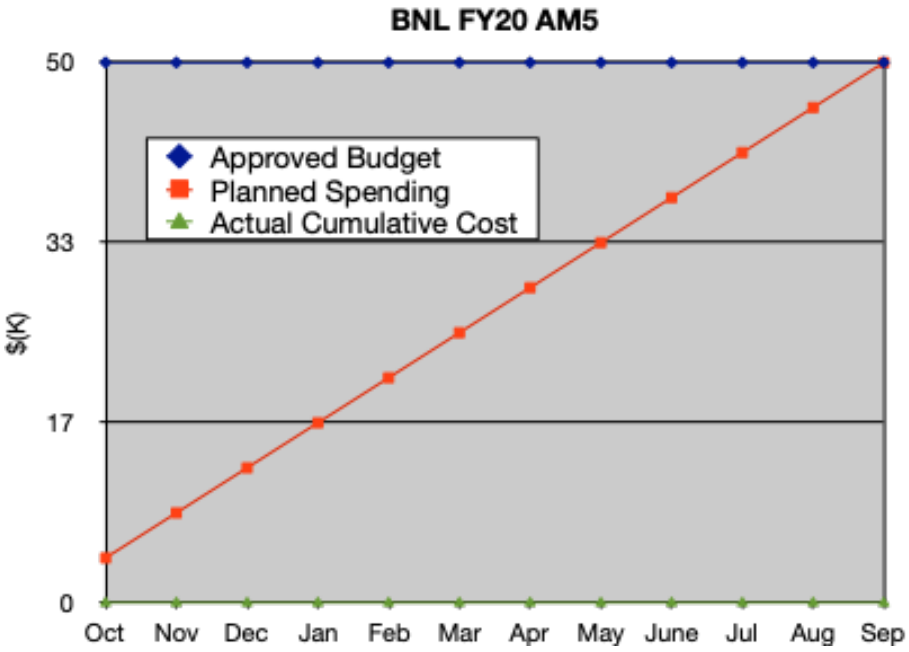
NUCLEAR CRITICALITY SAFTEY PROGRAM (NCSP)

FY2020 1st QUARTER REPORTS

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: Analytical Methods AM5 Task Title: FUDGE Generation of a Complete ENDF/B-VIII.0 Library for Testing in Production Codes M&O Contractor Name: BNL Point of Contact Name: David Brown Point of Contact Phone: 631-344-2814	Reference: DP 0902000 Date of Report: Jan. 24, 2020
BUDGET	**ACCOMPLISHMENTS**
 1. **Carryover into FY 2020** = $ 0 2. **Approved FY 2020 Budget** = $ 50,000 3. **Actual spending for 1st Quarter FY 2020** = $0 4. **Actual spending for 2nd Quarter FY 2020** = $ 5. **Actual spending for 3rd Quarter FY 2020** = $ 6. **Actual spending for 4rd Quarter FY 2020** = $ 7. **Projected carryover into FY 2021 =** $	Work on this task hasn't begun at BNL yet.

NCSP Quarterly Progress Report (FY-2020 Q1)

BNL ND Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone
			

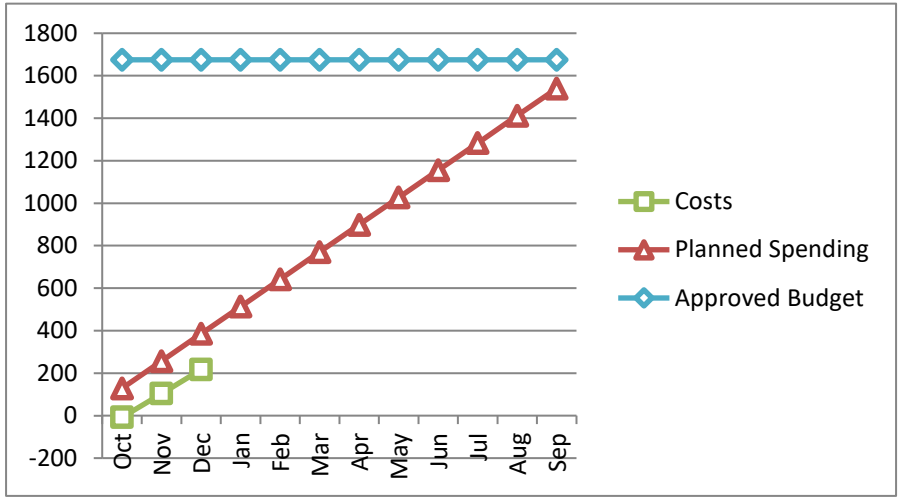
QUARTER	MILESTONE	STATUS	ISSUES/PATH FORWARD
Q1			
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**	**no**	
Q2	**N/A**	**no**	
Q3	**N/A**	**no**	
Q4	**N/A**	**no**	
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**	No	
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: AM1, 2, 4, 5, 7 Task Title: see last page M&O Contractor Name: LANL Point of Contact Name: Brian Bluhm / Bob Little Point of Contact Phone: 505-667-2440 / 505-665-3487	Reference: B&R DP0902000 Date of Report: January 21, 2020
BUDGET	**MAJOR ACCOMPLISHMENTS**



