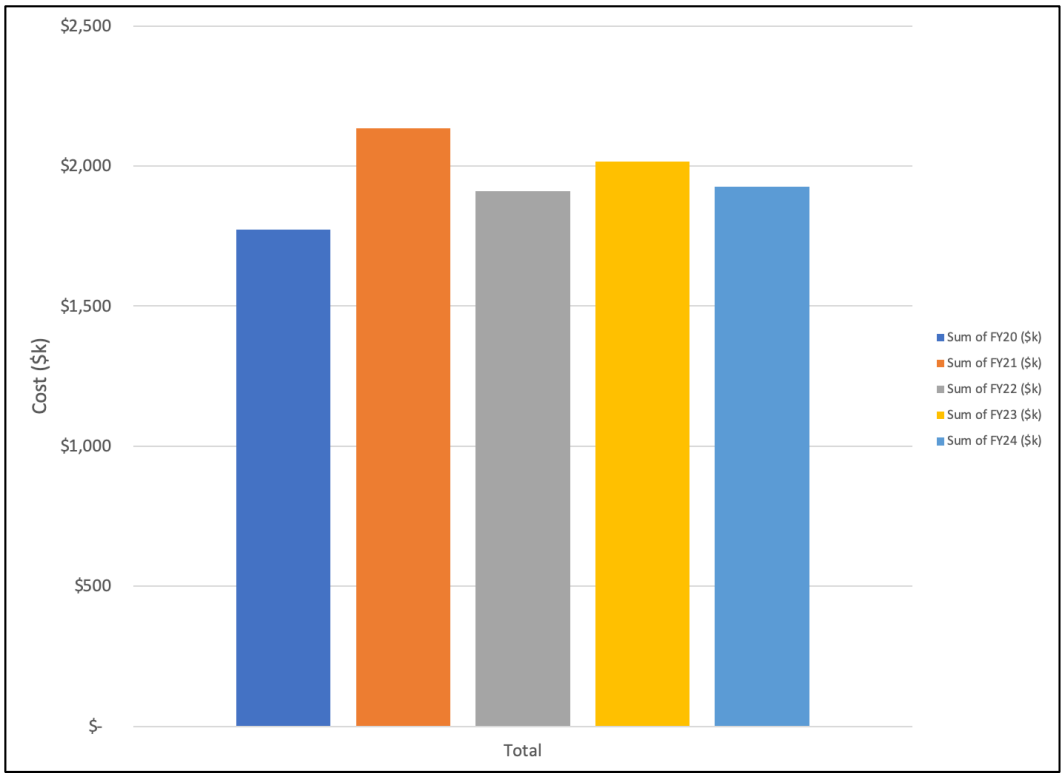
Task Name	Task Title
ORNL ND6	SAMMY Nuclear Data Evaluation Code Modernization
Budget	**Collaborators**
$382K	JRC-Geel, RPI

This a continuing task to modernize the SAMMY software that is an essential tool needed by nuclear data evaluators to analyze measured cross-section data and produce nuclear data evaluations with covariance data for the NCSP. SAMMY is primarily used to analyze differential data from the RPI Gaerttner linear accelerator, IRMM Geel Electron Linear Accelerator (GELINA), and Los Alamos Neutron Science Center (LANSCE) to produce nuclear data evaluations. An initial step toward modernization will be the merger of SAMMY under the SCALE continuous integration (CI) development framework. Once complete, SAMMY will be developed under the SCALE software quality assurance plan (SQAP) thereby providing increased confidence in the quality of the data evaluations developed and deployed by SAMMY. Once SAMMY is completely under SQA and integrated with the SCALE/AMPX CI development framework, the work will be performed to modernize SAMMY by utilizing modern computing frameworks and libraries that harness the emerging computing power of parallel architectures, and that enable a rapid development of new data analysis capabilities. The overall modernization work effort will ensure the SAMMY software is up-to-date and positioned for long-term sustainability in order to support NCSP nuclear data evaluation needs.

Task Name	Task Title
ORNL ND10	Monte Carlo Evaluation of Differential and Integral Data
Budget	**Collaborators**
$133K	None

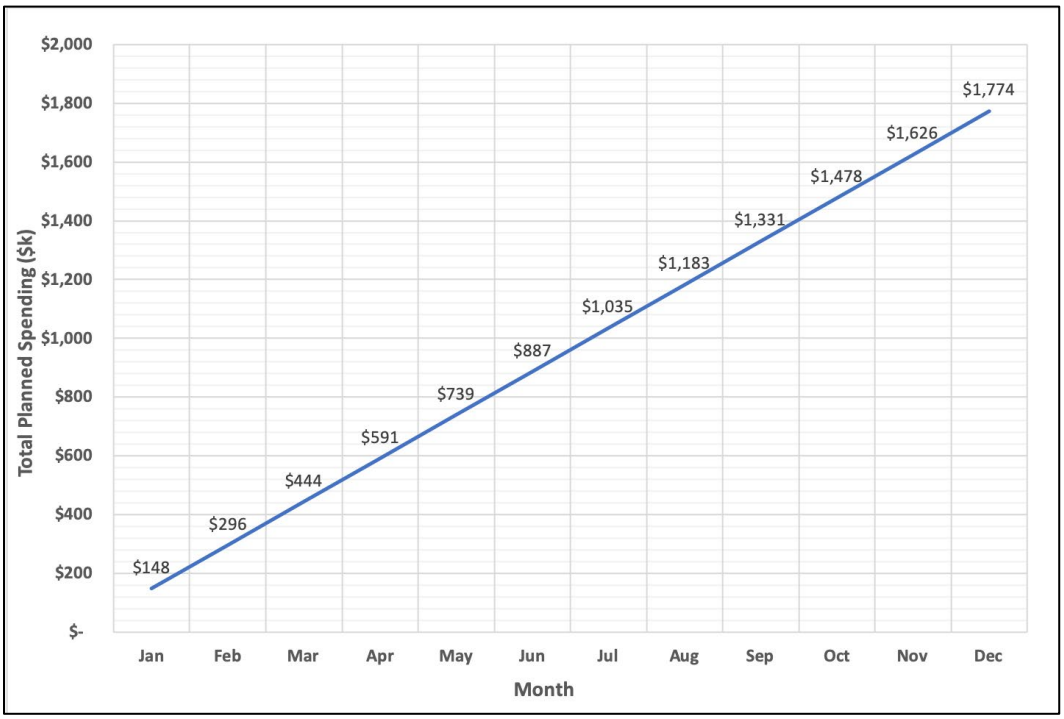
This is new work to build on ORNL's recent applications of Monte Carlo method to some of the VALID library IBEs (350), and to the Monte Carlo evaluation of thermal neutron scattering data on light water, while applying most recent advances in Bayesian Monte Carlo methods. The Monte Carlo evaluation of R-matrix resonance parameters would be leveraged by the ORNL's nuclear data evaluation code SAMMY that is being modernized in the NCSP ORNL-ND6 task. The proposed framework would complement the S/U tools in SCALE by computing response sensitivities, it would quantify the magnitude of presently neglected non-linear effects, and when used for simultaneous evaluation of differential and integral data it would obviate the need for conventional data adjustment. After this methodology is developed, it will be demonstrated on a small scale and results provided to the NCSP manager. Ultimately, if the results are successful, this task will be scaled up to the level of the proposal (FY19, proposal 35) and be used to prioritize nuclear data measurements.

Figure 2.4-9 ORNL ND Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
ORNL budgets are very stable from FY20-FY24. The increase from FY20 to FY21 is due to the initiation of ORNL-ND9, "Evaluation of Thermal and Resolved Resonance Ranges of UO_2 and PuO_2."

Figure 2.4-10 ORNL ND Planned Spending (FY2020)



ORNL ND Milestones:

Occurs all 4 Quarters

- Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND1, ND3, ND4, ND6, ND7, ND9, ND10).
- Provide status reports on ORNL participation in US and International Nuclear Data collaborations, and for foreign travel, provide a brief trip summary report to NCSP Manager on items of NCSP interest (ND1).
- Complete cross-section measurement and evaluation deliverables per the nuclear data schedule in Appendix B (ND1).

Quarter 4

- Document SAMMY modernization progress and report status annually to the NCSP Manager (ND6).

2.4.2.5 Renssalaer Polytechnic Institute (RPI)

Task Name	Task Title
RPI ND1	Resonance Region Nuclear Data Measurement Capability at RPI
Budget	**Collaborators**
$344K	None

This is an ongoing approved task in collaboration with ORNL to support the resonance region Nuclear Data Measurement Capability at RPI and to perform cross-section measurements and qualification of the new capabilities. Aligns with LANL-ND1 and ORNL-ND1 (evaluation).

Task Name	Task Title
RPI ND2	Thermal Neutron Scattering Measurement for Improvement of Criticality Calculations and Propagation of Scattering Kernel Uncertainties
Budget	**Collaborators**
$150K	None

This is an ongoing approved task in collaboration with ORNL to support the thermal Neutron Scattering Measurement for Improvement of Criticality Calculations and Propagation of Scattering Kernel Uncertainties. This task also supports the work to broaden and maintain the U.S. capabilities to support NCSP experimental nuclear data needs by providing priority NCSP thermal scattering law data. Aligns with ORNL-ND4.

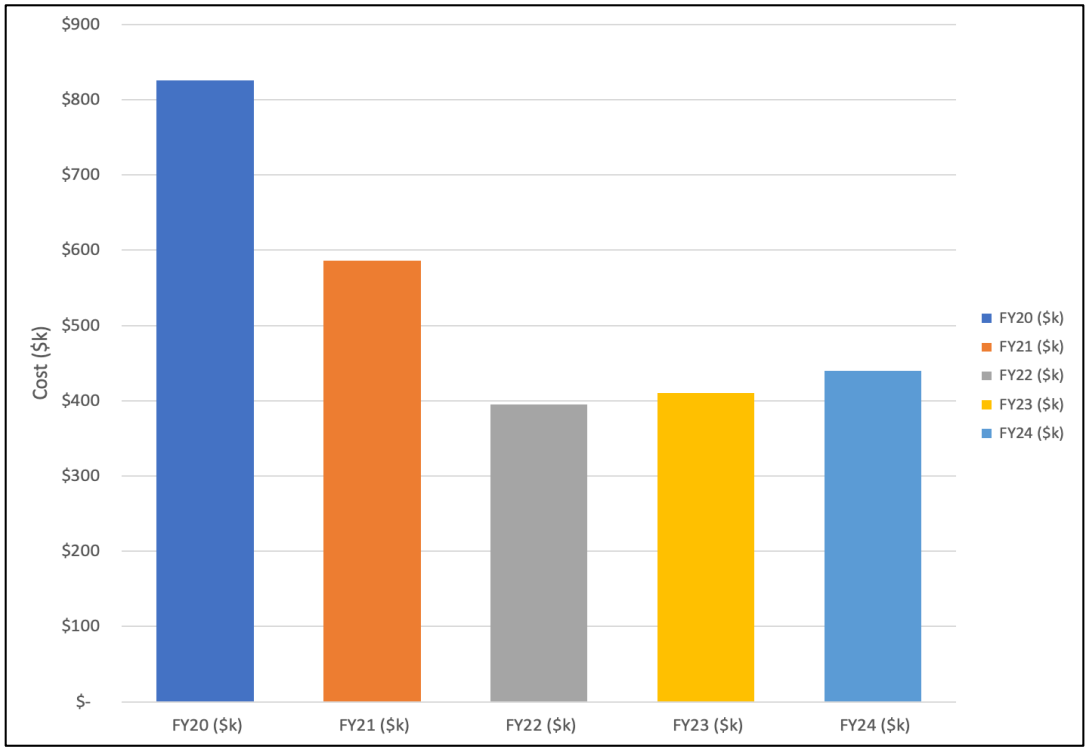
Task Name	Task Title
RPI ND3	RPI/ORNL: LINAC 2020 Nuclear Data Capabilities Maintenance Plan
Budget	**Collaborators**
$303K	Naval Nuclear Laboratory

This is an ongoing approved task to support the RPI/ORNL: Linear Accelerator (LINAC) 2020 Nuclear Data Capabilities Maintenance Plan in collaboration with Naval Reactors (NA-30) who is co funding 2/3 of the total refurbishment costs. In order to be able to continue to deliver a reliable neutron beam with the proper conditions required for these experiments, a long-term maintenance and update plan is being implemented.

Task Name	Task Title
RPI ND4	NNL – Support for NDAG Chair activities
Budget	**Collaborators**
$29K	None

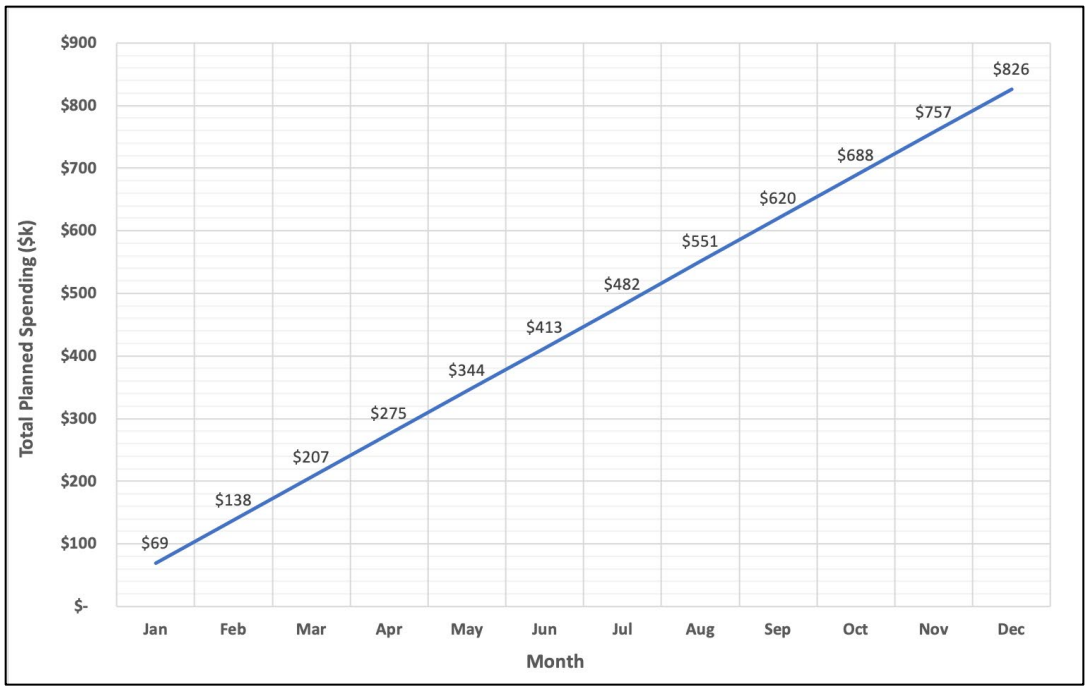
This is a ongoing RPI task for the FY20 5-year plan (new for Rev. 2). Provide support for NDAG Chair activities, participate in relevant Working Groups and domestic and international nuclear data meetings as the nuclear data lead for the NCSP, and coordinate NCSP ND element work program with current and future DOE needs. Support the development of the 5-year plan by coordinating and planning nuclear data prioritization meetings and working with the NCSP management team for tracking progress nuclear data tasks over the course of the year. *Funding will be sent to NNL and not RPI for this task.* **(Modified from NCSP TS9 in FY20 5-year plan, Rev. 2.)**

Figure 2.4-11 RPI ND Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
The completion of the RPI ND3 task, "RPI/ORNL: LINAC 2020 Nuclear Data Capabilities Maintenance Plan," for upgrading the RPI LINAC results in sharp reduction in the budget trend from FY20 to FY22 (more than $500K in funding).

Figure 2.4-12 RPI ND Planned Spending (FY2020)



RPI ND Milestones:

Occurs all 4 Quarters

- Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND1, ND2, ND3)
- Provide status reports on RPI participation in US and International Nuclear Data collaborations, and for foreign travel, provide a brief trip summary report to NCSP Manager on items of NCSP interest (ND1, ND2)

Quarter 1

- Complete analysis of measurement from FY-18 (ND1)
- Factory acceptance tests of RF Modulators 2 and 3 (ND3)

Quarter 2

- Complete cold moderator preliminary design phase (ND2)
- Delivery of RF Modulator 1 and Klystron 1 (ND3)
- Factory acceptance tests of RF Modulators 4 and 5 (ND3)

Quarter 3

- Complete transmission measurement per the nuclear data schedule in Appendix B (ND1).
- Complete capture measurement per the nuclear data schedule in Appendix B (ND1)
- Factory Acceptance test for Tapered Phase Velocity and Speed of Light #1 Accelerator Sections (ND3)

Quarter 4

- Complete data analysis for transmission and capture measurements and provide the data to ORNL as needed to support the evaluation effort per the nuclear data schedule in Appendix B (ND1)
- Complete cold moderator design (ND2)
- Delivery and of TPV and SOL1 Accelerator Sections (ND3)

2.4.2.6 Y-12 National Security Complex

Task Name	Task Title
Y12 ND1	Y-12 Fabrication of New Uranium Target for IRMM/GELINA for Cross-section Measurements
Budget	**Collaborators**
$0K (FY19 funds to be used)	IRMM

This FY2019 task involves the fabrication of a new depleted uranium/molybdenum target for IRMM/GELINA for cross section measurements. As part of the IRMM collaboration, this task will ensure continued availability of the accelerator for NCSP nuclear data measurements.

There are no ND budget items in FY2020-FY2024 to produce a budget trend or planned spending figures.

EOC – for out-year peaks and dips in budget plots:
This is not applicable.

Y-12 ND Milestones

Occurs all 4 Quarters

- As necessary, provide a status report of the fabrication of a depleted uranium/molybdenum target per IRMM/GELINA specifications to the NCSP Manager. (ND1)

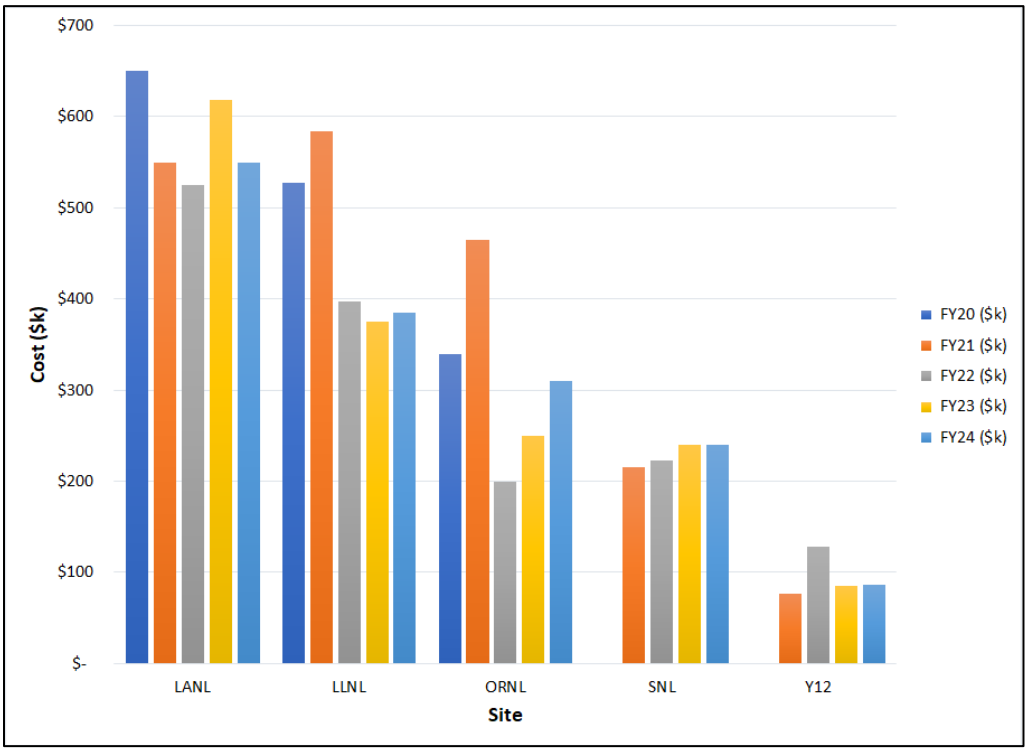
2.5 Training and Education (TE)

2.5.1 Program Element Description

The Training and Education (TE) program element continues to offer hands-on training courses as needed by DOE and identify training needs and develop training resources in areas where no suitable materials exist. The primary purpose of the TE element is to maintain the technical capabilities of criticality safety professionals and provide for the training and education of people entering the criticality safety discipline from related scientific fields. A significant portion of the TE work effort is to provide both the 2-week hands-on criticality safety courses for criticality safety engineers and 1-week hands-on criticality safety courses for supervisors and managers.

Each year, at the annual Budget Execution Meeting, the NCSP Manager will review and determine the location of the Classroom portion of the Hands-on Training course. Out-year budget profiles will be revised at that time, and funding profiles will not be increased until the location of the course is determined.

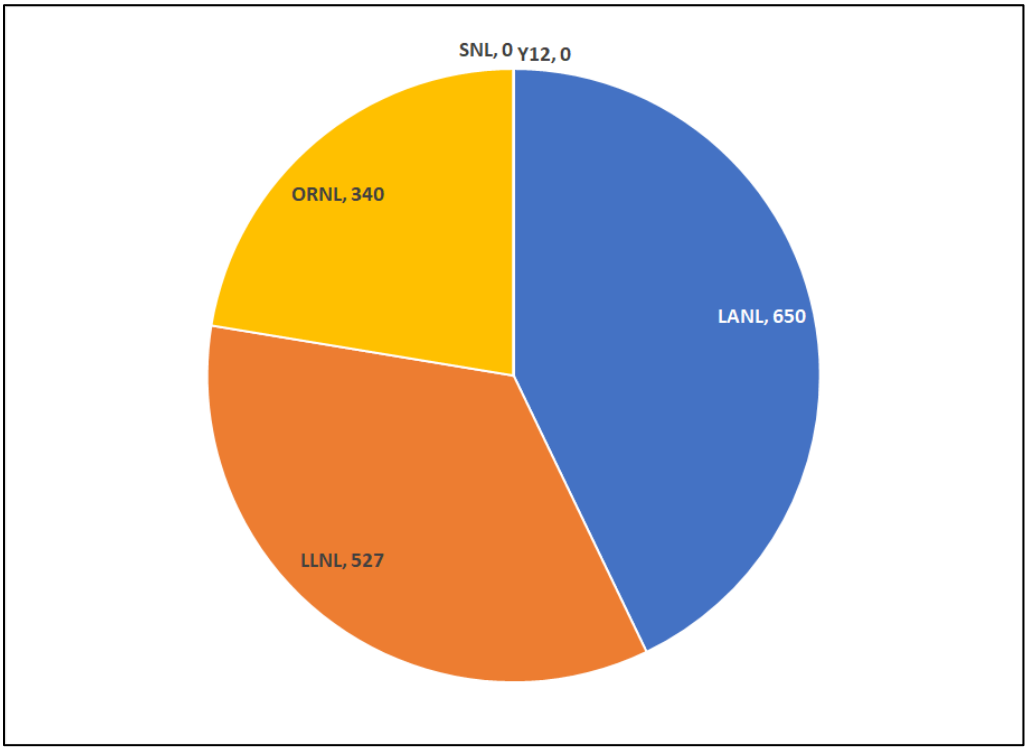
Figure 2.5-1 TE Budget (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
For LANL, there is a reduction in funding from FY20 to FY21 as a result of completing tasks LANL-TE6, "Development of a University Pipeline for Criticality Safety Professionals," and LANL-TE7 "Design and Development of a new Criticality Safety Officer Course at DOE/NNSA Facilities." The LANL budget increases in FY23 due to increases in LANL-TE3, "Conduct Hands-On Criticality Safety Training Course at NCERC," and the start of task LANL-TE5, "Criticality Safety Tutorials." For LLNL, there is a significant spike in budget in FY21 due to the start of task LLNL-TE7, "Criticality Simulator to Demonstrate Criticality Physics Fundamentals to Process Operators." After FY21, the LLNL budget decreases due to the completion of LLNL-TE7 and LLNL-TE6, "Mobile (CAT III/IV) Hands-on Critical or Near Critical Demonstration Capability"

tasks. ORNL has a budget increase in FY21 due to the initiation of tasks ORNL-TE6, "SlideRule NCSET Module," ORNL-TE7 & ORNL-TE8, "Criticality Safety Tutorials." There is a significant decrease in ORNL TE funding after FY21 due to the completion of tasks ORNL-TE3, "Hand-Calculation Primer Expansion – LA-14244-M," ORNL-TE6, ORNL-TE7, and ORNL-TE8. There is a slight increase in ORNL funding in FY23 and FY24 for an small increase ($50K in FY23) in ORNL-TE1, "Manage and Provide Instruction for the DOE Nuclear Criticality Safety Training and Education Program," and the start of task ORNL-TE11, "NDA NCSET Module," ($50K). SNL has a zero TE budget in FY20 to excessive carry over funding from FY19. In FY21, the budget levels return to a normal level, ~$220K. The Y-12 budget is essentially stable over the period FY20 to FY24.