1. **Carryover into FY 2020 = $0**
2. **Approved FY 2020 Budget = $1,675,000 (includes carryover)**
3. **Actual spending for 1st Quarter FY 2020 = $216,459**
4. **Actual spending for 2nd Quarter FY 2020 = $**
5. **Actual spending for 3rd Quarter FY 2020 = $**
6. **Actual spending for 4rd Quarter FY 2020 = $**
7. **Projected carryover into FY 2021 = $135,000**

AM-1 (MCNP)

- We submitted a detailed foreign trip report from the ICNC 2019 Conference & OECD-NEA-WPNCS Subgroup Meetings, held in Paris, France, 15-27 September 2019. LANL participants were Brown, Rising, and Alwin.
- Our detailed MCNP class report is provided separately. As highlights, we taught 100 students total during the quarter, including 22 students attending "Criticality Calculations with MCNP6" at Y-12.
- We have merged the new methods for automated acceleration and convergence testing into MCNP6.3, which is now included as part of all XCP-3 distributions. In addition, we made direct distributions of these new methods to 3 early adopters.
- We completed a draft of the final report for WPNCS Subgroup-6 (statistical testing for convergences in MC NCS calculations) and posted it on the OECD-NEA website for review.
- Supported MCNP users through MCNP Forum, MCNP web site, email, direct interactions, etc.
- Several presentations on work accomplishments were made by our summer interns (bolded below) at International Conferences:
  - **D.H. Timmons,** M.E. Rising, C.M. Perfetti, "The Use of MCNP 6.2 KCODE for High Fidelity, Near Critical Benchmarks" (M&C 2019)
  - **P. Grechanuk,** M.E. Rising, T.S. Palmer, "Identifying Sources of Bias from Nuclear Data in MCNP6 Calculations Using Machine Learning Algorithms" (M&C 2019)
  - **P.A. Grechanuk,** M.E. Rising, and T.S. Palmer, "Comparing the Whisper Validation Methodology with Machine Learning Methods" (ICNC)
  - **B. Merryman,** F. Brown, J. Alwin, and C. Perfetti, "Investigating Region-Wise Sensitivities for Nuclear Criticality Safety Validation" (ICNC)

- We are working on re-releasing the ENDF/B-VIII.0-based thermal scattering library, processed with the latest NJOY2016 and its new capabilities. We intend to release this library in Q2 of FY2020 on our website https://nucleardata.lanl.gov.

AM-2 (NJOY)

- We have made a number of incremental releases of NJOY2016 to improve the handling of thermal scattering data.
- Progress is being made on completing the implementation of the modern RECONR module and integrating it into NJOY21. We anticipate completing this work in Q4 of FY2020.
- Continued to support NJOY users.
- Student supported at MIT has completed the implementation of a modernized version of LEAPR. She is currently working on THERM integration in to NJOY21.

AM-4 (S/U Comparison Study)

- We arranged a lunchtime meeting during ANS to meet with IRSN and ORNL and discuss status and upcoming efforts associated with this study.
- We incorporated updates to our benchmark suite (see AM-5) and used these updates to re-calculate the USL from Whisper for the four selected test cases. Results did not change significantly and were provided to IRSN and ORNL.

AM-5 (Benchmark Comparison Study)

- As a result of input from IRSN and LLNL as part of the ongoing 4-lab benchmark comparison study, we have identified issues and updated several of our benchmark models. In some instances we made changes to the MCNP specification of the benchmark, and in others made changes to the benchmark k-eff and / or uncertainty. There were other suspicious cases identified wherein we found no issues and made no changes.