Figure 2.5-2 TE Budget (FY2020)



2.5.2 Approved Tasks

2.5.2.1 Los Alamos National Laboratory (LANL)

Task Name	Task Title
LANL TE3	Conduct Hands-On Criticality Safety Training Course at NCERC
Budget	**Collaborators**
$425K	None

This is an ongoing approved task to conduct criticality safety hands-on training at NCERC according to an integrated schedule developed by ORNL and approved by the NCSP manager. The cost reflects a special 2-week course for Y-12.

Task Name	Task Title
LANL TE4	On-Site Introductory Training for the NCS Practitioner on Modern Approaches to Validation using Sensitivity and Uncertainty Analysis Tools
Budget	**Collaborators**
$30K	None

This is an ongoing LANL task in collaboration with ORNL to facilitate the increased usage of modern sensitivity/uncertainty (S/U) tools and practices in DOE-site validation efforts. The objective of this task is to provide a 1-day onsite introductory validation training class to multiple DOE sites that are selected by the NCSP Manager. The training will be "code agnostic" and will expand upon the 1.5-hour validation-training lecture provided in the current NCSP 2-week hands-on training class for NCS practitioners. The overarching objective is to familiarize DOE sites with the power of S/U tools for validation and help address questions/concerns for implementation of S/U tools for validation at each specific DOE site.

Task Name	Task Title
LANL TE6	Development of University Pipeline for Criticality Safety Professionals
Budget	**Collaborators**
$95K	None

Development of a University Pipeline for Criticality Safety Professionals.

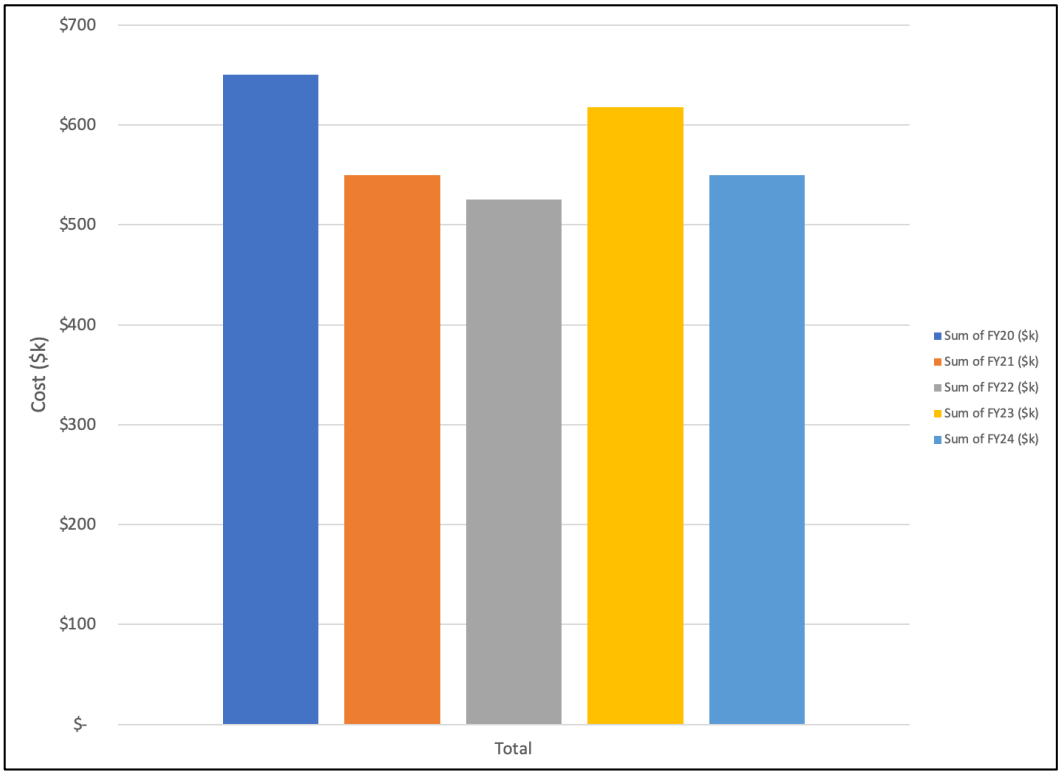
Task Name	Task Title
LANL TE7	Design and Develop a New NCSP T&E Course Criticality Safety Officers at DOE/NNSA Nuclear Facilities
Budget	**Collaborators**
$25K	ORNL (ORNL TE9), SNL (SNL TE2), LANL (LANL TE7)

At the direction of ORNL, assist as a team member in the design and development of a new NCSP TE Course for Criticality Safety Officers at DOE/NNSA Nuclear Facilities. This task will use a CSSG tasking response as a roadmap for course development.

Task Name	Task Title
LANL TE8	Reactivity Simulation Aids
Budget	**Collaborators**
$75K	None

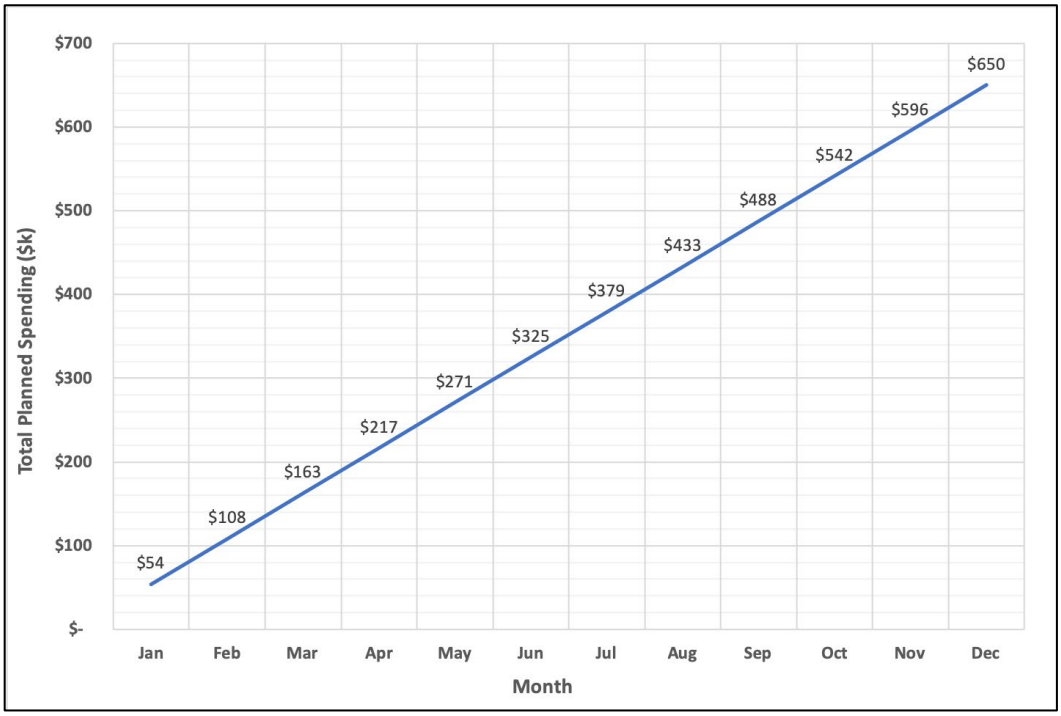
Further develop existing and new reactivity simulation aids that can be used to support the NCSP mission, along with the Training and Education (TE) simulation aid goals for the DOE Complex.

Figure 2.5-3 LANL TE Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
For LANL, there is a reduction in funding from FY20 to FY21 as a result of completing tasks LANL-TE6, "Development of a University Pipeline for Criticality Safety Professionals," and LANL-TE7 "Design and Development of a new Criticality Safety Officer Course at DOE/NNSA Facilities." The LANL budget increases in FY23 due to increases in LANL-TE3, "Conduct Hands-On Criticality Safety Training Course at NCERC," and the start of task LANL-TE5, "Criticality Safety Tutorials."

Figure 2.5-4 LANL TE Planned Spending (FY2020)



LANL TE Milestones:

Occurs all 4 Quarters

- Provide status reports on all training activities to the NCSP Manager. (TE3, TE4, TE6, TE7, TE8)

Quarter 4

- In collaboration with ORNL, provide introductory 1-day S/U workshop training to one or more DOE sites in FY20. (TE4)

2.5.2.2 Lawrence Livermore National Laboratory (LLNL)

Task Name	Task Title
LLNL TE1	Conduct Hands-on Training at the DAF (TACS)
Budget	**Collaborators**
$255K	None

This is an ongoing approved task to provide unique "hands-on" training at the Device Assembly Facility (DAF) using the Training Assembly for Criticality Safety (TACS). This task also supports continued LLNL coordination of the course registration process for all courses at NSF, NATM, NCERC and SNL. The cost reflects a special 2-week course for Y-12.

Task Name	Task Title
LLNL TE3	Classroom Criticality Safety Training
Budget	**Collaborators**
$82K	None

This is an ongoing approved task to provide LLNL support for FY2019 classroom instruction at the Nevada Site Facility and participation in T&E development activities. The cost reflects a special 2-week course for Y-12.

Task Name	Task Title
LLNL TE6	Mobile (CAT III or IV material) Hands on Critical or Near Critical Demonstration Capability
Budget	**Collaborators**
$115K	None

This new task is for a feasibility study to look at the possibility of developing a mobile CAT III or CAT IV for performing hands-on critical or near-critical operations to support NCSP training missions.

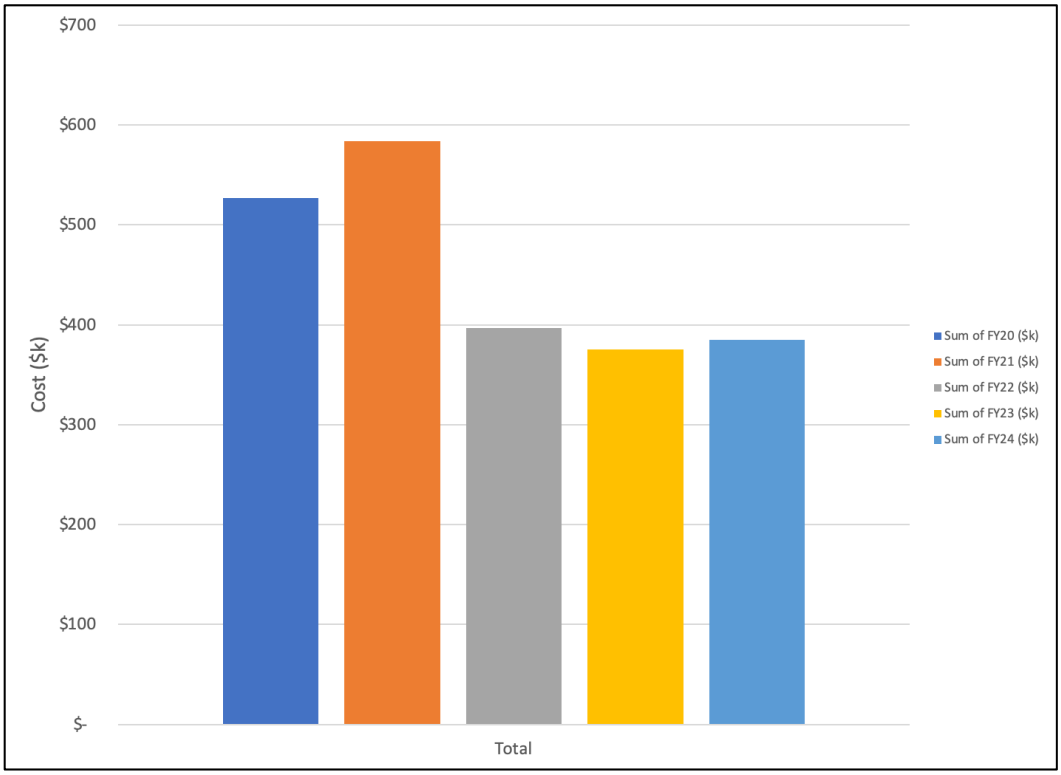
Task Name	Task Title
LLNL TE7	Criticality Simulator to Demonstrate Criticality Physics Fundamentals to Process Operators
Budget	**Collaborators**
$50K	None

This new task is for LLNL to develop a criticality simulator to demonstrate criticality physics fundamentals to process operators.

Task Name	Task Title
LLNL TE9	Design and Develop a New NCSP T&E Course for Criticality Safety Officers at DOE/NNSA Nuclear Facilities
Budget	**Collaborators**
$25K	None

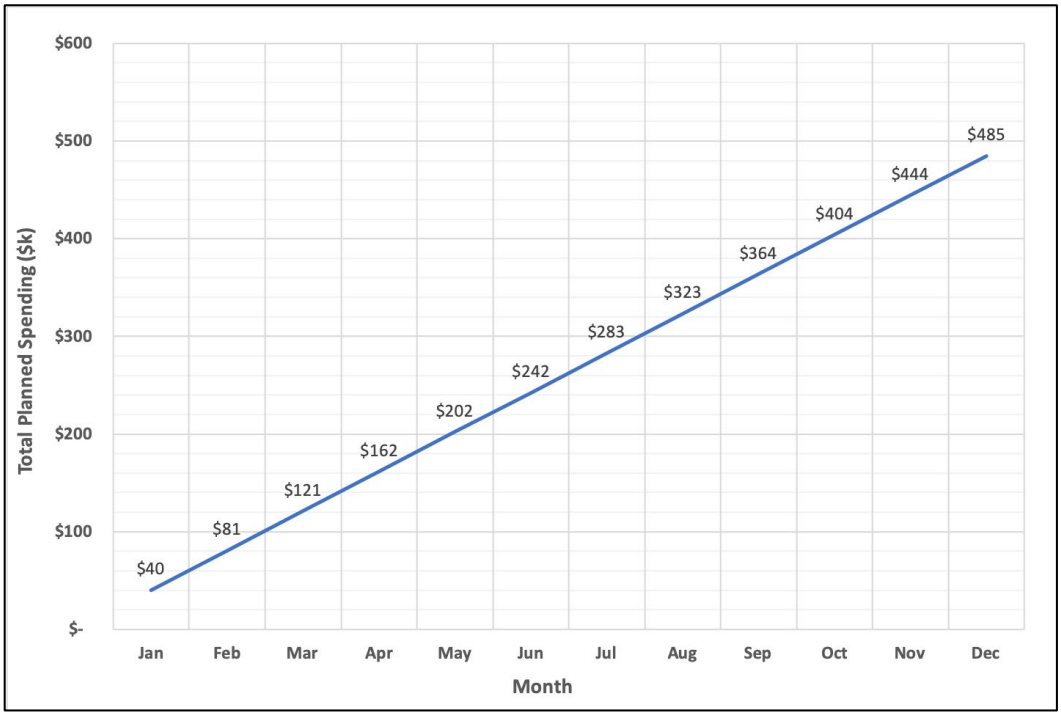
At the direction of ORNL, assist as a team member in the design and development of a new NCSP TE Course for Criticality Safety Officers at DOE/NNSA Nuclear Facilities. This task will use a CSSG tasking response as a roadmap for course development.

Figure 2.5-5 LLNL TE Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
For LLNL, there is a significant spike in budget in FY21 due to the start of task LLNL-TE7, "Criticality Simulator to Demonstrate Criticality Physics Fundamentals to Process Operators." After FY21, the LLNL budget decreases due to the completion of LLNL-TE7 and LLNL-TE6, "Mobile (CAT III/IV) Hands-on Critical or Near Critical Demonstration Capability" tasks.

Figure 2.5-6 LLNL TE Planned Spending (FY2020)*



* LLNL Planned Spending reduced by approximately 8% to account for required laboratory hold-back during FY CR funding uncertainty.

LLNL TE Milestones:

Occurs all 4 Quarters

- Update, maintain and support the registration process and provide classroom and "hands on" TACS training in accordance with the schedule approved by the NCSP Manager (TE1, TE3, TE6, TE7).
- Conduct subcritical measurements using beryllium shells and finalize training materials addressing the concept of superior reflection. (TE7)
- Provide a status report of the status of efforts to develop a new CSO/FMH course for the NCSP for piloting in FY20. (TE9)

2.5.2.3 Oak Ridge National Laboratory (ORNL)

Task Name	Task Title
ORNL TE1	Manage and Provide Instruction for the DOE Nuclear Criticality Safety Training & Education Program
Budget	**Collaborators**
$185K	IRSN (IRSN TE1), AWE (AWE TE1)

Ongoing ORNL task to manage the collaborative multi-laboratory development, designing, and scheduling of the multi-faceted and phased NCSP training program and manage the execution of the program. The task also includes support for an ORNL nondestructive assay (NDA) expert, an NCS expert, and an NCS expert with federal experience to support the 2-week hands-on and manager courses. This task will also provide leadership and support necessary to complete resolution of the CSSG Training and Education assessment conducted in FY2016 under CSSG tasking 2016-01.

Task Name	Task Title
ORNL TE3	Hand-calculation Primer Expansion, LA-14244-M
Budget	**Collaborators**
$100K	None

This task is to expand the current Hand Calculation Primer, LA-14244-M, to include new methods, examples, and to fix errors. This document will be generated as an ORNL document.

Task Name	Task Title
ORNL TE5	On-Site Introductory Training for the NCS Practitioner on Modern Approaches to Validation using Sensitivity and Uncertainty Analysis Tools
Budget	**Collaborators**
$30K	None

As part of an effort to facilitate the increased usage of modern sensitivity/uncertainty (S/U) tools and practices in DOE-site validation efforts, the objective of this task is to collaborate with LANL to provide a 1-day onsite introductory validation training class to multiple DOE sites that are selected by the NCSP Manager. The training will be "code agnostic" and will expand upon the 1.5-hour validation-training lecture provided in the current NCSP 2-week hands-on training class for NCS practitioners. The overarching objective is to familiarize DOE sites with the power of S/U tools for validation and help address questions/concerns for implementation of S/U tools for validation at each specific DOE site.

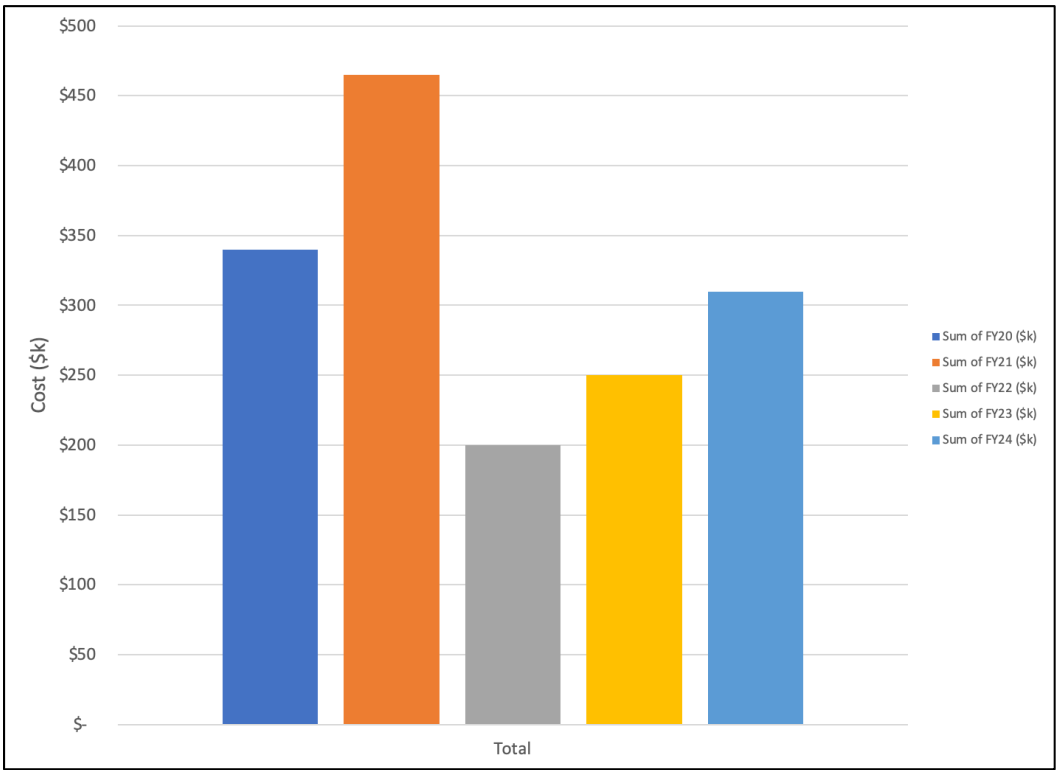
Task Name	Task Title
ORNL TE9	Design and Develop a New NCSP T&E Course for Criticality Safety Officers at DOE/NNSA Nuclear Facilities
Budget	**Collaborators**
$25K	LLNL (LLNL TE9), SNL (SNL TE2), LANL (LANL TE7)

At the direction of ORNL, assist as a team member in the design and development of a new NCSP TE Course for Criticality Safety Officers at DOE/NNSA Nuclear Facilities. This task will use a CSSG tasking response as a roadmap for course development.