AM-6 (Pitzer Formulation)

- LANL contributions to AM6 complete. Search resulted in discovery of existing data for uranium sulfate solution density; added to ORNL final report. Search is complete and no other existing solution data found.

	AM-7 (University of Michigan) • This is a new start in FY20 "Incorporation of Benchmark Experiment Correlations into the Whisper Nuclear Criticality Safety Software." AM-7 is a University Project at the University of Michigan. LANL procurement is behind on issuing the contract; we will therefore slip the AM-7 milestones each by one quarter.

NCSP Quarterly Progress Report (FY-2020 Q1)

LANL AM Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	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)		
	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)		As indicated above, due to delays in LANL procurement, we will need to slip the University of Michigan AM-7 milestones each by one quarter.
Q2	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)		

	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)		
Q3	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)		
	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)		
Q4	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)		
	Demonstrate modernized ACER capabilities for processing fast neutron files with NJOY21 (AM2)		

	Modernize and implement PURR capabilities in NJOY21 (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)		
	Process ENDF/B-VIII.1 beta evaluations in ACE format for internal testing at LANL (AM1)		

NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	OECD/NEA Paris, France May-20 AM2 Attend annual WPEC meeting and associated Sub-Group meetings (Conlin, Haeck) Contributor to multiple sub-groups-Conlin co-leads SG43; Haeck leads SG45.		
	Cambridge, England Apr-20 AM2 IE3 Attend PHYSOR 2020 meeting of the ANS. NCSP task that travel is performed under: LANL AM2 (Conlin, McKenzie, Hutchinson) Present NJOY updates and improvements Present research results.		
	Vienna, Austria TBD-date AM2 Consultancy meeting at IAEA (Conlin, Haeck) Participate in IAEA consultancy meeting on ACE processing		
	OECD/NEA Paris, France Jul-20 AM1 OECD Expert Group Meetings for NCSP, collaboration with IRSN on NCS (Brown, Rising) Participation provides state-of-art information for improving MCNP®, Whisper, and other computational methods		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**

NCSP Quarterly Progress Report (FY-2020 Q1)

Q1	Foreign trip report from the ICNC 2019 Conference & OECD-NEA-WPNCS Subgroup Meetings, held in Paris, France, 15-27 September 2019.	Yes	
Q1	D.H. Timmons, M.E. Rising, C.M. Perfetti, "The Use of MCNP 6.2 KCODE for High Fidelity, Near Critical Benchmarks" (M&C 2019)	No	Will submit before quarterly call
Q1	P. Grechanuk, M.E. Rising, T.S. Palmer, "Identifying Sources of Bias from Nuclear Data in MCNP6 Calculations Using Machine Learning Algorithms" (M&C 2019)	Yes	
Q1	P.A. Grechanuk, M.E. Rising, and T.S. Palmer, "Comparing the Whisper Validation Methodology with Machine Learning Methods" (ICNC)	Yes	
Q1	B. Merryman, F. Brown, J. Alwin, and C. Perfetti, "Investigating Region-Wise Sensitivities for Nuclear Criticality Safety Validation" (ICNC)	No	Will submit before quarterly call
Q2			
Q3			
Q4			

Task Title:

AM1 MCNP Maintenance and Support, Uncertainty Analysis Development, and Modernization

AM2 NJOY Development and Maintenance, Uncertainty Analysis Development, and Modernization

AM4 Sensitivity/Uncertainty Comparison Study with a Focus on Upper Subcritical Limits