Task Name	Task Title
ORNL TE10	Design of a Subcritical Assembly at ORNL for use with the CSO/FMH Courses
Budget	**Collaborators**
$0K (FY19 Carry-over)	Y12 (Y12-TE3)

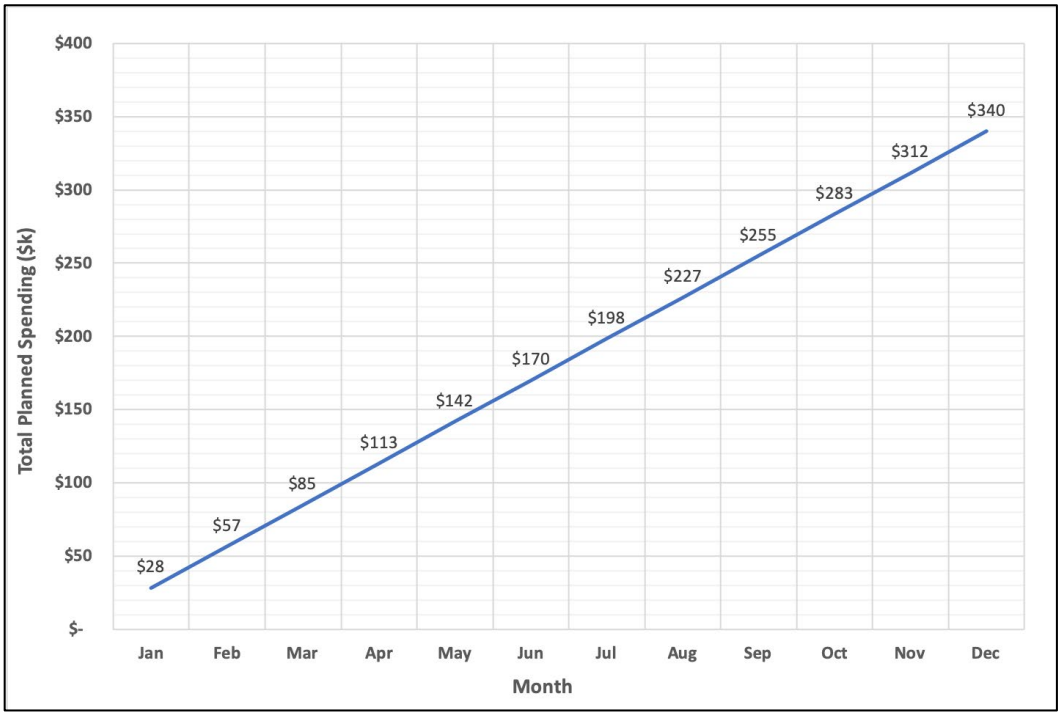
This task involves the feasibility for the design and installation of a subcritical assembly for use in the NCSP CSO training course being developed by the NCSP starting in FY2019. If feasible, this task will involve the development of a new proposal for FY20 for a detailed design and installation of a subcritical assembly at ORNL using existing resources at Y-12. This task will be finalized in FY20, as necessary, to complete the task.

Figure 2.5-6 ORNL TE Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
ORNL has a budget increase in FY21 due to the initiation of tasks ORNL-TE6, "SlideRule NCSET Module," ORNL-TE7 & ORNL-TE8, "Criticality Safety Tutorials." There is a significant decrease in ORNL TE funding after FY21 due to the completion of tasks ORNL-TE3, "Hand-Calculation Primer Expansion – LA-14244-M," ORNL-TE6, ORNL-TE7, and ORNL-TE8. There is a slight increase in ORNL funding in FY23 and FY24 for an small increase ($50K in FY23) in ORNL-TE1, "Manage and Provide Instruction for the DOE Nuclear Criticality Safety Training and Education Program," and the start of task ORNL-TE11, "NDA NCSET Module," ($50K).

Figure 2.5-7 ORNL TE Planned Spending (FY2020)



ORNL TE Milestones:

Occurs all 4 Quarters

- Provide a status report in NCSP Quarterly Progress Reports on implementation of the NCS training program and resolution of CSSG comments from CSSG tasking 2016-01. (TE1)
- Provide a status report on progress made to develop an updated Hand Calculation Primer (TE3)
- Provide a status report in NCSP Quarterly Progress Reports on the progress of 1-day onsite introductory validation training conducted at one or more DOE sites. (TE5)
- Provide a status report of the status of efforts to develop a new CSO/FMH course for the NCSP for piloting in FY20. (TE9)

Quarter 2

- Complete a feasibility report to the NCSP manager for the design and installation of a subcritical assembly at ORNL using existing resources at Y-12. If the concept is feasible, submit a proposal for consideration for FY20. (TE10)

2.5.2.4 Sandia National Laboratories (SNL)

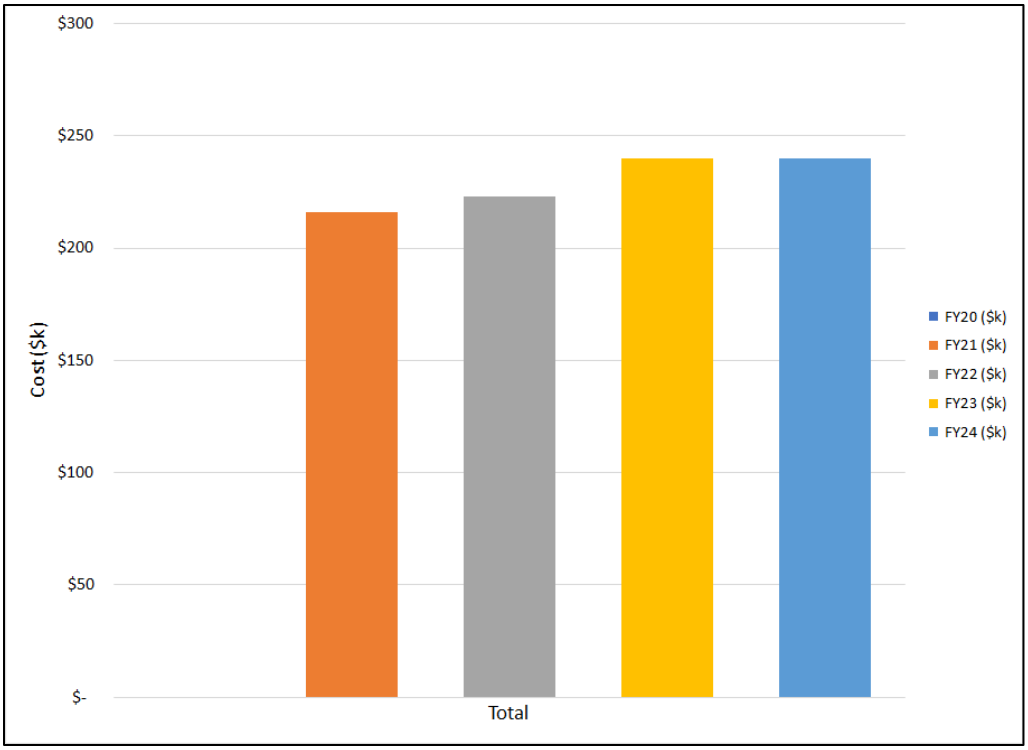
Task Name	Task Title
SNL TE1	Prepare for and Conduct Hands-on Criticality Safety Training at SNL
Budget	**Collaborators**
$0K (FY19 funds to be used)	IRSN (IRSN-TE1), AWE (AWE-TE1)

This is an ongoing approved task to conduct hands-on criticality safety training classes at SNL according to an integrated schedule developed by ORNL and approved by the NCSP Manager. Provide Human Factors and Equipment Reliability module support to the training class. Due to excessive FY19 carry over, the FY20 budget was reduced to zero.

Task Name	Task Title
SNL TE2	Design and Develop a New NCSP T&E Course Criticality Safety Officers at DOE/NNSA Nuclear Facilities
Budget	**Collaborators**
$0K	ORNL (ORNL TE9), LLNL (LLNL TE9), LANL (LANL TE7)

At the direction of ORNL, assist as a team member in the design and development of a new NCSP TE Course for Criticality Safety Officers at DOE/NNSA Nuclear Facilities. This task will use a CSSG tasking response as a roadmap for course development. **(SNL TE2 was modified from $25K to $0K (moved to LANL IE1 and LANL IE3) in FY20 5-year plan, Rev. 3)**

Figure 2.5-8 SNL TE Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
SNL has a zero TE budget in FY20 to excessive carry over funding from FY19. In FY21, the budget levels return to a normal level, ~$220K. The Y-12 budget is essentially stable over the period FY20 to FY24.

SNL T&E Milestones:

All Quarters

- Conduct hands-on training classes at Sandia and provide Human Factors and Equipment Reliability module support to the LANL training classes in accordance with the approved schedule. (TE1)
- Work with LLNL, ORNL, LANL to develop and deploy a 1-week hands-on NCSP T&E course for fissile material handlers and criticality safety officer. (TE2)

2.5.2.5 Y-12 National Security Complex

Task Name	Task Title
Y12 TE1	Conduct Hands-On Criticality Safety Training Course (Lecture support week 1 of 2-week hands-on course and course material development)
Budget	**Collaborators**
$0K (Other FY20 funding to be used to complete this task for FY20)	ORNL (ORNL TE9), LLNL (LLNL TE9), LANL (LANL TE7)

This is an ongoing integrated, approved task for Y12 to assist in conducting the current criticality safety training classes at NFO and NCERC (as necessary). This task will also involve assisting with generating new training materials at the NFO classroom portion of the course as necessary. **(Y12 TE1 was modified from $75K to $0K (moved to LANL IE1 and LANL IE3) in FY20 5-year plan, Rev. 3)**

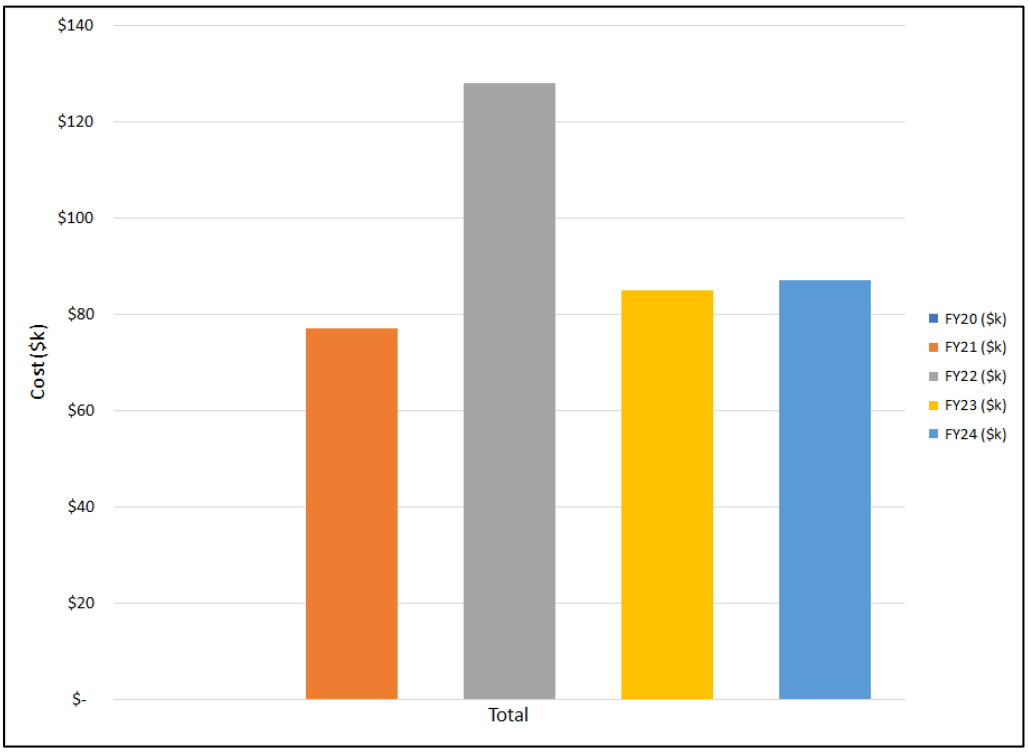
Task Name	Task Title
Y12 TE3	Design of a Subcritical Assembly at ORNL for use with the CSO Courses
Budget	**Collaborators**
$0K (FY19 Carry-over)	ORNL (ORNL TE10)

Support the task to determine the feasibility of a subcritical assembly for use in the NCSP and CSO training being designed by the NCSP in FY2019.

Task Name	Task Title
Y12 TE4	Design and Develop a New NCSP T&E Course for Criticality Safety Officers at DOE/NNSA Nuclear Facilities
Budget	**Collaborators**
$0K (Other FY20 funding to be used to complete this task for FY20)	LLNL (LLNL TE9), SNL (SNL TE2), LANL (LANL TE7)

At the direction of ORNL, assist as a team member in the design and development of a new NCSP TE Course for Criticality Safety Officers at DOE/NNSA Nuclear Facilities. This task will use a CSSG tasking response as a roadmap for course development. **(Y12 TE4 was modified from $25K to $0K (moved to LANL IE1 and LANL IE3) in FY20 5-year plan, Rev. 3)**

Figure 2.5-10 Y12 TE Budget Trend (FY2020-FY2024)



EOC – for out-year peaks and dips in budget plots:
The Y-12 budget is essentially stable over the period FY20 to FY24.

Y12 TE Milestones:

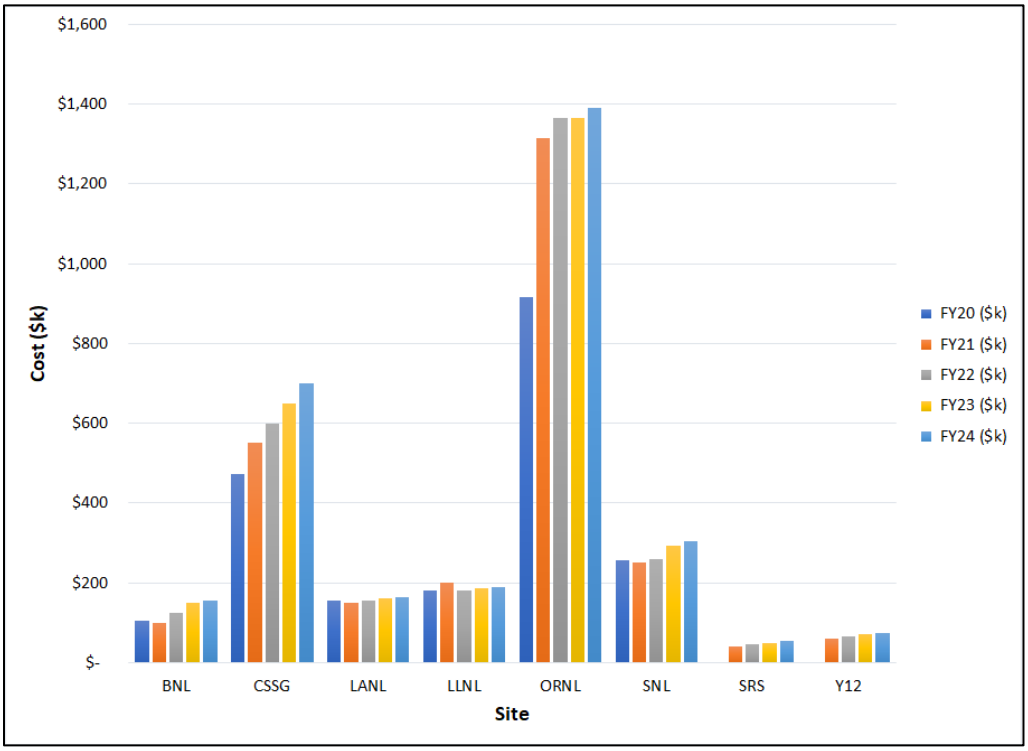
All Quarters

- Conduct hands-on training classes at NFO and NCERC to support the training classes in accordance with the approved schedule. (TE1, TE3)
- Provide a progress report on Y-12 support to ORNL for a subcritical assembly feasibility study (TE4)

3.0 NCSP Technical Support

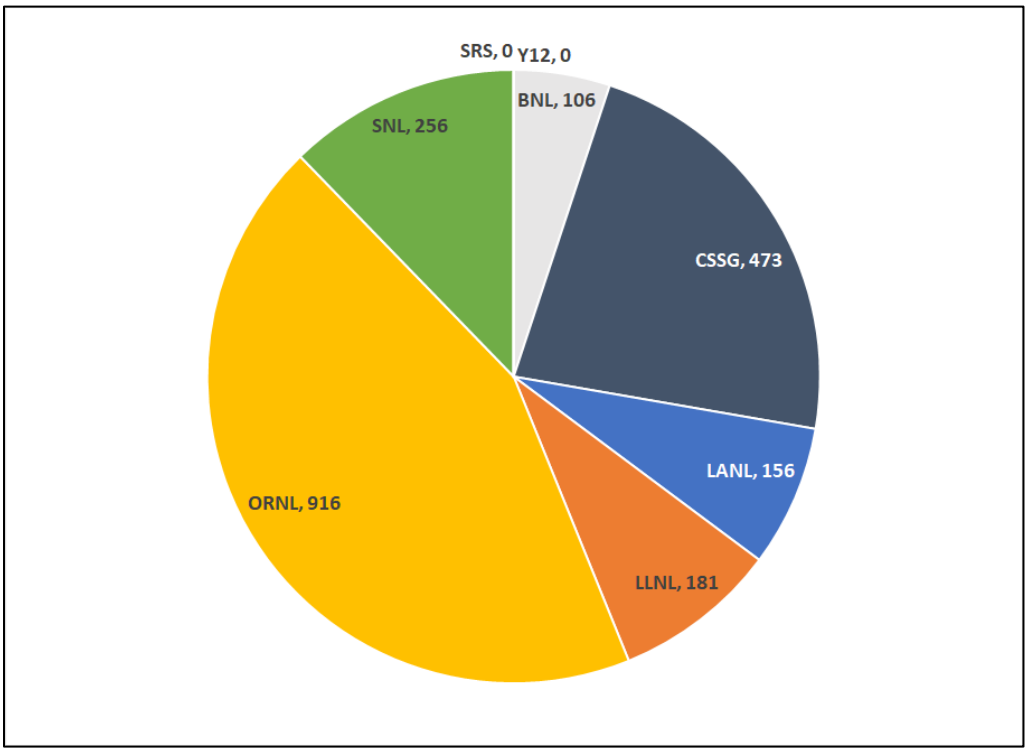
NCSP Technical Support to assist the NCSP Management Team in the program management and execution of the NCSP and funding for the succession planning of key program elements as defined in the 10-year Mission and Vision.

Figure 3.1 NCSP Technical Support (FY2020-FY2024) - by Laboratory



EOC – for out-year peaks and dips in budget plots:
The TS budgets are stable for BNL, LANL, LLNL, SNL, SRS, and Y12. The CSSG budget increases each year based on tasking estimates and could change to more steady budgets in the outyears. For ORNL, the NCSP budget has been increased to fund the ORNL-TS13, "NDA Technical Support Group and NDA Technical Infrastructure Project." In FY20, the funding for ORNL-TS13 was slated to be $250K; however, Nuclear Safety Research and Development funds from FY18 and FY19 are sufficient to fund FY20 activities, so the FY20 allocation is $0K. Starting in FY21, ORNL-TS13 will be fully funded at $250K into the outyears.

Figure 3.2 NCSP Technical Support (FY2020-FY2024) - by Laboratory



Task Name	Task Title
NCSP TS1	CSSG – Support for the Criticality Safety Support Group
Budget	**Collaborators**
$473K	None
Site	**CSSG Member Site Budget Distribution**
NCSP MGR	$0K
ANL	$0K (FY2019 funds available)
DOE-EM	$0K
LANL	$60K
	$65K
LLNL	$50K
ORNL	$35K
	$35K
	$60K
	$5K
	$30K
	$83K **(Rev. 3 – moved $33K from NCSP MGR to ORNL)**
SRS	$50K

The CSSG is comprised of recognized criticality safety experts from DOE offices and contractor organizations. The primary function of the CSSG is to provide operational and technical expertise to the DOE through the NCSP Manager. The CSSG also provides the NCSP Manager with technical reviews of orders, standards, rules, and guides issued by DOE related to criticality safety. In addition, the CSSG responds to requests from the NCSP Manager for information, technical reviews, and evaluations of criticality safety issues throughout the complex. There are normally 10 CSSG members (periodically there could be additional members in order to support new member transition and overlap). Only contractor members of the CSSG are modestly funded. One CSSG member is funded by DOE-EM. This is an ongoing approved task to provide Technical

Support as tasked by NCSP Manager through approved CSSG Taskings as documented and provided on the NCSP Website. **(Modified from NCSP TS1 in FY20 5-year plan, Rev. 3.)**

Task Name	Task Title
NCSP TS2	ORNL – Support for Lead Lab to Execute the NCSP
Budget	**Collaborators**
$660K	None

Ongoing ORNL task to support the NCSP Management Team in the program management and execution of the NCSP.

Task Name	Task Title
NCSP TS3	SNL – Support for Experimentalist Succession Planning
Budget	**Collaborators**
$81K	None

In accordance with the ten-year Mission and Vision, the NCSP has identified the need to develop and implement succession plans for key staff expert capabilities to support continued execution of the NCSP Mission. At SNL, there is a need to maintain the integral experiment expertise using the SNL critical experiment capabilities. The work associated with this task is to develop and execute IE Succession Planning for new experimentalists at SNL.

Task Name	Task Title
NCSP TS4	LANL – AM, IE, ND Succession Planning
Budget	**Collaborators**
$156K	None

In accordance with the ten-year Mission and Vision, the NCSP has identified the need to develop and implement succession plans for key staff expert capabilities to support continued execution of the NCSP Mission. There is a need to maintain expertise in the analytical methods, integral experiments and nuclear data capabilities that currently exist at LANL. The work associated with this task is to develop and execute AM, IE, and ND Succession Planning at LANL as defined in the NCSP Mission and Vision document for cross-section processing developers, radiation transport methods developers, experimentalists, and nuclear data evaluators.

Task Name	Task Title
NCSP TS5	LLNL – AM, IE, ND Succession Planning
Budget	**Collaborators**
$156K	None

In accordance with the ten-year Mission and Vision, the NCSP has identified the need to develop and implement succession plans for key staff expert capabilities to support continued execution of the NCSP Mission. There is a need to maintain expertise in the analytical methods and integral experiment capabilities that currently exist at LLNL. The work associated with this task is to develop and execute AM and IE Succession Planning at LLNL as defined in the NCSP Mission and Vision document for integral experiment equipment Support, facility support, and radiation transport methods developers.

Task Name	Task Title
NCSP TS6	BNL – ND Succession Planning
Budget	**Collaborators**
$106K	None

In accordance with the ten-year Mission and Vision, the NCSP has identified the need to develop and implement succession plans for key staff expert capabilities to support continued execution of the NCSP Mission. There is a need to maintain expertise in the nuclear data analysis capabilities that currently exist at BNL. The work associated with this task is to develop and execute ND Succession Planning at BNL as defined in the NCSP Mission and Vision document for nuclear data analysis capabilities needed to support operations at the National Nuclear Data Center.

Task Name	Task Title
NCSP TS7	ORNL – AM, ND Succession Planning
Budget	**Collaborators**
$156K	None

Task to address key nuclear data and analytical methods succession planning needs for the NCSP. As part of this task, junior ORNL staff (e.g., post-doctoral staff member or entry-level staff member) will work with key ORNL ND and AM specialists to complete NCSP ND and AM work tasks thereby training the next generation of experts to perform key NCSP nuclear data and analytical methods tasks.

Task Name	Task Title
NCSP TS8	ORNL – NCSP Program Management Tools Development
Budget	**Collaborators**
$100K	None

This task continues work initiated in FY2017 to develop a program management tool that will improve the overall efficiency of managing the NCSP. Conceptual planning for this new system is currently underway. Specifically, the tool will streamline the tasks to develop the NCSP Five Year Plan as well as manage and track the annual site work tasks, especially integral experiment tasks. As a longer-term objective, an additional task is proposed to develop a NCSP management tool to streamline management and tracking of NCSP IE tasks and machine schedule availability at NCERC.

NCSP TS9 – deleted. NCSP TS9 was converted to RPI ND4 (**FY20 5-year plan, Rev. 2**).

Task Name	Task Title
NCSP TS11	ORNL – NCSP CEdT Manager Support
Budget	**Collaborators**
$0K (Other FY20 funding to be used to complete this task for FY20)	None

Activities for this task include integral experiment request (IER) tracking, experimental facility metrics, C_EdT duties, Work for Others tracking/approval, keeping the NCSP management team informed about DAF NCSP activities, 5YP IE plan support, working with task MGRs to submit BCR forms, conduct integral experiment (IE) telecons to track IE NCSP work, availability of NCERC and Sandia critical assemblies for NCSP work, and other tasks at the discretion of NCSP manager or execution manager. **(NCSP TS11 was modified from $50K to $0K (moved to ORNL-IE4) FY20 5-year plan, Rev. 3.)**

Task Name	Task Title
NCSP TS12	Sandia – NCSP C_EdT Manager Support
Budget	**Collaborators**
$175K	None

Activities for this task include integral experiment request (IER) tracking, experimental facility metrics, C_EdT duties, Work for Others tracking/approval, keeping the NCSP management team informed about DAF NCSP activities, 5YP IE plan support, working with task MGRs to submit BCR forms, conduct integral experiment (IE) telecons to track IE NCSP work, availability of NCERC and Sandia critical assemblies for NCSP work, and other tasks at the discretion of NCSP manager or execution manager. These funds support the transition of the C_EdT Manager role from ORNL to Sandia from FY2019 mid-Quarter 2 to the end of the fiscal year.

Task Name	Task Title
NCSP TS13	NDA Technical Support Group and NDA Technical Infrastructure Project
Budget	**Collaborators**
$0K (FY19 NSR&D Funds to be Used in FY20)	None

This task involves the creation of an NDA program Mission and Vision document and 5-year plan to initiate a new federal program to resolve criticality safety issues related to fissionable material holdup and other issues related to NDA technology for NCS purposes. A DOE standard, development of ANSI/ANS-8.28 standard for NDA NCS administrative practices, and support for the NDA Technical Support Group (TSG). Sites involved currently are ORNL, SRS, and Y-12. LLNL is currently helping with NDA website development.

Task Name	Task Title
NCSP TS14	Y-12 - NDA Technical Support Group and NDA Technical Infrastructure Project
Budget	**Collaborators**
$0K (FY19 NSR&D Funds to be Used in FY20)	None

This task involves the creation of an NDA program Mission and Vision document and 5-year plan to initiate a new federal program to resolve criticality safety issues related to fissionable material holdup and other issues related to NDA technology for NCS purposes. A DOE standard, development of ANSI/ANS-8.28 standard for NDA NCS administrative practices, and support for the NDA Technical Support Group (TSG). Sites involved currently are ORNL, SRS, and Y-12.

Task Name	Task Title
NCSP TS15	SRS - NDA Technical Support Group and NDA Technical Infrastructure Project
Budget	**Collaborators**
$0K (FY19 NSR&D Funds to be Used in FY20)	None

This task involves the creation of an NDA program Mission and Vision document and 5-year plan to initiate a new federal program to resolve criticality safety issues related to fissionable material holdup and other issues related to NDA technology for NCS purposes. A DOE standard, development of ANSI/ANS-8.28 standard for NDA NCS administrative practices, and support for the NDA Technical Support Group (TSG). Sites involved currently are ORNL, SRS (TSG Chair), and Y-12.

Task Name	Task Title
NCSP TS16	LLNL - NDA Website Support
Budget	**Collaborators**
$25K	None

This task is to provide support for the new NDA website that went online in FY19. Extensive updates to the website are envisioned to support NDA program development.

NCSP TS Milestones:

Occurs all 4 Quarters

- Provide the NCSP manager with a summary of CSSG activities, meetings, and tasks. (TS1)
- Manage C_EdT process and coordinate execution of planned IERs each FY. (TS2)
- Maintain up-to-date spreadsheet of proposed tasks for NCSP Manager after the NCSP proposal review meeting and through the final task prioritization effort by the NCSP Management Team. (TS2)
- Provide NCSP Manager a status report of progress on the development of a program management tool. (TS8)
- Provide the NCSP manager with a summary of NDAG chair activities, meetings, and tasks. (TS9)
- Provide the NCSP manager with a summary of NCSP CEdT support. (TS11, TS12)
- Provide the NCSP manager an update of NDA Technical Support Group and NDA Technical Infrastructure Project activities. (TS13, TS14, TS15)
- Provide the NCSP manager with a summary of NDA Website support (TS16).

Quarter 4

- Participate in Q4 Budget Execution Meeting and assist NCSP Manager in finalization of approved tasks for next FY. (TS2)
- Publish final Five-Year Plan. (TS2)
- Provide NCSP Manager annual report of succession planning efforts. (TS3, TS4, TS5, TS6, and TS7)

Appendix A

Work Authorization Statements for Nuclear Criticality Safety Program Funding for Execution Year FY2020 Provided to the NA-50 Budget Office in August 2019

Brookhaven National Laboratory (BNL): $427K
Task: Nuclear Data

Reflects funds to continue supporting nuclear data activities, including shepherding new data evaluations through the Cross-Section Evaluation Working Group (CSEWG) process, subsequent publication of these data in the United States Evaluated Nuclear Data File (ENDF), and nuclear data succession planning, as delineated in the Nuclear Criticality Safety Program (NCSP) FY20 Five-Year Plan dated October 2019, or as directed by the NCSP Manager.

BNL POC: David Brown (631-344-2814), dbrown@bnl.gov
DOE POC: Angela Chambers, NNSA (806-573-6407), Angela.Chambers@nnsa.doe.gov

Los Alamos National Laboratory (LANL): $12,683K
Tasks: Analytical Methods, Integral Experiments, Nuclear Data, Training and Education, and the Criticality Safety Support Group

Reflects funds to continue analytical methods; integral experiments; nuclear data; and training and education support, as delineated in the Nuclear Criticality Safety Program (NCSP) FY20 Five-Year Plan dated October 2019, or as directed by the NCSP Manager; succession planning for cross-section processing developers, radiation transport developers, experimentalists, and/or nuclear data developers/evaluators; and for participation in the Criticality Safety Support Group (CSSG), as it provides technical support to the NCSP Manager regarding planning and execution of the NCSP. **(LANL funding was increased by $1 million to be split 50/50 between LANL IE1 and IE3 tasks FY20 5-year plan, Rev. 3.)**

LANL POC: Brian Bluhm (505-667-2440), bkb@lanl.gov
DOE POC: Angela Chambers, NNSA (806-573-6407), Angela.Chambers@nnsa.doe.gov

Lawrence Livermore National Laboratory (LLNL): $3987K
Tasks: Analytical Methods, Information Preservation and Dissemination, Integral Experiments, Nuclear Data, Training and Education, and the Criticality Safety Support Group

Reflects funds to continue support for analytical methods; information preservation and dissemination; integral experiments; nuclear data; training and education, as delineated in the Nuclear Criticality Safety Program (NCSP) FY20 Five-Year Plan dated October 2019, or as directed by the NCSP Manager; succession planning for equipment support, facility support, and/or radiation transport developers; and for participation in the Criticality Safety Support Group (CSSG), as it provides technical support to the NCSP Manager regarding planning and execution of the NCSP. **(LLNL funding was decreased by $200K to be split 50/50 between LANL IE1 and IE3 tasks FY20 5-year plan, Rev. 3) (LLNL funding was modified by moving $200K from LLNL IPD tasks into LLNL ND tasks FY20 5-year plan, Rev. 4)**

LLNL POC: David Heinrichs (925-424-5679), heinrichs1@llnl.gov

DOE POC: Angela Chambers, NNSA (806-573-6407), Angela.Chambers@nnsa.doe.gov

Mission Support & Test Services (MSTS): $3,735K
Task: Integral Experiments, Analytical Methods, and Nuclear Data Support

Reflects funds to continue support for integral experiments, nuclear data, analytical methods tasks as delineated in the Nuclear Criticality Safety Program (NCSP) FY20 Five-Year Plan dated August 2019.

MSTS POC: Sylvia Wright-Reader (702-2950597), WrightSD@nv.doe.gov
DOE POC: Angela Chambers, NNSA (806-573-6407), Angela.Chambers@nnsa.doe.gov

Oak Ridge National Laboratory (ORNL): $6,049K
Tasks: NCSP Technical Support, Analytical Methods, Information Preservation and Dissemination, Integral Experiments, Nuclear Data, and Training and Education

Reflects funds to continue support for analytical methods; information preservation and dissemination; integral experiments; nuclear data; and training and education, as delineated in the Nuclear Criticality Safety Program (NCSP) FY20 Five-Year Plan dated August 2019, or as directed by the NCSP Manager; Technical Support for NCSP management; and for succession planning for cross-section processing developers, radiation transport developers, and/or nuclear data evaluators/experimentalists/developers, and for support to the Criticality Safety Support Group (CSSG). **(ORNL funding was increased by $33K for ORNL CSSG work FY20 5-year plan, Rev. 3.)**

ORNL POC: Douglas G. Bowen (865-576-0315), bowendg@ornl.gov
DOE POC: Angela Chambers, NNSA (806-573-6407), Angela.Chambers@nnsa.doe.gov

Renssalaer Polytechnic Institute (RPI): ($797K) and NDAG Chair at NNL ($29K) – $826K total
Task: Nuclear Data and NDAG Support at NNL

Reflects funds to conduct differential measurements as delineated in the Nuclear Criticality Safety Execution (NCSP) FY20 Five-Year Plan dated August 2019 and continue work, as defined in the RPI LINAC 2020 Nuclear Data Capabilities Maintenance Plan, or as directed by the NCSP Manager. Funds will be sent to the NNL M&O partner, Fluor Marine Propulsion (FMP).

RPI Funds for ND tasks - $797K.
NDAG Chair funds for Mike Zerkle at NNL - $29K.

RPI POC: Yaron Danon (518-276-4008), danony@rpi.edu
NNL POC: Tim Trumble (518-395-5203), timothy.trumbull@unnpp.gov
DOE POC: Angela Chambers, NNSA (806-573-6407), Angela.Chambers@nnsa.doe.gov

Washington River Protection Services (WRPS)/Richland Operations Office (RL): $25K
Tasks: Integral Experiments Design Support in Collaboration with LLNL

Reflects funds to assist LLNL with experimental design of IER 519, "Thermal/Epithermal Experiments (TEX) Pu with Absorbers to Provide Validation Benchmarks for Hanford Tank Farms," as described in the NCSP integral experiment section of the 5-year plan. WRPS will provide calculational and technical support of the TEX-Pu with Fe and Mn absorbers design to ensure the experiments will address the validation needs of the Hanford Tank Farms.

WRPS POC: Alyssa Kersting (509-376-6354), alyssa_r_kersting@rl.gov
LLNL POC: Catherine Percher (925-423-9345), percher1@llnl.gov

Sandia National Laboratories (SNL): $769K
Tasks: Integral Experiments and Training and Education

Reflects funds to continue support for integral experiments; training and education; CEdT Manager Support, and succession planning for experimentalists as, delineated in the Nuclear Criticality Safety Program (NCSP) FY20 Five-Year Plan or as directed by the NCSP Manager. **(SNL funding was decreased by $500K to be split 50/50 between LANL IE1 and IE3 tasks FY20 5-year plan, Rev. 3.)**

SNL POC: Gary Harms (505-845-3244), gaharms@sandia.gov
DOE POC: Angela Chambers, NNSA (806-573-6407), Angela.Chambers@nnsa.doe.gov

Savannah River Site (SRS): $98K
Tasks: Information Preservation and Dissemination and the Criticality Safety Support Group

Reflects funds to update and maintain ARH-600 as delineated in the Nuclear Criticality Safety Program (NCSP) FY20 Five-Year Plan dated August 2019, or as directed by the NCSP Manager, and to continue support as the CSSG Chair during FY20, as directed by the NCSP Manager and for participation in the CSSG, as it provides technical support to the NCSP Manager regarding planning and execution of the NCSP.

SRS POC: David Erickson (803-557-9445), david.erickson@srs.gov
DOE POC: Angela Chambers, NNSA (806-573-6407), Angela.Chambers@nnsa.doe.gov

Y-12 National Security Complex (Y-12): $25K
Tasks: Training and Education, Nuclear Data, and the Criticality Safety Support Group

Reflects funds to support the training and education program, the fabrication of a uranium target needed for nuclear data measurements, the design of integral experiments involving systems with enriched uranium, chlorine, and lithium-6, and the study of a solution reactor design in collaboration with IRSN, as delineated in the Nuclear Criticality Safety Program (NCSP) FY20 Five-Year Plan dated August 2019, or as directed by the NCSP Manager. Further, an additional task is funded for general NCSP and CSSG support, as required. **(Y-12 funding was decreased by $150K to be split 50/50 between LANL IE1 and IE3 tasks FY20 5-year plan, Rev. 3.)**

Y-12 POC: Kevin Reynolds (865-241-9067), keven.reynolds@cns.doe.gov

DOE POC: Angela Chambers, NNSA (806-573-6407), Angela.Chambers@nnsa.doe.gov

NCSP Manager: CSSG Hold Back – $0K
Reflects DOE HQ Hold Back for the CSSG that will be held as HQ reserve funds. **(CSSG NCSP Manager Holdback was decreased by $33K to be added to ORNL CSSG funding FY20 5-year plan, Rev. 3.)**

DOE POC: Angela Chambers, NNSA (806-573-6407), Angela.Chambers@nnsa.doe.gov

Appendix B
Nuclear Data Priorities, Basis Statements, and Milestones

Nuclear Data Measurements							
Materials	**Pre-FY2020**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**Post-FY2024**
Cerium (^{142}Ce)	ORNL	ORNL					
Basis	Neutron transmission and capture of ^{142}Ce in the resonance range at GELINA. Cerium is an element that is predominately ^{140}Ce (88.450 a/o) and ^{142}Ce (11.114 a/o) and can be found in chemical processing streams because it is commercially used as a catalyst or additive for chemical applications (e.g., glass polishing powder). As a result, cerium appears as an admixed material in process streams. ^{142}Ce is also a stable fission product. The primary interest for cerium cross sections is for poison credit in NCS analyses. The need for improved cerium cross sections has been specifically identified for the Hanford Plutonium Finishing Plant and other similar operations. Isotopically enriched sample required. Additional transmission measurements needed in FY2020 to improve statistics.						
Chlorine (^{35}Cl)			ORNL	ORNL			
			LANL	LANL			
Basis	Measurement of the ^{35}Cl (n,p) cross section in the resonance range using LENZ at LANL. Chlorine is present in fuel cycle facilities in Pu solutions, electrorefining processes, chloride salts, and as brine/drift in some repository environments. Improved ^{35}Cl (n,p) cross sections needed for poison credit in these in these environments. A need for improved ^{35}Cl cross sections has been specifically identified at LANL and Y-12.						
Chromium (^{53}Cr)		RPI					
Chromium (^{50,53}Cr)					ORNL		
Basis	Measurement of the ^{53}Cr neutron capture cross section in the 2-10 keV energy range is needed to resolve discrepancies observed in historical fast assembly benchmarks containing stainless steel. The RPI measurement will address data request by CSEWG and IAEA. ORNL will measure ^{50,53}Cr neutron capture below 10 keV at GELINA using diluted samples to reduce or minimize multiple scattering effect impacting prior measurements.						
Copper (^{nat}Cu)	RPI	RPI					
Basis	Measurement of neutron scattering angular distribution of ^{nat}Cu in the keV and MeV energy range at RPI. This data is needed to help resolve historical issue with Cu reflected critical benchmarks (ZEUS).						
Fluorine (^{19}F)				ORNL			
Basis	Measurement of the ^{19}F inelastic scattering reaction channels at GELINA that appear to be underestimated in the current evaluation. Analysis and evaluation of the angular distributions in the RRR. Errors in fluorine may be contributing to bias in ^{233}U benchmarks. Fluorine is used in the uranium enrichment process and molten salt reactor coolants.						
Iodine							RPI
Basis	Measurement of neutron capture cross section of Iodine at RPI needed to resolve large discrepancies in simulations of large NaI detectors used for neutron capture cross section measurements. Will also support improved modeling of NaI gamma detectors in neutron fields for other DOE and DOD applications.						
Iron (^{54}Fe)			RPI				
Basis	Measurement of the neutron capture cross section for ^{54}Fe in the keV energy range at RPI is needed to support development of consistent Fe cross section evaluations. Recent measurement and evaluation work on ^{56}Fe has highlighted the need for new measurements and evaluation for ^{54}Fe. Iron is a ubiquitous element used in reactor, fuel cycle facility, spent fuel storage, and radiation shielding applications. IRSN is interested in this measurement as well.						
Lanthanum (^{nat}La)	ORNL						

Nuclear Data Measurements							
Materials	**Pre-FY2020**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**Post-FY2024**
Basis	Measurement of neutron transmission and yield of ^{nat}La in the resonance range at GELINA. Lanthanum is an element that is predominately ^{139}La (99.910 a/o) and a stable fission product. The primary NCS interest is for fission product credit. In the latest edition of the ENDF nuclear data library, the resonance analysis is based on parameters obtain with an experimental set up which is known to have certain problems. Currently, ENDF/B-VIII evaluations for La do not have adequate covariance data based on experimental data. Improved covariance data are needed to support sensitivity/uncertainty analyses for fission product credit applications. Natural samples can be used.						
Molybdenum (^{95}Mo)					RPI	RPI	RPI
					NNL	NNL	NNL
Basis	Measurement of neutron capture in ^{95}Mo in resonance range, URR at RPI. Neutron transmission measurements previously completed at RPI. ^{95}Mo is a stable fission product and the primary absorbing nuclide in natural Molybdenum. Molybdenum isotopes are currently encountered in irradiated fuel as fission products or in molybdenum alloys in research reactors and space reactors. The current primary interest in NCS is for fission product credit for transport casks, irradiated fuel storage, and reprocessing plants (UPu-MoZr deposits in French reprocessing plant equipment for example). Needs identified by NR and IRSN for fission product credit and Y-12 for U-Mo applications (lower priority). Isotopically enriched sample required.						
Neptunium (^{237}Np)				ORNL	ORNL	ORNL	ORNL
				LANL	LANL	LANL	LANL
Basis	Measurement of ^{237}Np fission cross section in fast energy range at LANL. ^{237}Np is an actinide of interest in nuclear criticality safety for applications at ORNL and other sites. Applications include ^{238}Pu production w/ HFIR at ORNL (low NCSP priority) and fast burst reactor for LANL. Nuclear data improvements will improve critical mass estimates. On the HPRL there is a request for fission cross section in the energy range from 200 keV to 20 MeV. The application list was fast systems, and the required accuracy is 1.5-4%. This requirement comes from the desire to improve the current low accuracy in the covariance matrix (6-8%).						
Plutonium (^{240}Pu)		LANL	LANL	LANL			
Basis	Measure ^{240}Pu prompt fission neutron energy spectra (PFNS) with Chi-Nu detector at LANL (LANCSE/WNR). The need for more accurate PFNS has been recognized. Supports applications with WG Pu and reactor grade Pu.						
Strontium (^{86,87}Sr)							ORNL
Basis	Enriched ^{86,87}Sr transmission and capture measurements at GELINA are needed to supplement existing ^{88}Sr ORNL measurements to support complete RR evaluation for natural strontium isotopes for ENDF/B. ^{86,87}Sr are minor isotopes representing about 18% of natural strontium.						
Tantalum (^{181}Ta)	RPI	RPI					
Basis	^{181}Ta transmission and capture in resonance range at RPI. Natural samples can be used since ^{181}Ta is 99.988 a/o. Tantalum is used at Y-12 for recovering uranium from machine turnings and at LANL for Pu casting operations in PF-4 where it may provide modest moderation and reflection of fissile material. Tantalum is chosen due to its material properties, as it is one of the few materials that can contain molten plutonium metal. Due to this characteristic, tantalum is often used as crucible, distributer, launder, or molds for plutonium casting operations. The wall thickness of these materials varies from a few mm all the way up to a few cm. ^{181}Ta evaluation is one of the oldest in ENDF and long overdue for update. ^{181}Ta transmission and capture measurements with 100m flight station for transmission and 45m for capture. High resolution data resolving resonance structure up to 10 keV and Unresolved self-shielding test using transmission through thick samples. RPI is also trying to resolve issues with resolved resonance region discrepancies. Integral experiments in progress to validate Ta cross sections.						

Nuclear Data Measurements							
Materials	**Pre-FY2020**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**Post-FY2024**
Uranium (^{233}U)		ORNL	ORNL	ORNL			
		LANL	LANL	LANL			
Basis	^{233}U neutron capture measurements in resonance range and the unresolved fast energy range at the Lujan center at LANCE/LANL using the DANCE detector. ORNL report on ^{233}U data assessment concluded that a new evaluation with revised (renormalized) fission cross section is needed. New capture cross section measurements (resonance region) needed to support this evaluation. ORNL and LANL will measure capture cross section using the DANCE detector multiplicity features. NCS applications at LANL (CMR), ORNL, DAF/NCERC, spare unirradiated LWBR modules at INL.						
Uranium (^{236}U)							ORNL
Basis	^{236}U high-resolution transmission measurements in the RRR at GELINA or LANL to complement recent LANL fast energy evaluation. ^{236}U is a minor activation product present in HEU. Improved ^{236}U cross section evaluation supports all DOE programs using HEU.						
Vanadium (^{51}V)				ORNL			
Basis	Recent vanadium measurements showed large multiple scattering corrections needed to be accounted for neutron energies below 10 keV. Additional measurements are needed at GELINA possible using diluted samples on order to reduce or minimize the neutron sensitivity to experimental setup. Vanadium is used in some fissile material containers.						
Zirconium ($^{90,91,92,94,96}Zr$)	ORNL	ORNL	ORNL	ORNL	ORNL	ORNL	ORNL
	RPI	RPI					
Basis	Neutron transmission and capture measurements in resonance range at GELINA. Isotopically enriched samples likely required. Zirconium is a key structural element that is primarily used in cladding for fuel rods and is currently in consideration for use with advanced nuclear fuel matrices in the form of zirconium hydride. The main application is reactor fuel cladding. ^{nat}Zr transmission measurements were recently completed by ORNL. At RPI ^{nat}Zr neutron scattering measurements in the keV range are in progress under NR funding, the measurements will provide information on angular distributions. NR continues to be unsatisfied with Zr evaluations in ENDF.						
Polystyrene (C_8H_8)		ORNL	ORNL				
Basis	Polystyrene is a moderator material found in several thermal systems (PCT001, PCT02, MCT012, MCT013, MCT014, MCT016). Currently, polyethylene is used as a surrogate to represent thermal scattering in polystyrene in neutron transport simulations. This SNS measurement and evaluation will determine the validity of this approximation, as well as inform future substitutions for other hydrocarbons found in benchmarks. RPI could perform subthermal transmission measurements to support this TSL evaluation.						