AM5 Proposed Benchmark Intercomparison Study

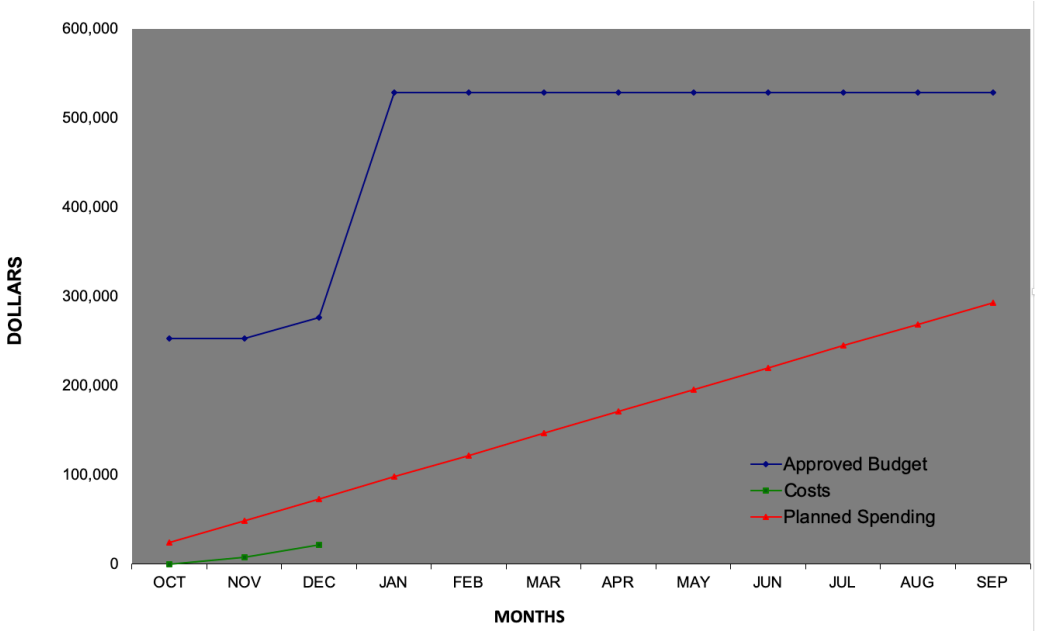
AM7 Incorporation of Benchmark Experiment Correlations into the Whisper Nuclear Criticality Safety Software

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtasks: AM2, 3, 5, 6, 7, 8
Task Titles: See last page
M&O Contractor Name: Lawrence Livermore National Laboratory
Point of Contact Name: David Heinrichs
Point of Contact Phone: (925) 424-5679

Reference: B&R DP0909010
Date of Report: January 31, 2020

BUDGET



1. **Carryover into FY 2020** = $209,244
2. **Approved FY 2020 Budget** = $528,244 (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $21,786
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021 =** $42,260 (8%)

MAJOR ACCOMPLISHMENTS

1. LLNL multiphysics methods development continues with development and testing of delayed neutrons in the sub-prompt super-critical regime (AM2).
2. Updated https://ncsp.llnl.gov/am_criticality_sliderule.php to include the summary paper for Phase 3, *Update of the Nuclear Criticality Slide Rule Calculations: Studies with Common Shielding Materials* (AM3).
3. Provided additional high-precision COG (k_{eff}) benchmark results using ENDF/B-VII.1, ENDF/B-VIII.0 and JEFF-3.3 to Isabelle Duhamel (IRSN) for a total of 2,703 ICSBEP benchmark cases for inclusion in the Benchmark Intercomparison Study (AM5) as follows:

```
PU: 766     U233: 193     MIX: 204
HEU: 818    IEU:  188     LEU: 534
```

4. LLNL-PRES-796197, *β_{eff} benchmarks*, was presented at CSEWG on November 4, 2019, summarizing LLNL (COG) and NNL (MC21) results for 22 benchmarks (AM5).
5. COG and MERCURY began testing FUDGE preliminary data for the unresolved resonance region (AM8).

NCSP Quarterly Progress Report (FY-2020 Q1)

LLNL AM Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	Provide status on LLNL AM activities in NCSP Quarterly Progress Reports (AM2, AM3, AM5, AM6, AM7, and AM8).		IRSN to appoint a replacement for Matthieu Duluc to lead AM3
Q2	Provide status on LLNL AM activities in NCSP Quarterly Progress Reports (AM2, AM3, AM5, AM6, AM7, and AM8).		
Q3	Provide status on LLNL AM activities in NCSP Quarterly Progress Reports (AM2, AM3, AM5, AM6, AM7, and AM8).		
Q4	Provide status on LLNL AM activities in NCSP Quarterly Progress Reports (AM2, AM3, AM5, AM6, AM7, and AM8).		