List Legend	ORNL	RPI	LANL	LLNL/NCSU	IRSN	NNL	Low Priority

Nuclear Data Evaluations							
Materials	**Pre-FY2020**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**Post-FY2024**
Beryllium (^{9}Be)	LANL	LANL					
Basis	Be-9 evaluations continue to be challenged by benchmark critical experiments. See pg. 167 of the ENDF/B-VIII.0 report. The accompanying text indicates "there is considerable spread in these Be assembly results." The ENDF/B-VIII.0 evaluation of Be-9 carried over cross sections from ENDF/B-VII.1, but adopted JENDL-4.0 evaluations of elastic scattering angular distribution and (n,2n) angular and energy distributions. This leaves a less-than-satisfactory inconsistency between the elastic angular distributions and integrated cross sections that should be resolved. The proposed approach is to employ a new representation of the four-body (2n,2 alpha) breakup channel in the R-matrix analysis.						
Cerium (Ce)	ORNL	ORNL	ORNL				
Basis	Neutron transmission and capture of ^{142}Ce in the resonance range. Cerium is an element that is predominately ^{140}Ce (88.450 a/o) and ^{142}Ce (11.114 a/o) and can be found in chemical processing streams because it is commercially used as a catalyst or additive for chemical applications (e.g., glass polishing powder). As a result, cerium appears as an admixed material in process streams. ^{142}Ce is also a stable fission product. The primary interest for cerium cross sections is for poison credit in NCS analyses. The need for improved cerium cross sections has been specifically identified for the Hanford Plutonium Finishing Plant and other similar operations.						
Chlorine (^{35}Cl)		ORNL	ORNL	ORNL	ORNL		
Basis	Revise ^{35}Cl resonance evaluation based on ^{35}Cl (n,p) measurements. Chlorine is present in fuel cycle facilities in Pu solutions, electrorefining processes, chloride salts, and as brine/drift in some repository environments. Improving ^{35}Cl (n,p) cross sections needed for poison credit in these environments. A need for improved ^{35}Cl cross sections has been specifically identified at LANL and Y-12.						
Chromium (^{50,53}Cr)						ORNL	ORNL
Basis	Measurement and evaluation of ^{50,53}Cr neutron capture cross section below 10 keV energy range is needed to resolve discrepancies observed in historical fast assembly benchmarks containing stainless steel. ORNL will measure ^{50,53}Cr neutron capture below 10 keV at GELINA using diluted samples to reduce or minimize multiple scattering effect impacting prior measurements.						
Copper (^{63,65}Cu)		ORNL					
Basis	A revised evaluation of copper isotopes is needed to improve the benchmark performance above 100 keV up to 300 keV. This will include a statistical analysis of the resonance parameters above 100 keV to quantify the impact of the missing resonances in the measured data as well as a guidance in the level spin assignment. Due to the importance of the copper being used in critical assembly applications as reflector, additional work on the angular distributions is needed. Moreover, since benchmark sensitivity extends above 300 keV, a careful analysis of the high energy cross sections might be needed.						
Dysprosium (Dy)	ORNL						
Basis	Completion of the new ^{160,162,163,165}Dy resonance evaluations will demonstrate the ability of using the RPI linear accelerator to provide measured data to support the NCSP nuclear data evaluation efforts. In addition, the evaluated nuclear data files do not have evaluated covariance data for the dysprosium isotopes, and completion of the evaluation work will provide much needed evaluated covariance data in the resonance region.						
Fluorine (^{19}F)					ORNL		
Basis	Evaluation of the ^{19}F inelastic scattering reaction channels that appear to be underestimated in the current evaluation. Analysis and evaluation of the angular distributions in the RRR. Errors in fluorine may be contributing to bias in ^{233}U benchmarks. Fluorine is used in the uranium enrichment process and molten salt reactor coolants.						

Nuclear Data Evaluations							
Materials	**Pre-FY2020**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**Post-FY2024**
Gadolinium ($^{155\text{-}158,160}$Gd)	ORNL						
	NNL						
Basis	Revisit resonance evaluation. Recent work results indicate under-prediction of the capture cross section in the ENDF/B-VIII.0 and over-prediction in ENDF/B-VII.1. NCS need is freshly irradiated fuel and shipping container use in NNSA applications.						
Hafnium (^{176,177,178,179,180}Hf)		ORNL	ORNL	ORNL	ORNL	ORNL	
		IRSN	IRSN	IRSN	IRSN	IRSN	
Basis	Hafnium is a neutron poison used in reactor and fuel cycle applications. IRSN and ORNL will review the existing Hf RRR and URR evaluations and develop new evaluations if needed to improve agreement with the TEX HEU/Hf experiment.						
Iron (^{54,56,57}Fe)		ORNL	ORNL	ORNL			
		IRSN	IRSN	IRSN			
Basis	Although the effort on the Fe isotopes was planned as joint effort between ORNL and IRSN, IRSN mainly led the evaluation effort and it is unclear the status of this set of evaluations. The ORNL contribution to 56-Fe was the generation of a preliminary ENDF file solving the problem with the benchmark performance. However, a rigorous evaluation work is still needed for the three major isotopes mainly for the assessment of the inelastic scattering reaction channel. ORNL will revise the 54-Fe, 56-Fe, and 57-Fe resonance evaluations.						
Iron (^{56}Fe)	ORNL	ORNL	ORNL	ORNL			
	IRSN	IRSN	IRSN	IRSN			
Basis	Revise high energy resonance region evaluation. Iron is a key element of structural materials in the DOE Complex (e.g., steel) and is used in many configurations (e.g., tanks, piping, admixed material that can serve as neutron absorber, etc.). ^{56}Fe has numerous resonances in the resonance range. Currently, the latest ^{56}Fe evaluation in the ENDF/B data files does not have detailed resonance parameters; rather, the evaluation provides a pointwise representation. The ^{56}Fe resonance evaluation will significantly improve radiation transport calculations for systems involving iron (i.e., critical benchmark analyses and criticality safety analyses of processes in the DOE Complex). Evaluation work was performed at IRSN in the past but was not apparently included in ENDF (this will be reviewed and considered for inclusion in ENDF). BNL also participating under DOE-SC funding.						
Lanthanum (La)	ORNL	ORNL	ORNL				
Basis	^{139}La resonance range evaluation based on ^{nat}La measurements. Lanthanum is an element that is predominantly ^{139}La (99.910 a/o) and a stable fission product. The primary NCS interest is for fission product credit. In the latest version of ENDF nuclear data library, the resonance analysis is based on parameters obtained with an experimental set up which is known to have certain problems. Currently, ENDF/B-VIII evaluations for La do not have adequate covariance data based on experimental data. Improved covariance data are needed to support sensitivity/uncertainty analyses for fission product credit applications.						
Lead (^{208}Pb)	LANL						
Lead (^{204,206,207,208}Pb)		ORNL	ORNL	ORNL			
Basis	Lead is a ubiquitous material in the nuclear industry. Lead possesses not only high photon attenuation properties, which make it almost a universal choice as a gamma-ray shielding material, but also desirable neutronic qualities. Our ability to match experimental data with Pb (reflectors and as a scattering target) is less that we desire. Pb-208 is the majority isotope of natural lead. The current ENDF evaluation is known to suffer from deficiencies in neutron angular distributions. The emphasis of the re-evaluation work is on these angular distributions. We will judge success of this work based on recent semi-integral measurements performed at RPI. ORNL proposed to revisit RRR to address angular distribution concerns.						

Nuclear Data Evaluations							
Materials	**Pre-FY2020**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**Post-FY2024**
Lithium (^{6}Li)			LANL	LANL	LANL	LANL	
Basis	The Li-6 evaluation in ENDF/B-VIII.0 was based on a combination of EDA R-Matrix fits to all reactions open in the Li-7 system up to ~ 4 MeV, influenced by the standards GMA 2017 result for the (n,t) reaction, and ENDF/B-VII.1 values above ~4 MeV. Li-6 is important for a number of reasons, including as a detector (and reference) in experiments, for example, for Chi-Nu measurement of prompt fission neutron spectra. It is important to extend the R-Matrix analysis to the full 20 MeV range for better precision and more complete (covariance information) at the important lower energy scale of a few MeV. Supports need at Y-12 for the new electrorefining process.						
Molybdenum (^{95}Mo)					RPI	RPI	RPI
					NNL	NNL	NNL
Basis	Resonance region evaluation. ^{95}Mo is a stable fission product and the primary absorbing nuclide in natural molybdenum. Molybdenum isotopes are currently encountered in irradiated fuel as fission products or in molybdenum alloys in research reactors and space reactors. Current primary interest for NCS is for fission product credit for transport casks, irradiated fuel storage, and reprocessing plants (UPu-MoZr deposits in reprocessing plant equipment for example). Needs identified by NR and IRSN for fission product credit and Y-12 for U-Mo applications (lower priority).						
Neptunium (^{237}Np)					ORNL	ORNL	
					LANL	LANL	
Basis	Fast energy range evaluation. ^{237}Np is an actinide of interest in nuclear criticality safety for applications at ORNL and other sites. Applications include 238Pu production w/ HFIR (low NCSP priority) and fast burst reactor for LANL. Nuclear data improvements will improve critical mass estimates. On the HPRL there is a request for fission cross section in the energy range from 200 keV to 20 MeV. The application list was fast systems, and the required accuracy is 1.5-4%. This requirement comes from the desire to improve the current low accuracy in the covariance matrix (6-8%).						
Nitrogen (^{14}N)			ORNL	ORNL	ORNL		
	Nitrogen cross section are important in the reprocessing process and related analyses. Nitrogen was recently included as action item in the series of INDEN meetings for light nuclei evaluations. In the ENDF/B-VIII.0 library there are no resonance parameters for nitrogen.						
Plutonium (^{239}Pu)	LANL	LANL	LANL				
	ORNL	ORNL	ORNL	ORNL	ORNL	ORNL	
		IRSN	IRSN	IRSN	IRSN	IRSN	
Basis	^{239}Pu is one of the three major fissile isotopes of interest in Nuclear Criticality Safety. ^{239}Pu is used at LANL, LLNL, Hanford, SRS, and other locations in sufficient quantities to be an NCS concern. ^{239}Pu is a major factor in countless ICSBEP benchmarks. NCSP driver includes inadequate agreement of computations with PU-SOL-THERM benchmarks (biased high). Major experimental campaigns at LANSCE for ^{239}Pu fission cross section and PFNS are nearing conclusion and the resulting data need to be incorporated into an updated evaluation. ORNL to assist with evaluation work. ORNL and IRSN will collaborate on a review of existing RRR and URR evaluation data and prepare new RRR/URR evaluations that will improve agreement with TEX Pu experimental results.						
Plutonium (^{240}Pu)					ORNL	ORNL	
					LANL		
Basis	Pu-240 is a meaningful component of almost all Pu benchmark experiments, and a significant component in some. This isotope is the next major constituent of plutonium and can reach 20% or more enrichment in reactor fuel. Some changes were made in ENDF/B-VIII.0, but there have been no accurate prompt fission spectra measurements previously. Such experiments, and subsequent re-evaluation will benefit criticality safety analysis for MOX fuel reprocessing, fabrication and disposal.						

Nuclear Data Evaluations							
Materials	**Pre-FY2020**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**Post-FY2024**
Rhodium (^{103}Rh)							ORNL
Basis	Update resonance evaluation based on RPI transmission and capture measurements in the RRR. ^{103}Rh is a stable fission product, NCS interest is for fission product credit. Integral experiments are in process that will determine need for new evaluations. Evaluation currently low priority - elevate priority if IE results indicate need for new evaluation.						
Strontium (^{88}Sr)	ORNL	ORNL	ORNL				
Basis	^{88}Sr RR evaluation based on existing ORNL transmission and capture measurements. Strontium is a fission product typically found in spent fuel. Sr is found in high level waste tanks at Hanford and Savanah River.						
Strontium (^{86,87}Sr)							ORNL
Basis	^{86,87}Sr RR evaluation based on transmission and capture measurements performed at GELINA to supplement existing ^{88}Sr ORNL measurements to support complete RR evaluation for natural strontium isotopes for ENDF/B. ^{86,87}Sr are minor isotopes representing about 18% of natural strontium.						
Tantalum (Ta)	ORNL	ORNL	ORNL	ORNL	ORNL		
	NNL	NNL	NNL	NNL	NNL		
Basis	Resonance evaluation based on GELINA and RPI measurements. Tantalum is used at Y-12 for recovering uranium from machine turnings and at LANL for Pu casting operations in PF-4 where it may provide modest moderation and reflection of fissile material. Tantalum is chosen due to its material properties, as it is one of the few materials that can contain molten plutonium metal. Due to this characteristic, tantalum is often used as crucible, distributer, launder, or molds for plutonium casting operations. The wall thickness of these materials varies from a few mm all the way up to a few cm. ^{181}Ta is one of the oldest evaluations in ENDF and long overdue for update. Integral experiments in progress to validate Ta cross sections.						
Uranium-233		ORNL	ORNL	ORNL	ORNL	ORNL	
				LANL	LANL	LANL	
Basis	^{233}U is a fissile nuclide of interest to criticality safety. The availability of ^{233}U of importance to NCS mainly at Y-12, ORNL, and at NCERC. 1. New evaluation of the thermal region. Reevaluate differential data to check the renormalization of ORNL fission data. ENDF is not fitting the Guber and n_TOF fission data, which agree within 2% from 10 eV to 100 keV. Above 100 eV, there are serious discrepancies between ENDF and the new experimental fission data (from Guber and n_TOF) of up to 10% in the 1–10 keV range (Guber). Update with the new standards. RPI has ^{233}U capture data, which is likely the Weston data (Danon). 2. New evaluation fast. Fission spectrum is important for intermediate benchmarks. Renormalize to new standards. RR evaluation at ORNL and fast at LANL.						
Uranium-234	LANL	LANL					
Basis	While ^{234}U makes up a small fraction of natural uranium, previous studies have shown that ignoring ^{234}U for HEU metal benchmarks can lead to a non-conservative result by as much as 0.4%. Recent advances in the capabilities of the DANCE detector at LANSCE, combined with improved theoretical modeling of the capture reaction (for example, including the M1 scissors-mode contribution to the gamma strength function) have enabled more accurate evaluations of (n,g) cross sections. This work to update the ^{234}U capture cross section will utilize both the experimental and theoretical advances.						

Nuclear Data Evaluations							
Materials	**Pre-FY2020**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**Post-FY2024**
Uranium-235	LANL	LANL	LANL	LANL			
				ORNL			
Basis	^{235}U is one of the three major fissile isotopes of interest in Nuclear Criticality Safety. ^{235}U is used at LANL, LLNL, Hanford, SRS, and GDPs, Y-12, and other locations in sufficient quantities to be an NCS concern. ^{235}U is a major factor in countless ICSBEP benchmarks. Major LANSCE experiments of ^{235}U fission cross section and PFNS are concluding in the next few years, and the resulting data needs to be incorporated into an updated evaluation. Inelastic scattering cross section measurements are also planned, which will allow evaluators to better address these high-uncertainty interactions. Improvement of ^{235}U URR because based on old average resonance parameters. Includes ORNL revisiting ^{235}U URR evaluation.						
Uranium-236	LANL						
							ORNL
Basis	^{236}U needs to be considered in modeling of spent fuel. Recent advances in the capabilities of the DANCE detector at LANSCE, combined with improved theoretical modeling of the capture reaction (for example, including the M1 scissors-mode contribution to the gamma strength function) have enabled more accurate evaluations of (n,g) cross sections. This work to update the ^{236}U capture cross section will utilize both the experimental and theoretical advances. ORNL will evaluate ^{236}U high-resolution transmission measurements in the RRR to complement recent LANL fast energy evaluation. ^{236}U is a minor activation product present in HEU. Improved ^{236}U cross section evaluation supports all DOE programs using HEU.						
Uranium-238	LANL	LANL	LANL				
Basis	^{238}U is a ubiquitous isotope in HEU, LEU, natural uranium, and depleted uranium. It's presence in HEU and LEU fuels makes it a significant contributor to their reactivity and performance. NU and DU are often used as reflectors or shielding materials, and ^{238}U is obviously the dominant isotope in these materials. ^{238}U is a major factor in countless ICSBEP benchmarks. Major LANSCE experiments of ^{238}U fission cross section and PFNS are concluding in the next few years, and the resulting data needs to be incorporated into an updated evaluation.						
Vanadium (^{51}V)	ORNL	ORNL	ORNL	ORNL			
Basis	Vanadium is a key structural element and is predominately ^{51}V (99.75 atom %). Primary NCS application is fire resistant cans. Recent data testing by LANL for ICSBEP critical benchmarks involving vanadium (i.e., HMF25, HMF40, and HMM16) results in an over-predication of the experiment eigenvalue. In addition, the HMF25 series of experiments exhibit an increasing calculated eigenvalue trend with increasing reflector thickness. The integral data testing indicates that there may be deficiencies in either the elastic scattering angular distributions or secondary energy distributions. In addition, the latest ENDF/B-VII.1 resonance evaluation is based on the JENDL-4.0 evaluation and does not have covariance data. Also, the ENDF/B-VII.1 and JENDL 4.0 resonance evaluations are based on the parameters provided in the Atlas of Neutron Resonances up to 42.5 keV, and the entire resolved resonance evaluation (up to 100 keV) is represented by the multi-level Breit Wigner (MLBW) formalism. As a result, the MLBW resonance evaluation does not account for the resonance-resonance interference effects. Therefore, the evaluated resonance parameters are not based on a detailed R-matrix analysis. Differential measurements are needed in the resonance region to accurately predict the neutron resonances, and a corresponding resonance evaluation is needed to provide detailed resonance parameters and covariance data. In addition, the SAMMY evaluation software has the capability to generate angular scattering distributions from the resonance parameters thereby providing detailed resonance scattering structure that will improve the elastic scattering modeling in the evaluation. The request is for ORNL to complete new ^{51}V cross-section measurements and a resonance evaluation to address computational biases with the existing ^{51}V evaluation. New measurement/evaluation of fast scattering angular distribution recommended.						

Nuclear Data Evaluations							
Materials	**Pre-FY2020**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**Post-FY2024**
Zirconium ($^{90,91,92,94,96}Zr$)					ORNL	ORNL	ORNL
Basis	Resonance evaluations. Zirconium is a key structural element that is primarily used in cladding for fuel rods and is currently in consideration for use with advanced nuclear fuel matrices in the form of zirconium hydride. The latest ENDF/B-VII.1 resonance evaluation relies on JENDL-4 data and resonance parameters from the Atlas of Neutron Resonances. As a result, the evaluated resonance parameters are not based on detailed R-matrix analyses. In addition, newer RPI total cross-section measurements on natural zirconium indicate that the older ENDF/B-VI.8 data match the recent RPI measurements better than the newer isotopic evaluations. Furthermore, improved differential measurements of the zirconium isotopes have been identified on the OECD/NEA nuclear data High Priority Request List (HPRL). Differential measurements are needed in the resonance region to accurately predict the neutron resonances for the zirconium isotopes, and corresponding resonance evaluations are needed to provide detailed resonance parameters and covariance data. In addition, the SAMMY evaluation software has the capability to generate angular scattering distributions from the resonance parameters thereby providing detailed resonance scattering structure that will improve the elastic scattering modeling for the zirconium isotope evaluations. NR continues to be unsatisfied with Zr evaluations in ENDF.						
Water (H_2O)	LLNL/NCSU	LLNL/NCSU					
Basis	TSL evaluation. Water is this most important moderator and moderating reflector material for criticality safety and light water reactor physics. Problems with evaluations submitted by CAB at elevated temperatures (that were noticed during the ENDF/B-VIII.0 evaluation process) warrant re-evaluating this essential material using the latest methods developed under LLNL ND2, ND3.						
Hydrofluoric Acid (HF)	LLNL/NCSU	LLNL/NCSU	LLNL/NCSU				
Basis	TSL evaluation. HEU-SOL-THERM-039, "Mixture of Uranium (93%) Hexafluoride and Hydrofluoric Acid (Low H/U Ratio) in a Hot-Water-Reflected Spherical Tank," critical experiments overpredict k-eff from 2-6% regardless of cross-section library or code utilized. An appropriate thermal scattering law for the liquid Hydrofluoric acid (HF) moderator will likely resolve this calculational discrepancy.						
Uranium Hexafluoride (UF_6)	LLNL/NCSU	LLNL/NCSU	LLNL/NCSU				
Basis	TSL evaluation. As the H/U ratio is "low" in HEU-SOL-THERM-039, correcting for F in UF_6 may be necessary as a moderator. A thermal scattering law for this fissile compound will be useful for the advanced Doppler broadening methods currently under development as LLNL ND5.						
Hydraulic Fluid (Silicone Oil)		LLNL/NCSU	LLNL/NCSU	LLNL/NCSU			
Basis	TSL evaluation. Requested by the Naval Nuclear Laboratory for use in criticality safety evaluations.						
Paraffin (C_nH_{2n+2})			LLNL/NCSU	LLNL/NCSU	LLNL/NCSU		
Basis	TSL evaluation. A common moderator and moderating reflector material for which there are numerous critical benchmarks in the ICSBEP Handbook. A thermal scattering law for paraffin will improve simulations through higher fidelity and reduce uncertainties.						
Triuranium Octoxide (U_3O_8)				LLNL/NCSU	LLNL/NCSU	LLNL/NCSU	
Basis	TSL evaluation. A common fissile compound for which there are numerous critical experiments in the ICSBEP Handbook. A thermal scattering law for U_3O_8 will improve Doppler broadening using advanced methods currently under development as LLNL ND5.						
Uranyl Fluoride (UO_2F_2)					LLNL/NCSU	LLNL/NCSU	LLNL/NCSU
Basis	TSL evaluation. A common fissile compound for which there are numerous critical experiments in the ICSBEP Handbook. A thermal scattering law for UO_2F_2 will improve Doppler broadening using advanced methods currently under development as LLNL ND5.						

Nuclear Data Evaluations							
Materials	**Pre-FY2020**	**FY2020**	**FY2021**	**FY2022**	**FY2023**	**FY2024**	**Post-FY2024**
Uranium Silicide (U_3Si_2)						LLNL/NCSU	LLNL/NCSU
Basis	TSL evaluation. A common fissile compound in use in advanced nuclear reactor fuel. A thermal scattering law for U_3Si_2 will improve Doppler broadening using advanced methods currently under development as LLNL ND5.						
Uranium Carbide (UC)							LLNL/NCSU
Basis	TSL evaluation. A common fissile compound under consideration for high-temperature advanced nuclear reactor fuel. A thermal scattering law for UC will improve Doppler broadening using advanced methods currently under development as LLNL ND5.						
Plutonium Oxide (PuO_2)							LLNL/NCSU
Basis	TSL evaluation. A common fissile compound for which there are critical experiments in the ICSBEP Handbook. A thermal scattering law for PuO_2 will improve Doppler broadening using advanced methods currently under development as LLNL ND5.						
Uranium Hydride (UH_3)						NNL	NNL
Basis	TSL evaluation. A common fissile compound in use in fissile material operations using hydride/de-hydride processes. A thermal scattering law for UH_3 will improve Doppler broadening using advanced methods currently under development as LLNL ND5.						
Plutonium Hydride (PuH_{2+x})						NNL	NNL
Basis	TSL evaluation. A common fissile compound in use in fissile material operations using hydride/de-hydride processes. A thermal scattering law for PuH_{2+X} will improve Doppler broadening using advanced methods currently under development as LLNL ND5.						
Polystyrene (C_8H_8)		ORNL	ORNL	ORNL			
Basis	Polystyrene is a moderator material found in several thermal systems (PCT001, PCT02, MCT012, MCT013, MCT014, MCT016). Currently, polyethylene is used as a surrogate to represent thermal scattering in polystyrene in neutron transport simulations. This measurement and evaluation will determine the validity of this approximation, as well as inform future substitutions for other hydrocarbons found in benchmarks. RPI could perform sub-thermal transmission measurements to support this TSL evaluation.						

List Legend	ORNL	RPI	LANL	LLNL/NCSU	IRSN	NNL	Low Priority

B-1 Differential Measurements and Evaluations
(The following list provides the specific milestones to refer to for each element work schedule in Table B-1)

- Beryllium (Be-9)
- Cerium (Ce)
- Chlorine (Cl-35)
- Chromium (Cr-50,53)
- Copper (^{nat}Cu)
- Fluorine (F-19)
- Hafnium (Hf-176,177,178,179,180)
- Iron (Fe-54,56,57)
- Lanthanum (La)
- Lead (Pb-208)
- Lead (Pb-204,206,207,208)
- Lithium (Li-6)
- Molybdenum (Mo-95)
- Neptunium (Np-237)
- Plutonium (Pu-239)
- Plutonium (Pu-239) (ORNL/IRSN Collaboration)

- Plutonium (Pu-240)
- Strontium (Sr-88)
- Tantalum (Ta)
- Uranium-233 (U-233)
- Uranium-234 (U-234)
- Uranium-235 (U-235)
- Uranium-238 (U-238)
- Vanadium (V-51)
- Zirconium (Zr-90, 91, 92, 94, 96)

Completed Work

- Calcium (Ca)
- Cobalt (Co-59)
- Copper (Cu-63, 65)
- Dysprosium (Dy-161, 162, 163, 164)
- Gadolinium (Gd-155, 156, 157, 158, 160)
- Lead (Pb-208)
- Nickel (Ni-58, 60)
- Oxygen (O-16)
- Tungsten (W-182, 183, 184, 186)
- Uranium-234 (U-234)
- Uranium-236 (U-236)

Completed Differential Measurements and Evaluations – Elements

(Evaluations have been submitted to NNDC and are candidates for the next ENDF release. Testing will be performed as part of ENDF release effort, and additional revisions may be requested by NNDC before evaluations are formally released. The GANTT charts are retained in the Five-Year Plan pending release of the new evaluations by NNDC.)

Table B-1. Differential Measurements and Evaluations

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
[redacted]				
Beryllium (Be-9)	11/1/11	6/30/18		
Employ a new representation of the four-body (2n,2 alpha) breakup channel in the R-matrix analysis	11/15/19	4/15/20	ORNL (IRMM)	Transmission and capture measurements were performed in FY19, however, additional transmission measurements for 142-Ce are needed to have better statistics.
Finalize Evaluation and Deliver to NNDC	10/1/19	10/30/20	ORNL	
Phase I Testing, Post to ENDF/A and Broadcast	6/1/20	10/1/20	BNL	
CSEWG Validation Testing	8/3/20	1/1/21	NDAG	
CSEWG Approval of Complete Evaluation	1/4/21	4/1/21	BNL	
[redacted]				
Cerium (Ce-142)	11/1/11	6/30/18		
Transmission and Capture Measurements	11/15/19	4/15/20	ORNL (IRMM)	Transmission and capture measurements were performed in FY19, however, additional transmission measurements for 142-Ce are needed to have better statistics.
Experimentalist Data Reduction and Testing	4/15/19	7/1/20	ORNL	
Resolved Resonance Region Evaluation	11/15/19	10/30/20	ORNL	
Assess Data for URR Evaluation and Complete URR Evaluation	10/1/19	10/30/20	ORNL	
Finalize Resonance Evaluation and Deliver to NNDC	10/1/19	10/30/20	ORNL	
Phase I Testing, Post to ENDF/A and Broadcast	6/1/20	10/1/20	BNL	
CSEWG Validation Testing	8/3/20	1/1/21	NDAG	
CSEWG Approval of Complete Evaluation	1/4/21	4/1/21	BNL	
[redacted]				
Chlorine (Cl-35)	10/1/20	9/30/23		
Perform Capture or (n,p) Measurements	10/1/20	9/30/21	ORNL/LANL	Funding source: LANL ND1/ORNL ND1
Perform SAMMY Analysis	10/1/21	3/30/22	ORNL	
Resolve Resonamce Region Evaluation	4/1/22	9/30/22	ORNL	
Finalize isotopic Evaluation Resonance Region Evaluation and Deliver to NNDC	10/1/22	10/15/22	ORNL	
Phase I testing , Post to ENDF/A and Broadcast	10/16/22	10/30/22	ORNL	
CSEWG Validation Testing	11/1/22	11/15/22	BNL	
CSEWG Approval of Complete Evaluation	11/16/22	12/30/22		
[redacted]				
Chromium (Cr-50, 53)				The two links below describe the problem and motivation for the proposed work. In addition ORNL plans to 1) to develop procedure to treat large multiple scattering (MS) corrections in
Perform Capture Measurements	10/1/23	12/30/23	ORNL	
Perform SAMMY Analysis	1/1/24	9/30/24	ORNL	

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
Resolved Resonance Region Evaluation for Cr-50, 53				SAMMY. Currently, in SAMMY one can account only for small MS corrections. https://www.oecd-nea.org/dbdata/hprl/hprlview.pl?ID=518 and https://www.oecd-nea.org/dbdata/hprl/hprlview.pl?ID=519 . Measurements for both isotopes below 10 keV neutron energy region should be performed with diluted sample to reduce or minimize the neutron sensitivity of the experimental set up.
Finalize isotopic Evaluation Resonance Region Evaluation and Deliver to NNDC				
Phase I testing , Post to ENDF/A and Broadcast	10/16/24	10/30/24	BNL	
CSEWG Validation Testing	11/1/24	11/15/24	NDAG	
CSEWG Approval of Complete Evaluation	11/16/24	12/30/24	BNL	
Cu (Cu-63,65)				A revised evaluation on copper isotopes is needed to improve the benchmark performance above 100 keV up to 300 keV. This will include a statistical analysis of the resonance parameters above 100 keV to quantify the impact of the missing resonances in the measured data as well as a guidance in the level spin assignment. Due to the importance of the copper being used in reactor applications as reflector, additional work on the angular distributions is needed. Moreover, since benchmark sensitivity extends above 300 keV, a careful analysis of the high energy cross sections might be needed.
Perform Capture Measurements	<FY19	<FY19	–	
Perform SAMMY Analysis	10/1/19	9/30/20	ORNL	
Resolved Resonance Region Evaluation for Cu-63,65				
Finalize isotopic Evaluation Resonance Region Evaluation and Deliver to NNDC				
Phase I testing , Post to ENDF/A and Broadcast	10/16/20	10/30/20		
CSEWG Validation Testing	11/1/20	11/15/20		
CSEWG Approval of Complete Evaluation	11/16/20	12/30/20		
Dysprosium (Dy-161,162,163,164)	Completed			Listed as complete in Section B-1.
Perform Capture Measurements				
Perform SAMMY Analysis				
Resolve Resonance Region Evaluation for DY-161,162,163,164				
Finalize isotopic Evaluation Resonance Region Evaluation and Deliver to NNDC				
Phase I testing , Post to ENDF/A and Broadcast				
CSEWG Validation Testing				
CSEWG Approval of Complete Evaluation				
Fluorine (F-19)	12/30/21	9/30/23		F-19 might be the main cause bias in ^{233}U solution benchmarks. There are no resonance parameters in the ENDF/B-VIII.0 library because the RRR evaluation was converted to point wise cross sections. There are no high-resolution measured data for F-19 inelastic scattering reaction channel, e.g. (n,n'), (n,n0),
Perform Inelastic Measurements (IRMM)	12/30/21	9/30/22	ORNL	
Perform SAMMY Analysis	12/30/22	9/30/23	ORNL	
Resolve Resonance Region Evaluation for F-19				

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
Finalize isotopic Evaluation Resonance Region Evaluation and Deliver to NNDC				(n,n1), that in the current evaluation seems to be underestimated. Analysis and evaluation on the angular distributions in RRR is required.
Phase I testing , Post to ENDF/A and Broadcast	10/1/23	10/15/23	BNL	
CSEWG Validation Testing	10/15/23	11/1/23	NDAG	
CSEWG Approval of Complete Evaluation	11/1/23	12/31/23	BNL	
Gadolinium (Gd-155,156,157,158,160)	Completed			Listed as complete in Section B-1.
Perform Capture Measurements				
Perform SAMMY Analysis				
Resolve Resonance Region Evaluation for Gd-155,156,157,158,160				
Finalize Resonance Region Evaluation and Deliver to NNDC				
Phase I Testing , Post to ENDF/A and Broadcast				
CSEWG Validation Testing				
CSEWG Approval of Complete Evaluations				
Hafnium (Hf-176,177,178,179,180)	10/1/19			Resolved and unresolved resonance evaluations for Hf isotopes have been carried out mainly to address issues on benchmark results in the thermal energy region. IRSN and LLNL will be working on the development of the TEX-Hf experiments focusing in the epithermal energy region. Indeed, MORET calculations of the benchmark sensitive to Hf in the epithermal energy region have demonstrated discrepancies calculated and experimental multiplication factors result. The intent of the proposal is to review and re-evaluate the Hf cross sections in the resolved and unresolved resonance regions with additional covariance and uncertainty information.
Perform assessment of the available Hf evaluation in the resolved and unresolved resonance regions in the JEFF, ENDF and JENDL libraries; Perform detail study of the sensitivity of Hf cross sections in the calculations using the TEX-Hf benchmarks; Examine the results from different cross section libraries; Initiate resonance parameter evaluation in the resolved and unresolved resonance regions.	10/1/19	9/30/20	ORNL/IRSN	
Continue tasks initiated in previous year; Incorporate experimental differential data in the evaluation process as they become available; Continue evaluation using computer evaluation tool.	10/1/20	9/30/21	ORNL/IRSN	
Complete the resolved resonance and resonance parameter covariance evaluation; Use the evaluation for testing in benchmark calculation; Work with ORNL on the benchmark validation; Submit the evaluation to JEFF and ENDF for further testing;	10/1/21	9/30/22	ORNL/IRSN	

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
Initiate the unresolved resonance region evaluation; Incorporate experimental differential data in the evaluation process as they become available; Continue evaluation using computer evaluation tool;	10/1/22	9/30/23	ORNL/IRSN	
Complete the unresolved resonance and cross section covariance evaluation; Use the evaluation for testing in benchmark calculation; Work with ORNL on the benchmark validation; Submit the evaluation to JEFF and ENDF for further testing.	10/1/23	9/30/24	ORNL/IRSN	
CSEWG Approval of Complete Evaluations				
Fe (Fe-54, 56, 57)	1/1/11	11/30/19		Although the effort on the Fe isotopes was planned as joint effort between ORNL and IRSN, IRSN mainly led the evaluation effort and it is unclear the status of this set of evaluations. The ORNL contribution to 56-Fe was the generation of a preliminary ENDF file solving the problem with the benchmark performance. However, a rigorous evaluation work is still needed for the three major isotopes mainly for the assessment of the inelastic scattering reaction channel.
Perform Capture Measurements	10/1/11	9/30/16	RPI	
Perform SAMMY Analysis	1/1/11	1/1/20	ORNL	
Resolved Resonance Region Evaluation for Fe-54, 56, 57	1/1/20	9/30/22	ORNL	
Finalize isotopic Evaluation Resonance Region Evaluation and Deliver to NNDC	10/1/22	10/15/22	BNL	
Phase I testing , Post to ENDF/A and Broadcast	10/16/22	9/30/24	NDAG	
CSEWG Validation Testing	10/1/24	10/15/24	ORNL	
CSEWG Approval of Complete Evaluation	10/15/24	11/1/14	BNL	
Lanthanum (La)				Updated from FY2019
Transmission and Capture Measurements	10/1/17	6/1/18	ORNL	
Experimentalist Data Reduction and Testing	6/1/18	9/30/19	ORNL	
Resolved Resonance Region Evaluation	10/1/19	6/30/21	ORNL	
Finalize Resonance Evaluation and Deliver to NNDC	7/1/21	9/30/21	ORNL	
Phase I Testing, Post to ENDF/A and Broadcast	10/1/21	10/15/21	BNL	
CSEWG Validation Testing	10/15/21	11/1/21	NDAG	
CSEWG Approval of Complete Evaluation	11/1/21	12/31/21	BNL	
Lead (Pb-208)	10/1/15	12/31/17		Changes consistent with discussion at August BEM Meeting and text in basis statement
Update High-Energy Neutron Angular Distributions	10/1/17	3/31/19	LANL	
Test New Scattering Data Using Semi-Integral Experiment and Recommend Path Forward	4/1/19	9/30/19	LANL	

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
Phase I Testing, Post to ENDF/A and Broadcast	10/1/19	10/14/19	BNL	
CSEWG Validation Testing	10/15/19	10/31/19	NDAG	
CSEWG Approval of Complete Evaluation	11/1/19	12/31/19	BNL	
Lead (Pb-204,206,207,208)	10/1/20	12/31/22		Changes consistent with discussion at August BEM Meeting and text in basis statement
Resolved Resonance Region Evaluation	4/1/20	9/30/22	ORNL	
Phase I Testing, Post to ENDF/A and Broadcast	10/1/22	10/14/22	BNL	
CSEWG Validation Testing	10/15/22	10/31/22	NDAG	
CSEWG Approval of Complete Evaluation	11/1/22	12/31/22	BNL	
Lithium (Li-6)	10/1/20	9/30/24		The Li-6 evaluation in ENDF/B-VIII.0 was based on a combination of EDA R-Matrix fits to all reactions open in the Li-7 system up to ~ 4 MeV, influenced by the standards GMA 2017 result for the (n,t) reaction, and ENDF/B-VII.1 values above ~ 4 MeV. Li-6 is important for a number of reasons, including as a detector (and reference) in experiments, for example, for Chi-Nu measurement of prompt fission neutron spectra. It is important to extend the R-Matrix analysis to the full 20 MeV range for better precision and more complete (covariance information) at the important lower energy scale of a few MeV.
R-Matrix analysis to the full 20 MeV range	10/1/20	TBD	ORNL	
CSEWG Approval of Complete Evaluation	TBD	TBD	BNL	
Phase I Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	9/30/24	BNL	
Molybdenum (Mo-95)	10/1/22	>FY24		
Transmission and Capture Measurements	10/1/22	>FY24	RPI	
Experimentalist Data Reduction and Testing	TBD	TBD	RPI	
Resolved Resonance Region Evaluation	TBD	TBD	RPI/NNL	
Finalize Resonance Evaluation and Deliver to NNDC	TBD	TBD	RPI/NNL	
Phase I Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	>FY24	BNL	
Neptunium (Np-237)	10/1/21	>FY24		
Transmission, Fission, and Capture Measurements (LANL)	10/1/21	9/30/23	ORNL/LANL	Extended to allow more time for measurements to be completed.
Fast Region Evaluation	10/1/23	9/30/24	LANL	
Fast Region Evaluation	TBD	TBD	ORNL	
Finalize Resonance Evaluation and Deliver to NNDC	TBD	TBD	LANL	

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
Phase I Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	>FY24	BNL	
Nitrogen (N-14)	12/30/20	9/30/23		Nitrogen cross section are important in the reprocessing process and related analyses. Nitrogen was recently included as action item in the series of INDEN meetings for light nuclei evaluations. In the ENDF/B-VIII.0 library there are no resonance parameters for nitrogen.
Transmission and Capture Measurements	–	–		
Experimentalist Data Reduction and Testing	–	–		
Resolved Resonance Region Evaluation	12/30/20	9/30/23	ORNL	
Assess Data for URR Evaluation and Complete URR Evaluation				
Phase I Testing, Post to ENDF/A and Broadcast	10/1/23	10/15/23	BNL	
CSEWG Validation Testing	10/15/23	11/1/23	NDAG	
CSEWG Approval of Complete Evaluation	11/1/23	12/30/23	BNL	
Oxygen (O-16)	10/1/13	12/31/21		To be discussed by NDAG in FY2021. Not in App. B tables.
Update evaluation as part of Ceilo Project	<FY19	6/30/21	ORNL	This milestones is based on the availability of the (n,a) measured at LANL. After several years, this data should be ready for release and put some light on the magnitude of the (n,a) reaction channel. Moreover, the quality of this evaluation is also linked to the updates in the SAMMY code regarding the multiple incident channel option.
Finalize Evaluation and Deliver to NNDC	7/1/21	9/30/21	ORNL	
Phase I testing, Post to ENDF/A and Broadcast	10/1/21	10/15/21	BNL	Define post evaluation process
CSEWG Validation Testing	10/15/21	11/1/21	NDAG	
CSEWG Approval of Complete Evaluation(s)	11/1/21	12/31/21	BNL	
Rhodium (Rh-103)	6/30/20	1/1/22		Per App. B evaluation table. Work to be scheduled.
Assess data for Resolved Resonance Region Evaluation	6/30/20	9/30/21	ORNL	IRSN worked on this evaluation (see TPR 2016). Unclear its status.
Finalize Resonance Evaluation and Deliver to NNDC			ORNL	
Phase I Testing, Post to ENDF/A and Broadcast	10/1/21	10/15/21	BNL	Define post process evaluation
CSEWG Validation Testing	10/15/21	11/1/21	NDAG	
CSEWG Approval of Complete Evaluation(s)	11/1/21	1/1/22	BNL	
Plutonium (Pu-239)	10/1/10	9/30/18		IRSN to collaborate with ORNL evaluation work.
Deliver p(nu) Data in ENDF/B format	<FY19	TBD	LANL	

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
Update Prompt Fission Neutron Spectra Based on LANSCE Low-Energy Emission Data	TBD	TBD	LANL	
Deliver Multiplicity-Dependent Fission Spectra	TBD	TBD	LANL	
Deliver Prompt Fission Gamma Spectra	TBD	TBD	LANL	
Update Prompt Fission Neutron Spectra Based on LANSCE High-Energy Emission Data	TBD	9/30/21	LANL	
WPEC SG34 Improved Resonance Evaluation	<FY19	TBD	ORNL	
URR Evaluation using Hwang-Leal Methodology	TBD	TBD	ORNL	
Finalize Resonance Region Evaluation and Deliver to NNDC	TBD	9/30/24	ORNL	
Phase I testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	TBD	BNL	
Evaluate PFNS and to evaluate PFNS and multiplicity consistently, including angular information about prompt neutrons	10/1/20	9/30/21	LANL	
Update Fission Cross-Section Based on TPC Results (based on Pu239/U235 ratio data)	10/1/19	9/30/20	LANL	
Update Evaluation Based on LANL Updates and CSEWG & WPEC Testing	10/1/20	>FY24	ORNL	
Plutonium-240 (Pu-240)	10/1/22	12/30/24		
Prompt fission spectra measurements	10/1/22	9/30/23	LANL	
Resolved Resonance Region Evaluation	10/1/22	9/30/24	ORNL	
Phase I Testing, Post to ENDF/A and Broadcast	10/1/24	10/15/24	BNL	
CSEWG Validation Testing	10/15/24	11/1/24	NDAG	
CSEWG Approval of Complete Evaluation(s)	11/1/24	1/1/24	BNL	
Strontium (Sr-88)	10/1/18	12/31/23		
Transmission and Capture Measurements	10/1/15	9/30/16	ORNL	There are high-enriched Sr-88 capture and transmission available from ORELA. The data have been analyzed but the resonance parameter were not included in the ENDF library. Moreover, for a complete evaluation, also minor isotopes, 86,87-Sr are needed because they represent about 18% of natural strontium.
Experimentalist Data Reduction and Testing	10/1/16	9/30/17	ORNL	
Resolved Resonance Region Evaluation	10/1/17	9/30/18	ORNL	
Assess Data for URR Evaluation and Complete URR Evaluation	10/1/18	9/30/21	ORNL	
Finalize Resonance Evaluation and Deliver to NNDC	10/1/21	10/15/21	ORNL	
Phase I Testing, Post to ENDF/A and Broadcast	10/16/21	10/30/21	BNL	

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
CSEWG Validation Testing	11/1/21	11/15/21	NDAG	
CSEWG Approval of Complete Evaluation	11/16/21	12/30/21	BNL	
Strontium (Sr-86,87)	10/1/24	12/30/28		
Transmission and Capture Measurements (Geel)	10/1/24	9/30/26	ORNL	
Experimentalist Data Reduction and Testing	10/1/26	3/30/27	ORNL	
Resolved Resonance Region Evaluation	4/1/27	9/30/28	ORNL	
Finalize Resonance Evaluation and Deliver to NNDC	10/1/28	10/15/28	ORNL	
Phase I Testing, Post to ENDF/A and Broadcast	10/16/28	10/30/28	BNL	
CSEWG Validation Testing	11/1/28	11/15/28	NDAG	
CSEWG Approval of Complete Evaluation	11/16/28	12/30/28	BNL	
Tantalum (Ta)	10/1/15	12/31/20		ORNL is/was not part of the measurement campaign. However, ORNL is working with RPI to generate an evaluation in the RRR.
Transmission and Capture Measurements	10/1/15	9/30/21	RPI	
Experimentalist Data Reduction and Testing	10/1/21	9/30/22	RPI	
Resolved Resonance Region Evaluation	10/1/18	9/30/22	NNL/ORNL	
Assess Data for URR Evaluation and Complete URR Evaluation			NNL/ORNL	
Finalize Resonance Evaluation and Deliver to NNDC			NNL/ORNL	
Phase I Testing, Post to ENDF/A and Broadcast	10/1/22	10/15/22	BNL	
CSEWG Validation Testing	10/15/22	11/1/22	NDAG	
CSEWG Approval of Complete Evaluation	11/1/22	1/1/23	BNL	
Uranium (U-233)	10/1/20	9/30/24		
Capture Measurements	10/1/20	TBD	ORNL	The measurements will be performed on the basis of the cross section evaluations and the performance with the benchmarks
Experimentalist Data Reduction and Testing	TBD	TBD	ORNL	
Resolved Resonance Region Evaluation	4/1/11	9/30/13	ORNL	
Assess data for Unresolved Resonance Region Evaluation	10/1/13	9/30/14	ORNL	
Finalize Fast Region Evaluation, including new DANCE capture data, and Deliver to NNDC	10/1/22	9/30/24	LANL	
Phase I testing, Post to ENDF/A and Broadcast	10/1/24	10/15/24	BNL	
CSEWG Validation Testing	10/16/24	11/1/24	NDAG	
CSEWG Approval of Complete Evaluations	11/1/24	1/1/25	BNL	

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
Uranium (U-234)	10/1/11	12/31/19		
Finalize Resonance Evaluation and Deliver to NNDC	10/1/11	9/30/14	ORNL	
Phase I testing, Post to ENDF/A and Broadcast	10/1/14	9/30/17	BNL	
CSEWG Validation Testing	10/1/17	12/31/17	NDAG	
CSEWG Approval of Complete Evaluations	10/1/15	12/31/16	BNL	
Revisit capture cross section and covariance based on new DANCE data	4/1/18	3/31/20	LANL	
Update U-234 evaluation based on new capture cross section and deliver to NNDC	10/1/19	9/30/20	LANL	
Uranium (U-235)	10/1/11	12/31/17		
Deliver p(nu) Data in ENDF/B Format	10/2/12	9/30/13	LANL	
Deliver Multiplicity-Dependent Fission Spectra	10/2/13	9/30/14	LANL	
Deliver Prompt Fission Gamma Spectra	10/1/14	3/31/16	LANL	
Review the evaluation of U-235 capture and fission cross sections based on new measurements at LANSCE	4/1/16	9/30/17	LANL	
Resolved Resonance Capture Evaluation Per WPEC SG29 Recommendations	10/1/11	9/30/14	ORNL	
CSEWG Validation Testing	10/1/14	9/30/17	NDAG	
CSEWG Approval of Complete Evaluation(s)	10/1/17	12/31/17	BNL	
Update Prompt Fission Neutron Spectra Based on LANSCE Low-Energy Emission Data	10/1/15	9/30/18	LANL	
Update Prompt Fission Neutron Spectra Based on LANSCE High-Energy Emission Data	10/1/15	9/30/18	LANL	
Use CGMF to evaluate PFNS and multiplicity consistently, including angular information about prompt neutrons	4/1/19	9/30/20	LANL	
Revisit fission cross section and covariance evaluation based on new TPC data	10/1/18	9/30/19	LANL	
Develop consistent evaluation of fission yields, neutron multiplicity, and spectra from thermal to 20 MeV	10/1/19	9/30/21	LANL	
Revisit elastic and inelastic cross sections based on planned LANSCE experiments	10/1/20	9/30/22	LANL	
Uranium (U-236)	10/1/11	12/31/18		

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
Revisit capture cross section and covariance based on new DANCE data	4/1/17	9/30/18	LANL	
Update U-236 evaluation based on new capture cross section and deliver to NNDC	10/1/18	3/31/19	LANL	
Uranium (U-238)	10/1/12	2/28/17		
Unresolved Resonance Region Evaluation Using the Hwang-Leal Methodology	10/1/13	12/31/15	ORNL	
Finalize URR Evaluation and Deliver to NNDC	1/1/16	1/1/16	ORNL	
Deliver p(nu) Data in ENDF/B Format	10/1/12	9/30/13	LANL	
Deliver Multiplicity-Dependent Fission Spectra	10/1/13	9/30/14	LANL	
Deliver Prompt Fission Gamma Spectra	10/1/14	3/31/16	LANL	
Phase I Testing, Post to ENDF/A and Broadcast	1/1/16	1/15/16	BNL	
CSEWG Validation Testing	1/16/16	12/31/16	NDAG	
CSEWG Approval of Complete Evaluation(s)	1/1/17	2/28/17	BNL	
Revisit fission cross section and covariance evaluation based on new TPC data (based on U238/U235 ratio data)	10/1/17	9/30/19	LANL	
Finalize Prompt Fission Neutron Spectra Based on LANSCE Chi-Nu Data	10/1/18	9/30/20	LANL	
Use CGMF to evaluate PFNS and multiplicity consistently, including angular information about prompt neutrons	10/1/20	9/30/21	LANL	
Vanadium (V-51)	10/1/14	12/31/18		Additional task for measurement was described above
Complete Resonance Region Capture Measurements (Geel)	12/30/21	9/30/22	ORNL	
Perform SAMMY Analysis	12/30/22	9/30/23	ORNL	The evaluation work should be started on the basis on the additional needed measurements
Resolved Resonance Region Evaluation for V-50, 51	FY19 Q3	FY20 Q4		
Assess data for Unresolved Resonance Region Evaluation	10/2/17	9/30/18	ORNL	
Finalize Resonance Evaluation and Deliver to NNDC	9/30/18	9/30/18	ORNL	
Phase I Testing, Post to ENDF/A and Broadcast	10/1/18	10/15/18	BNL	
CSEWG Validation Testing	10/16/18	10/31/18	NDAG	
CSEWG Approval of Complete Evaluation(s)	11/1/18	12/31/18	BNL	

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
Zirconium (Zr-90,91,92,94,96)	9/30/14	12/30/24		
Deliver Updated High-Energy Evaluation of Zr-90	10/1/14	9/30/15	LANL	
Phase I Testing, Post to ENDF/A and Broadeast	10/1/15	10/15/15	BNL	
CSEWG Validation Testing	10/16/15	10/31/16	NDAG	
CSEWG Approval of Complete Evaluations	11/1/16	12/31/16	BNL	
Transmission and Capture Measurements	3/30/20	3/30/25	ORNL	
Experimentalist Data Reduction and Testing			ORNL	
Resolved Resonance Region Evaluation	3/30/21	6/30/26	ORNL	
Assess Data for URR Evaluation and Complete URR Evaluation	TBD	TBD	ORNL	
Finalize Resonance Evaluation and Deliver to NNDC	TBD	TBD	ORNL	

B-2 Differential Measurements and Evaluations – Compounds
(The following list provides the specific GANTT chart to refer to for each element work schedule)

- Hydraulic Fluid (Silicone Oil)
- Hydrofluoric Acid (HF)
- Paraffin (C_nH_{2n+2})
- Plutonium Hydride (PuH_{2+x})
- Plutonium Oxide (PuO_2)
- Polyethylene (CH_2)
- Uranium Carbide (UC)
- Uranium Fluoride (UO_2F_2)
- Uranium Hexafluoride (UF_6)
- Uranium Oxide (U_3O_8)
- Uranium Silicide (U_3Si_2)
- Water (H_2O)

<u>Completed Work</u>

- Lucite ($C_5O_2H_8$)
- Polyethylene $(CH_2)_n$
- Beryllium (metal)
- Beryllium Oxide (BeO)
- Crystal Graphite
- Reactor Graphite
- Silicon Carbide (SiC)
- Silicon Dioxide (SiO_2)
- Uranium Dioxide (UO_2)
- Uranium Nitride (UN)
- Hexagonal Ice (H_2O) – evaluated by NNL
- Yttrium Hydride (YH_2) – evaluated by NNL
- FLiBe liquid
- Paraffinic Oil

Table B-2. Differential Measurements and Evaluations - Compounds

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
Water (H2O)	10/1/16	12/31/20		
Thermal Scattering Measurements	TBD	TBD	NCSU	
Thermal Scattering Evaluation	TBD	TBD	NCSU	
Finalize and Deliver Evaluation to NNDC	TBD	TBD	NCSU	
Phase 1 Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	12/31/20	BNL	
Hydrofluoric Acid (HF)	10/1/15	12/31/19		Unchanged from FY2019
Thermal Scattering Measurements	10/1/15	9/30/16	NCSU	
Thermal Scattering Evaluation	10/3/16	9/30/18	NCSU	
Finalize and Deliver Evaluation to NNDC	10/1/18	10/1/18	NCSU	
Phase 1 Testing, Post to ENDF/A and Broadcast	10/1/18	10/15/18	BNL	
CSEWG Validation Testing	10/16/18	10/31/19	NDAG	
CSEWG Approval of Complete Evaluation	11/1/19	12/31/19	BNL	
Uranium Hexafluoride (UF6)	10/1/23	12/31/24		
Thermal Scattering Measurements	TBD	TBD	NCSU	
Thermal Scattering Evaluation	TBD	TBD	NCSU	
Finalize and Deliver Evaluation to NNDC	TBD	TBD	NCSU	
Phase 1 Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	12/31/21	BNL	
Hydraulic Fluid (Silicone Oil)	10/1/19	12/31/23		Updated based on FY2019 GANTT Chart Data
Thermal Scattering Evaluation	10/1/20	9/30/22	NCSU	
Finalize and Deliver Evaluation to NNDC	9/30/22	10/1/22	NCSU	
Phase 1 Testing, Post to ENDF/A and Broadcast	10/1/22	10/15/22	BNL	
CSEWG Validation Testing	10/15/22	10/31/23	NDAG	
CSEWG Approval of Complete Evaluation	11/1/23	12/31/23	BNL	
Paraffin (CnH2n+2)	10/1/20	12/31/23		

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
Thermal Scattering Measurements	TBD	TBD	NCSU	
Thermal Scattering Evaluation	TBD	TBD	NCSU	
Finalize and Deliver Evaluation to NNDC	TBD	TBD	NCSU	
Phase 1 Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	12/31/23	BNL	
Triuranium Octoxide (U3O8)	10/1/21	9/30/24		Modified to be consistent with Appendix B table.
Thermal Scattering Measurements	TBD	TBD	NCSU	
Thermal Scattering Evaluation	TBD	TBD	NCSU	
Finalize and Deliver Evaluation to NNDC	TBD	TBD	NCSU	
Phase 1 Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	9/30/24	BNL	
Uranyl Fluoride (UO2F2)	10/1/19	12/31/21		
Thermal Scattering Measurements	TBD	TBD	NCSU	
Thermal Scattering Evaluation	TBD	TBD	NCSU	
Finalize and Deliver Evaluation to NNDC	TBD	TBD	NCSU	
Phase 1 Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	12/31/21	BNL	
Uranium Silicide (U3Si2)	10/1/23	12/31/24		
Thermal Scattering Measurements	TBD	TBD	NCSU	
Thermal Scattering Evaluation	TBD	TBD	NCSU	
Finalize and Deliver Evaluation to NNDC	TBD	TBD	NCSU	
Phase 1 Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	12/31/24	BNL	
Uranium Carbide (UC)	10/1/23	12/31/24		
Thermal Scattering Measurements	TBD	TBD	NCSU	
Thermal Scattering Evaluation	TBD	TBD	NCSU	

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
Finalize and Deliver Evaluation to NNDC	TBD	TBD	NCSU	
Phase 1 Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	12/31/24	BNL	
Plutonium Oxide (PuO2)	10/1/23	12/31/24		Per App. B evaluation table.
Thermal Scattering Measurements	TBD	TBD	NCSU	
Thermal Scattering Evaluation	TBD	TBD	NCSU	
Finalize and Deliver Evaluation to NNDC	TBD	TBD	NCSU	
Phase 1 Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	12/31/24	BNL	Per App. B evaluation table.
Uranium Hydride (UH3)	10/1/23	12/31/24		
Thermal Scattering Measurements	TBD	TBD	NNL	
Thermal Scattering Evaluation	TBD	TBD	NNL	
Finalize and Deliver Evaluation to NNDC	TBD	TBD	NNL	
Phase 1 Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	12/31/24	BNL	
Plutonium Hydride (PuH2+x)	10/1/24	>FY24		
Thermal Scattering Measurements	TBD	TBD	NNL	
Thermal Scattering Evaluation	TBD	TBD	NNL	
Finalize and Deliver Evaluation to NNDC	TBD	TBD	NNL	
Phase 1 Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	
CSEWG Approval of Complete Evaluation	TBD	>FY24	BNL	
Uranium Silicide (U3Si2)	10/1/23	12/31/24		
Thermal Scattering Measurements	TBD	TBD	NCSU	
Thermal Scattering Evaluation	TBD	TBD	NCSU	
Finalize and Deliver Evaluation to NNDC	TBD	TBD	NCSU	
Phase 1 Testing, Post to ENDF/A and Broadcast	TBD	TBD	BNL	
CSEWG Validation Testing	TBD	TBD	NDAG	

Isotope(s)	Start Date	End Date	Responsible Laboratory	Comments
CSEWG Approval of Complete Evaluation	TBD	12/31/24	BNL	
[redacted]				
Polystyrene (C8H8)	10/1/19	12/30/23		Polystyrene is a moderator material found in several thermal systems (PCT-001, -002; MCT-012, -013, -014, -016). Currently, polyethylene is used as a surrogate in neutron transport codes to represent the thermal scattering of polystyrene. This measurement and evaluation will determine the validity of that approximation, as well as inform future substitutions for other hydrocarbons found in benchmarks.
Procure Sample	10/1/19	6/30/20	ORNL	
Write Proposal for Beamtime	3/30/20	3/30/20	ORNL	
Experiment Preparations	6/30/20	6/30/20	ORNL	
Thermal Scattering Measurements (Ensuring correct energies, temperatures, sample thickness, etc.)	9/30/20	12/30/20	ORNL	
Data Reduction & Analysis	12/30/20	9/30/21	ORNL	
Thermal Scattering Evaluation	12/30/20	9/30/21	ORNL	
Finalize and Deliver Evaluation to NNDC	9/30/21	10/15/21	ORNL	
Phase 1 Testing, Post to ENDF/A and Broadcast	10/15/21	11/1/21	BNL	
CSEWG Validation Testing	11/15/21	12/1/21	NDAG	
CSEWG Approval of Complete Evaluation	12/1/21	12/30/21	BNL	

Appendix C

Fiscal Year 2020 Projected Foreign Travel

Destination	Date	Labs	Count	Costs ($)	One Sentence Description	Task	Milestone	Justification
OECD/NEA Paris, France	Oct-19	LANL (6) LLNL (3) SNL (2) **(FY20 5YP, Rev. 2)**	11	55,000	ICSBEP, IRPhE, and SINBAD Technical Review Meetings (Ames, Cutler, Hutchinson, Amundson, McKenzie, Thompson, McSpaden, Sanchez, Goda, Harms, Heinrichs, Kim, Percher, Smith,)	IE, IP&D, TS3, TS4, TS5, TS7	Provide brief trip summary report to NCSP Manager (Q2).	ICSBEP, IRPhE, and SINBAD Technical Review Meetings.
CNEA Buenos Aires, Argentina	Nov-19	LLNL (1)	1	5,000	International Conference on Research Reactors (Coleman)	IE	Provide brief trip summary report to NCSP Manager (Q2)	Premiere conference on research reactors hosted by IAEA.
Cambridge, UK	Mar-Apr-20	LLNL (3)	3	15,000	International Conference on the Physics of Reactors, PHYSOR 2020 (Heinrichs, Percher, Nelson)	IE1	Provide brief trip summary report to NCSP Manager (Q4)	Premiere international conference on reactor physics.
Chiba, Japan	May-20	LLNL (2)	2	10,000	Joint International Conference on Supercomputing in Nuclear Applications and Monte Carlo (Kim, Norris)	AM, IE	Provide brief trip summary report to NCSP Manager (Q4)	Premier conference on analytical methods and computing.
OECD/NEA Paris, France	May-20	LLNL (2)	2	10,000	WPEC Meeting (Heckmaier, Percher)	IE, ND, TS5	Provide brief trip summary report to NCSP Manager (Q4).	Technical meeting of international experts on nuclear data including SG38 (GND) and SG42 (Thermal scattering law).
OECD/NEA Paris, France	Jun-19	LLNL (2)	2	10,000	WPNCS Meeting (Percher, Scorby)	IPD1 TS5	Provide brief trip summary report to NCSP Manager (Q4).	Participate in activities of the Working Party on Nuclear Criticality Safety and expert group meetings on MC methods and excursion analyses.
Aldermaston, United Kingdom	TBD	LLNL (2)	2	10,000	JOWOG29/30 Meetings (Coleman, Zywiec)	AM, IE, I&D, ND, T&E, TS5	Provide brief trip summary report to NCSP Manager (Q4).	Coordinate joint AWE-LLNL work as described in Appendix F of the Five Year Execution Plan.
Paris, France	TBD	LLNL (2)	2	10,000	Coordinate International Collaboration Efforts with IRSN (Coleman, Percher)	AM, IE, IP&D, ND, TS5	Provide brief trip summary report to NCSP Manager (Q4).	Coordinate joint IRSN-LLNL work as described in Appendix E of the Five Year Execution Plan.

Destination	Date	Labs	Count	Costs ($)	One Sentence Description	Task	Milestone	Justification
OECD/NEA Paris, France	May-20	NDAG Chair	1	5,000	Participate in WPEC annual meeting (Zerkle)	NCSP-TS9	Provide brief trip summary report to NCSP Manager (Q3).	As NDAG Chair, participate in WPEC.
OECD/NEA Paris, France	Oct-19	NDAG Chair	1	5,000	ICSBEP and IRPhE Technical Review Meetings (Zerkle)	NCSP-TS9	Provide brief trip summary report to NCSP Manager (Q2).	Provide oversight of NCSP IE tasks as ICSBEP tasks are the end product of the NCSP IE process.
Cambridge, England	Apr-20	NDAG	1	5,000	Attend PHYSOR 2020 meeting of the ANS. NCSP task that travel. (Zerke)	NCSP TS9	Provide brief trip summary report to NCSP Manager (Q3).	Present paper on thermal neutron scattering.
OECD/NEA Paris, France	May-19	RPI	2	10,000	Participate in WPEC, and WPEC (Danon, Lui)	ND1 ND2	Provide brief trip summary report to NCSP Manager (Q3).	As US Measurements Chair, participate in WPEC and SG-40 annual meeting to present NCSP/RPI nuclear data measurement work. Participate in SG-?? (thermal scattering meeting) to present NCSP/RPI thermal scattering measurements and analysis.
OECD/NEA Paris, France	May-20	LANL	2	12,000	Attend annual WPEC meeting and associated Sub-Group meetings (Conlin, Haeck)	AM2	Provide brief trip summary report to NCSP Manager (Q3).	Contributor to multiple sub-groups-Conlin co-leads SG43; Haeck leads SG45.
OECD/NEA Paris, France	TBD	LANL	1	5,000	The NEA/WPEC Subgroup 38 is developing a modern nuclear database (XML) structure. The light-element evaluations must be coded in this structure and LANL personnel have been corresponding via email and phone meetings on the development of appropriate data structures to hold the R-matrix parameters for GNDS (Paris)	ND1	Provide brief trip summary report to NCSP Manager (Q3).	Contributor to multiple sub-groups-Paris co-leads SG38.
OECD/NEA Paris, France	TBD	LANL	1	5,000	The NEA/WPEC Subgroup 45 is "Validation of Nuclear Data Libraries (VaNDaL) Project." The goal of the Subgroup is to standardize quality assurance (QA) processes that would lead to reliable, standardized, and commonly available benchmark	ND1	Provide brief trip summary report to NCSP Manager (Q3).	Contributor to multiple sub-groups-Herman co-leads SG45.

Destination	Date	Labs	Count	Costs ($)	One Sentence Description	Task	Milestone	Justification
					suites for the reproducible validation of nuclear data libraries (Herman)			
OECD/NEA Paris, France	TBD	LANL	1	5,000	The NEA/WPEC Subgroup 46 is "Efficient and Effective Use of Integral Experiments for Nuclear Data Validation." This activity is of particular relevance to the objective to improve future data files using synergies from different nuclear data projects, while focusing on the requirements for specific new experimental programs and effectively accounting for users data needs (Herman)	ND1	Provide brief trip summary report to NCSP Manager (Q3).	Contributor to multiple sub-groups- Herman co-leads SG46.
Cambridge, England	Apr-20	LANL	3	18,000	Attend PHYSOR 2020 meeting of the ANS. NCSP task that travel is performed under: LANL AM2 (Conlin, McKenzie, Hutchinson)	AM2 IE3	Provide brief trip summary report to NCSP Manager (Q3).	Present NJOY updates and improvements Present research results.
Vienna, Austria	TBD	LANL	2	12,000	Consultancy meeting at IAEA (Conlin, Haeck)	AM2	Provide brief trip summary report to NCSP Manager (Q3).	Participate in IAEA consultancy meeting on ACE processing
OECD/NEA Paris, France	Jul-20	LANL	2	16,000	OECD Expert Group Meetings for NCSP, collaboration with IRSN on NCS (Brown, Rising)	AM1	Provide brief trip summary report to NCSP Manager (Q3).	Participation provides state-of-art information for improving MCNP®, Whisper, and other computational methods that are necessary and heavily used in NCSP work. In addition this allows for direct collaboration with IRSN.
OECD/NEA Paris, France	Oct.-19	ORNL	2	12,000	ICSBEP and IRPhE Technical Review Meetings (Bowen, Marshall)	TS1 IE AM2	Provide brief trip summary report to NCSP Manager (Q2).	Provide oversight of NCSP IE tasks as ICSBEP tasks are the end product of the NCSP IE process.
Cambridge, England	Apr-20	ORNL	2	12,000	Attend PHYSOR 2020 meeting of the ANS. (Bowen, Greene)	AM2	Provide brief trip summary report to NCSP Manager (Q3).	Present papers for ANS subcritical limits and progress on GA Tech NCSP tasks.

Destination	Date	Labs	Count	Costs ($)	One Sentence Description	Task	Milestone	Justification
IRMM Mol, Belgium	Jan-19 Apr-19 Jun-19 Sep-19	ORNL	1	65,000	Perform resonance region nuclear data measurements using GELINA facility at IRMM in accordance with Appendix B of the Five-Year Plan (Guber)	ND TS7	Provide brief trip summary report to NCSP Manager (Q4).	Continues cross-section measurements to support the production of new cross-section evaluations per the schedule in Appendix B of the Five-Year Plan.
Aldermaston, United Kingdom	TBD	ORNL	1	6,000	JOWOG29/30 Meetings (Bowen)	TS	Provide brief trip summary report to NCSP Manager (Q4).	Coordinate NCSP work as described in Appendix F of the Five Year Execution Plan. Bowen invited to participate.
London, UK or Paris, FR	Sep-20	ORNL	1	8,000	ISO TC85/SC5 Plenary and WG8 Nuclear Criticality Safety Meetings (Bowen)	NCSP-TS1	Provide brief trip summary report to NCSP Manager (Q3).	Continue to provide US leadership with ISO Nuclear Criticality Safety Standards
OECD/NEA Paris, France	Jun-20	ORNL	3	18,000	Participate in WPEC annual meeting, coordinate international nuclear data collaborations for the NCSP, and present NCSP/ORNL nuclear data evaluation work (Sobes, Pigni, Wiarda)	ND1, TS	Provide brief trip summary report to NCSP Manager (Q3).	Technical meeting of international experts on nuclear data including SG38 (GND), EG-GNDS, SG42 (thermal scatter), SG44 (covariance), SG45 (validation), SG46 (IE for ND evaluation)
Vienna, Austria	TBD	ORNL	2	10,000	Participate in IAEA working group meeting to improve nuclear data evaluations to support new evaluations of interest to the NCSP (Sobes, Pigni)	ND1	Provide brief trip summary report to NCSP Manager (Q3).	IAEA International Nuclear Data Evaluation Network (INDEN), Vienna, 1 week. International nuclear data evaluation collaboration. Represent NCSP and ORNL interests in international nuclear data evaluation.
OECD/NEA Paris, France	TBD	ORNL	4	20,000	WPNCS Meetings (Marshall, Bowen, Clarity, Wieselquist)	TS1, IE, AM2	Provide brief trip summary report to NCSP Manager (Q4).	AM collaboration; provide relationship between IAEA and ISO with respect to NCS standards.
Paris, France	TBD	ORNL	3	15,000	IRSN Meetings (Sobes, Wiarda, Holcomb)	AM, IE, IP&D, ND1, TS7	Provide brief trip summary report to NCSP Manager (Q3).	Coordinate joint IRSN-ORNL work per 5YP such as the Pu SlideRule; Collaborate with IRSN on the resonance evaluation of the isotopes of lead for the NCSP.
Tokyo, JP **(FY20 5YP, Rev. 2)**	Sep-20	ORNL	2	15,000	5th International Conference on Nuclear Data Covariances (Holcomb, Arbanas or Pigni)	ND1, TS	Provide brief trip summary report to NCSP Manager (Q4).	This conference is within the mission of ORNL ND work and aligned with the NCSP Mission and Vision.

NOTE: The above projected foreign travel meetings have been confirmed as technical working group meetings and not as conferences.

Appendix D

Baseline Budget Needs for Execution Year FY2020

Baseline budget need for the FY2020 Nuclear Criticality Safety Program (NCSP) is $26,887K with 95% of funding supporting NCSP FTE's, equating to approximately 55 national laboratory or facility contractor employees, who provide programmatic needs as outlined in the NCSP *The Mission and Vision of the United States Department of Energy Nuclear Criticality Safety Program for the Fiscal Years 2019-2028.* All tasks are approved based on their contribution to the achievement of the five- and ten-year goals as outlined in the Mission and Vision document.

NCSP includes the following five technical program elements plus support infrastructure, with each having the major deliverables for FY2020:

- Analytical Methods
  - Criticality Safety Computer Codes SCALE and MCNP support. Maintain Radiation Safety Information Computational Center who distributes all software. Also, development of updated Criticality SlideRule capability. ~8 FTEs supported. International collaborations: SCALE, NJOY, MCNP, AMPX work with AWE and IRSN.
- Information Preservation and Dissemination
  - NCSP website upgrade and maintenance. Four new ICSBEP evaluations and publications (OECD collaboration). Provide experimental uncertainty correlations.
- Integral Experiments
  - Execution of ~25 critical/subcritical experiment and 6 critical/subcritical experiment evaluations published (NCERC and SNL). ~26 FTEs supported. Permanent party staff supported. Control System upgrades needed. International collaborations: TEX experiments with IRSN and AWE, CAAS experiment design and execution for Y-12 with AWE and IRSN involvement.
  - The NCSP will complete benchmark publication activities for the KRUSTY "cold" and "hot" critical and delayed supercritical experiments.
  - Additional funding requirement to fund both Laboratory logistics costs and NNSS safety basis work.
- Nuclear Data
  - Nuclear data evaluations and measurements documented prioritized in FY2020 are shown in Appendix B. RPI refurbishment (NR collaboration) continues despite some cost overruns for ancillary equipment. Produce new scattering law data (NCSU and RPI collaboration). Modernization of SAMMY resonance analysis software. ~9 FTEs supported. International collaborations: Data testing and evaluations with AWE and IRSN. Measurements with IRMM.
- Training and Education
  - Two 2-week courses at NNSS/NCERC/Sandia. One 2-week course at Y-12/NCERC may be necessary to support new NCS staff undergoing training and qualification.
  - One 1-week managers course at Sandia. This course will be used to pilot new Criticality Safety Officer (CSO) training material.
  - One 1-week managers course at NCERC. This course will be used to pilot new training material.
- NCSP Technical Support: CSSG. NDAG. Succession Planning for key areas of NCSP expertise, including CSSG. ORNL management support. ~2 FTEs supported.

The approved Over target budget for FY2020 NCSP is $1.05M that would support 5 additional high priority tasks to address key Mission and Vision goals not addressed within the current budget target:

- Develop and deploy a mobile (CAT III or IV) critical/near critical hands-on demo capability ($200K)
- NCERC Integral Experiments Backlog and new Np experiment ($350K)
- Non-destructive Assay Technical Support Group ($300K)
- Expand radiochemistry laboratory capabilities at NNSS ($100K)
- Computer code (MCNP and SCALE) NCS analysis capability modernization ($100K)

Baseline Budget Needs for Execution Year FY2021

Baseline budget need for the FY2019 Nuclear Criticality Safety Program (NCSP) is $29,126K with 95% of funding supporting NCSP FTE's, equating to ~57 national laboratory or facility contractor employees, who provide programmatic needs as outlined in the NCSP *The Mission and Vision of the United States Department of Energy Nuclear Criticality Safety Program for the Fiscal Years 2019-2028.* All tasks are approved based on their contribution to the achievement of the five- and ten-year goals as outlined in the Mission and Vision document.

NCSP includes the following five technical program elements plus support infrastructure, with each having the major deliverables for FY2021:

- Analytical Methods
  - Criticality Safety Computer Codes SCALE and MCNP support. Maintain Radiation Safety Information Computational Center who distributes all software. Development of NCS excursion analysis capability, including an updated Criticality SlideRule capability. ~9 FTEs supported. International collaborations: SCALE, NJOY, MCNP, AMPX work with AWE and IRSN.
- Information Preservation and Dissemination
  - NCSP website upgrade and maintenance. ~2 FTEs supported. Three ICSBEP evaluations and publications (OECD collaboration). Provide experimental uncertainty correlations.
- Integral Experiments
  - Execution of ~20 critical/subcritical experiment and 6 critical/subcritical experiment evaluations published (NCERC and SNL). ~27 FTEs supported. Permanent party staff supported. Initiate design efforts for neptunium and Jezebel critical experiments. DSA changes and facility modifications for pneumatic rabbit system and NAD lab construction. International collaborations: TEX experiments with IRSN and AWE, CAAS experiment design with AWE, IRSN, Japan, SNL experiment design and execution with IRSN.
- Nuclear Data
  - Nuclear data evaluations and measurements documented prioritized in FY2021 are shown in Appendix B. RPI refurbishment (NR collaboration). Produce new scattering law data (NCSU and RPI collaboration). Modernization of SAMMY resonance analysis software. ~10 FTEs supported. International collaborations: Data testing and evaluations with AWE and IRSN. Measurements with IRMM.
- Training and Education
  - Two 2-week courses at NNSS/NCERC/Sandia.
  - One 1-week managers/criticality safety officer course at Sandia.
  - One 1-week managers/criticality safety officer course at NCERC.
- NCSP Technical Support: CSSG. NDAG. Succession Planning for key areas of NCSP expertise. ORNL management support. ~2 FTEs supported.

The approved Over target budget for FY2021 NCSP is $0.35M that would support one high priority task to address key Mission and Vision goals not addressed within the current budget target:

- Radiation Safety Information Computational Center (RSICC) to support code package distribution costs for university students ($350K)

Baseline Budget Needs for Execution Year FY2022

Baseline budget need for the FY2022 Nuclear Criticality Safety Program (NCSP) is $29,648K with 95% of funding supporting NCSP FTE's, equating to approximately 58 national laboratory or facility contractor employees, who provide programmatic needs as outlined in the NCSP *The Mission and Vision of the United States Department of Energy Nuclear Criticality Safety Program for the Fiscal Years 2019-2028.* All tasks are approved based on their contribution to the achievement of the five- and ten-year goals as outlined in the Mission and Vision document.

NCSP includes the following five technical program elements plus support infrastructure, with each having the major deliverables for FY2022:

- Analytical Methods
  - Criticality Safety Computer Codes SCALE and MCNP support. Maintain Radiation Safety Information Computational Center who distributes all software. Development of NCS excursion analysis capability, including an updated Criticality SlideRule capability. ~10 FTEs supported. International collaborations: SCALE, NJOY, MCNP, AMPX work with AWE and IRSN.
- Information Preservation and Dissemination
  - NCSP website upgrade and maintenance. Several new ICSBEP evaluations and publications (OECD collaboration) possible. ~2 FTEs supported. Provide experimental uncertainty correlations.
- Integral Experiments
  - Execution of ~18 critical/subcritical experiment and 9 critical/subcritical experiment evaluations published (NCERC and SNL). ~29 FTEs supported. Permanent party staff supported. Continue efforts to design and execute neptunium and Jezebel critical experiments. DSA changes and facility modifications for pneumatic rabbit system and NAD lab construction. International collaborations: TEX experiments with IRSN and AWE, CAAS experiment design with AWE, IRSN, Japan, SNL experiment design and execution with IRSN.
- Nuclear Data
  - Nuclear data evaluations and measurements documented prioritized in FY2022 are shown in Appendix B. RPI refurbishment (NR collaboration). Produce new scattering law data (NCSU and RPI collaboration). Modernization of SAMMY resonance analysis software ~9 FTEs supported. International collaborations: Data testing and evaluations with AWE and IRSN. Measurements with IRMM.
- Training and Education
  - Two 2-week courses at NNSS/NCERC/Sandia.
  - One 1-week managers course at Sandia.
  - One 1-week managers course at NCERC.
  - One 1-week CSO course at NCERC or Sandia.
- NCSP Technical Support: CSSG. NDAG. Succession Planning for key areas of NCSP expertise. ORNL management support. ~2 FTEs supported.

Appendix E

International Collaboration with the Institut de Radioprotection et de Sûreté Nucléaire (IRSN) for FY2020

IRSN has an active and growing program of collaboration with the NCSP that aims to underpin and enhance IRSN's nuclear criticality safety. IRSN will provide its expertise and capabilities to support the NCSP's mission and vision so that the collaboration is mutually beneficial to both organizations.

	REFERENCE		IRSN Contribution / POC			
IRSN Reference	**Task Title**	**DOE Reference**	**FY 2020 IRSN Contribution**	**IRSN Technical POC**	**DOE Technical POC**	**DOE LAB**
Analytical Methods						
IRSN-AM1	Validation and qualification methods	ORNL-AM2 ORNL-IPD4	Determination of the experimental correlations of MIRTE 1 experiments. To be discussed with ORNL.	I. DUHAMEL	D. BOWEN	ORNL
IRSN-AM5	Update of the slide rule	ORNL-AM6 LLNL-AM3 AWE-AM1	Subtask 2 of IRSN proposal Update of the "slide rule" for the rapid response estimation of a criticality accident (using COG, MCNP, MAVRIC, ATTILA…).	M. DULUC	D. BOWEN D. HEINRICHS R. JONES	ORNL LLNL AWE
IRSN-AM7	ACE QA testing and implementation	LANL-AM2	Implementation of the defined QA tests in ACEtk and integration in GAIA	L. LEAL	J. CONLIN	LANL
IRSN-AM8	Analytical Methods Working Group	NCSP-TS2	IRSN participation to NCSP analytical methods Working Group and IRSN participation to TPR meeting	S. EVO	F. BROWN D. BOWEN	NCSP
IRSN-AM9	Cross sections processing validation	ORNL-AM3	Development of an interface between GAIA and AMPX and test interface capabilities.	R. ICHOU	D. WIARDA D. BOWEN	ORNL
IRSN-AM13	Benchmark intercomparison study	LLNL-AM5 ORNL-AM10 LANL-AM5	Definition of common set of developed benchmark models Calculations for Pu and HEU systems. (Completion of this task before ORNL-AM9 and LANL-AM4 would be useful to identify common benchmarks.) IEU and LEU systems will be included in FY 2020.	I. DUHAMEL	D. HEINRICHS D. BOWEN F. BROWN	LLNL ORNL LANL

	REFERENCE		IRSN Contribution / POC			
IRSN Reference	**Task Title**	**DOE Reference**	**FY 2020 IRSN Contribution**	**IRSN Technical POC**	**DOE Technical POC**	**DOE LAB**
IRSN-AM14	Sensitivity/Uncertainty comparison study with a focus on Upper Subcritical Limits	ORNL-AM9 LANL-AM4	Definition of three test cases Calculations and intercomparison technical report	I. DUHAMEL	F. BROWN D. BOWEN	LANL ORNL
IRSN-AM15	MCNP Maintenance and Support / Uncertainty Analysis Development / Modernization / etc.	LANL-AM1	Interest for uncertainty analysis, source convergence development and modernization strategy	E. DUMONTEIL	F. BROWN	LANL
IRSN-AM17	Technical Data for the Pitzer Formulation of Solution Compositions to Include Uranium/Plutonium Solutions with Selected Admixed Absorbers	ORNL-AM16 LANL-AM6 LLNL-AM7	Contribution to measurements definition. Comparison of density laws (isopiestic law for instance)…	N. LECLAIRE	D. BOWEN	ORNL
Integral Experiments						
IRSN-IE1 **IER 184**	TEX - Ta experiment	LLNL-IE4	Sensitivity/uncertainty calculations Contribution to the evaluation of the first experiments.	M. BROVCHENKO	C. PERCHER	LLNL
IRSN-IE3 **IER 209**	New 7uPCX experiment	SNL-IE1	Contribution to ICSBEP reevaluation.	N. LECLAIRE	G. HARMS	SNL
IRSN-IE6 **IER 306**	Rh foils experiment	SNL-IE1	IRSN proposal: preliminary evaluation of experimental uncertainties prior to the experiment's CED-2 report.	N. LECLAIRE	G. HARMS	SNL
IRSN-IE7 **IER 305**	Mo foils and rods experiment	SNL-IE1	IRSN proposal: Leading the CED-3a report; Supplying the Mo rods for the experiment.	N. LECLAIRE	G. HARMS	SNL
IRSN-IE8 **IER 451**	Ti experiment	SNL-IE1	Analysis of the experiments Comparison with MIRTE program	N. LECLAIRE	G. HARMS	SNL
IRSN-IE11 **IER 297**	TEX - Hf experiment	LLNL-IE4	Contribution to Jemina plates characterization. Contribution to CED report.	M. BROVCHENKO	C. PERCHER	LLNL
IRSN-IE19	Solution reactor	Y12-IE2	Strong IRSN interest for participation in the design, specification… of a solution reactor	M. DULUC	P. ANGELO	Y-12
IRSN-IE25 **IER 296**	TEX - MOX experiment	LLNL-IE4	IRSN leads this proposal for design and will author the CED-1 & 2 reports with LLNL support. Characterization of moderator and reflector plates. IRSN contribution to the moderator and reflector plates funding.	M. BROVCHENKO	C. PERCHER	LLNL

	REFERENCE		IRSN Contribution / POC			
IRSN Reference	**Task Title**	**DOE Reference**	**FY 2020 IRSN Contribution**	**IRSN Technical POC**	**DOE Technical POC**	**DOE LAB**
IRSN-IE26 **IER 295**	TEX - Iron experiment	LLNL-IE4	Contribution to the experiments design. Contribution to CED reports and review.	M. BROVCHENKO	C. PERCHER	LLNL
IRSN-IE27 **IER ~~175~~498**	GODIVA CAAS benchmark	ORNL-IE4	Participation in the design. Provide IRSN materials for irradiation, analysis of results.	M. DULUC	D. BOWEN	ORNL
IRSN-IE28 **IER 406**	Cf-252 CAAS benchmark	LLNL-IE1	Participation in the design. Provide IRSN materials for irradiation, analysis of results	M. DULUC F. TROMPIER	D. HEINRICHS	LLNL
IRSN-IE29	Correction factor for dosimetry linked to the orientation of the victim	LLNL-IE1 AWE-IE7	Participation in the design. Provide IRSN materials for irradiation, analysis of results.	M. DULUC F. TROMPIER	D. HEINRICHS D. STONE	LLNL AWE
IRSN-IE30 **IER 513**	Full dosimetry exercise around GODIVA/FLATTOP reactors or TRIGA (AFFRI)	LLNL-IE1	Participation in the design. Provide IRSN materials for irradiation, analysis of results	M. DULUC F. TROMPIER	D. HEINRICHS	LLNL
IRSN-IE33	Sodium activation experiment around GODIVA/FLATTOP	LLNL-IE1	Participation in the design. Provide IRSN materials for irradiation, analysis of results	M. DULUC F. TROMPIER	D. HEINRICHS	LLNL
IRSN-IE34	HEU critical and Subcritical measurements	LANL-IE23	Participation in the definition and the design of the experiment. ICSBEP evaluation.	W. MONANGE	J. HUTCHINSON	LANL
IRSN-IE35 **IER 434**	Godiva benchmark for time dependent code validation	LANL-IE3	Participation in the preliminary design and CED-1 report.	M. DULUC	J. GODA	LANL
IRSN-IE36 **IER-514**	ICSBEP/SINBAD Shielding Benchmarks for Shipping Containers	LLNL-IE1 AWE-IE8	Participation in the preliminary design and CED-1 report	M. DULUC	D. HEINRICHS R. JONES	LLNL AWE
IRSN-IE37	Critical and subcritical measurements with a Zero-Power research reactor (On going task)	LANL-IE21	Analysis of the experiments, participation in the final technical report.	E. DUMONTEIL	J. HUTCHINSON	LANL
IRSN-IE40	CAAS performance testing	LLNL-IE21	Participation in testing activities. Provide IRSN materials and French CAAS probes. To be discussed with LLNL.	M. DULUC	D. HEINRICHS	LLNL
IRSN-IE41	Thermal/Epithermal Experiments (TEX) with Chlorine and Lithium	LLNL-IE23	Participation in experiments design and CED reports.	M. BROVCHENKO	D. HEINRICHS	LLNL
IRSN-IE42	Neptunium Subcritical Observations (NeSO) experiment	LANL-IE3	Independent review of the ICSBEP evaluation.	W. MONANGE	J. HUTCHINSON	LANL
IRSN-IE43 **IER 515**	Critical experiment with americium	LANL-IE3	Participation in experiments design and CED reports.	M. BROVCHENKO	G. MCKENZIE	LANL

	REFERENCE		IRSN Contribution / POC			
IRSN Reference	**Task Title**	**DOE Reference**	**FY 2020 IRSN Contribution**	**IRSN Technical POC**	**DOE Technical POC**	**DOE LAB**
IRSN-IE44 **IER 516**	ZTA (Zirconium Test Assembly)	LANL-IE3	Participation in experiments design and CED reports.	N. LECLAIRE	T. CUTLER	LANL
IRSN-IE45 **IER 517**	Integral Experiments for Validation of Molybdenum Neutron Cross Sections	LANL-IE3	Participation in experiments design and CED reports.	J.B. CLAVEL	D. HAYES T. CUTLER	LANL
IRSN-IE46 **IER 518**	High Multiplication Subcritical (Multiplicity) Benchmark Experiments	LLNL-IE1	Participation in experiments design and CED reports.	W. MONANGE	D. HEINRICHS G. HARMS	LLNL SNL
Information Preservation and Dissemination						
IRSN-IPD1	ICSBEP reviewing	LLNL-IPD1	IRSN ICSBEP reviewing tasks are reported in the IE tasks	I. DUHAMEL	D. HEINRICHS	LLNL
IRSN-IPD3	ICSBEP benchmark reviewing	LLNL-IPD1	IRSN ICSBEP reviewing tasks	I. DUHAMEL	J. FAVORITE	LANL
Nuclear Data						
IRSN-ND1	Contribution to new evaluations	ORNL-ND1	Contribution to new evaluation and validation for ^{54}Fe, ^{103}Rh, ^{55}Mn, Gd, Hf and ^{239}Pu isotopes.	L. LEAL	D. BOWEN	ORNL
IRSN-ND2	Nuclear data processing	LANL-ND1	Benchmark testing of ^{235}U and ^{239}Pu cross section library	L. LEAL	J. CONLIN	LANL
IRSN-ND3	Nuclear data processing	LLNL-ND4	Resonance evaluation of ^{233}U (Pending prioritization of ^{233}U ND tasks for the NCSP)	L. LEAL	D. HEINRICHS	LLNL
Training and Education						
IRSN-TE1	Hands-on criticality safety training	ORNL-TE1 LANL-TE3 LLNL-TE1 SNL-TE1	IRSN attendance to NCSP classes. Possible lectures by IRSN working with NCSP training and education coordinator.	S. EVO	D. BOWEN	NCSP

Appendix F
International Collaboration with the Atomic Weapons Establishment (AWE)

AWE has an active and growing program of collaboration with the NCSP that aims to underpin and enhance AWE's nuclear criticality safety and associated technologies. AWE will provide its expertise and capabilities to support the NCSP's mission and vision so that the collaboration is mutually beneficial to both organizations.

Reference			AWE Contributions and POCs			
AWE Reference	**Task Description**	**NCSP Reference**	**FY2018 AWE Contribution**	**AWE Technical POC**	**Collaborator POC**	**DOE Lab**
Analytical Methods						
AWE-AM1	Slide rule update	ORNL-AM6 LLNL-AM3 IRSN-AM5	Perform calculations; attend meetings; review analysis and reports	R. JONES	M. DULUC	ORNL
INTEGRAL EXPERIMENTS						
AWE-IE1	Inaugural international intercomparison of nuclear accident dosimetry using Flattop	LLNL-IE1 IRSN-IE15	Co-author final report (CED-4b)	C. WILSON	D. HICKMAN	LLNL
AWE-IE2	Development of Passive Neutron Spectrometer (PNS)		Fully commission TLD version of the PNS; Perform validation irradiations at NPL; develop unfolding tools for directionality	C. WILSON	D. HICKMAN	LLNL
AWE-IE3 **IER 406**	Cf-252 CAAS benchmark	LLNL-IE1 IRSN-IE28	Perform/support PNS(TLD) measurements with a shadow cone	C. WILSON	D. HEINRICHS	LLNL
AWE-IE4 **IER 175**	Godiva-IV CAAS benchmark	ORNL-IE4 IRSN-IE27	Review of experiment design. Provide measurement capability as required	C. WILSON	T. MILLER	ORNL
AWE-IE5	Correction factor for dosimetry linked to orientation of the victim	LLNL-IE1 IRSN-IE29	Participate in experiment design; use PNS data to determine directional components of neutron fields (Godiva, Flattop, LLNL RCL)	C. WILSON	D. HEINRICHS	LLNL
AWE-IE6	ICSBEP shielding benchmark for shipping containers	LLNL-IE13 IRSN-IE36	Participate in experiment design; PNS(TLD) could be deployed as primary measurement device AWE to do some preliminary design	C. WILSON	S. KIM	LLNL
AWE-IE7 **IER 153**	Measure fission neutron spectrum shape using threshold activation detectors	LANL-IE3	Provide input into foil selection; use AWE unfolding codes to provide independent analysis. TBC	C. WILSON	T. CUTLER B. MYERS	LANL

Reference			AWE Contributions and POCs			
AWE Reference	**Task Description**	**NCSP Reference**	**FY2018 AWE Contribution**	**AWE Technical POC**	**Collaborator POC**	**DOE Lab**
			AWE to provide foil suggestions per MYERS			
AWE-IE8	Diagnostic development for measurement of correlated leakage radiations	LLNL-IE1	A feasibility study is being developed at AWE to ascertain suitable counting scenarios and methods. An experimental design will then be produced in the following years based upon the outcomes of this study	N. KELSALL	D. HEINRICHS	LLNL
AWE-IE9 **IER 518**	(Neutron multiplicity experiments) AWE/LLNL NCT 5 year measurement campaign	LLNL-IE1	Participate in experiment design, measurements and reporting	N. KELSALL	D. HEINRICHS	LLNL
AWE-IE10	Enhanced methods of criticality accident dosimetry No funding for FY19 awe will provide proposal for FY20	LLNL-IE1 IRSN-30 IRSN-33 Naval Dosimetry Center	Develop prototypes, participate in design, execution and reporting of dosimetry experiments	C. WILSON	F. TROMPIER	LLNL
AWE-IE11	International intercomparison of nuclear accident dosimetry AWE to assist in preliminary design FY20 and FY21	LLNL-IE18 SNL-IE4	Produce experiment design; participate in exercise; produce final report. Repeat 2 - 3 years	C. WILSON	D. HICKMAN	LLNL
AWE-IE12	CIDAAS testing	LLNL-IE1	Deploy AWE CIDAAS for test irradiation. Repeat 2 - 3 years	T. BIRKETT	J. SCORBY	LLNL
AWE-IE13	Characterization of AFRRI TRIGA reactor radiation field AWE will provide onsite measurement	LLNL-IE18 SNL-IE4	Provide support to experiment design	C. WILSON	A. ROMANYUKHA	LLNL