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	Paris, France October 17, 2019 AM, IE, IP&D, ND, TS5 IRSN-LLNL Meeting (Percher, Heinrichs, Kim) Coordinate joint IRSN-LLNL work as described in Appendix E of the Five-Year Execution Plan.	**Yes** (LLNL-MI-796017)	
Q2	**N/A**		
Q3	**N/A**		
Q4	Chiba, Japan May-20 AM, IE Joint International Conference on Supercomputing in Nuclear Applications and Monte Carlo (Kim, Norris) Premier conference on analytical methods and computing.		
	Aldermaston, United Kingdom TBD-date AM, IE, I&D, ND, T&E, TS5 JOWOG29/30 Meetings (Coleman, Zywiec) Coordinate joint AWE-LLNL work as described in Appendix F of the Five Year Execution Plan.		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	Dave Heinrichs, Soon Kim, Ed Lent, David Griesheimer, Mike Zerkle, "β_{eff} Benchmarks," LLNL-PRES-796197, November 4, 2019	**Yes**	
	Isabelle Duhamel et al., "International Criticality Benchmark Comparison for Nuclear Data Validation," Transactions of the American Nuclear Society: **121**, 873-876, November 2019.	**Yes**	
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

Task Titles:

AM2 Multi-Physics Methods for Simulation of Criticality Excursions

AM3 Slide Rule Application

AM5 Proposed Benchmark Intercomparison Study

AM6 Proposed 1-D Multipoint Analytical Benchmark Comparison

AM7 Technical Data for the Pitzer Formulation of Solution Compositions to Include Uranium/Plutonium Solutions with Selected Admixed Absorbers

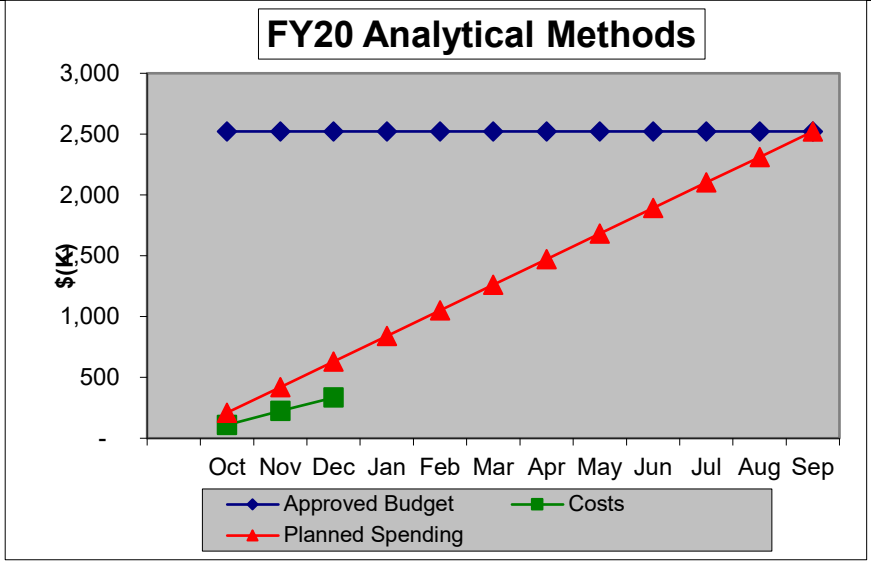
AM8 FUDGE Generation of a Complete ENDF/B-VIII.0 Library for Testing in Production Codes

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: ORNL – AM1, 2, 3, 6, 9, 10, 11, 15, 16, 20
Task Titles: See last page
M&O Contractor Name: ORNL
Point of Contact Name: Doug Bowen
Point of Contact Phone: (865) 576-0315

Reference: DP0909010/ORNL
Date of Report: January, 2020

BUDGET



1. **Carryover into FY 2020** = $367K
2. **Approved FY 2020 Budget** = $2522K (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $334K
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021 =** $

MAJOR ACCOMPLISHMENTS

AM1 – Radiation Safety Information Computational Center (RSICC)

- Distributed 478 software packages
- 113 SCALE, 169 MCNP®, and 0 COG packages distributed
- RSICC quarterly report issued.

AM2 - SCALE/KENO/TSUNAMI Maintenance and Support/Cross-Section Generation/Modernization/etc.

- Deployed SCALE 6.3 beta6 and beta7 release internally and externally with the following updates
  - Infrastructure/Maintenance
    - Updated codebase to compile with latest Apple LLVM 10 and Ninja configuration
    - Updated continuous testing with more compact test summary logs to facilitate identifying issues
    - Generated prototype chapter for manual refactor.
  - Code/Data enhancements (partial or whole support from NCSP)
    - Improved mixing table outputs for CSAS-Shift
    - Enable fully-functioning AMPX on Windows
    - Improved performance for large domains with small detectors in MAVRIC-Shift
    - Improved consistency of thermal scattering treatment in multi-group AMPX library generation and XSPROC self-shielding
    - Added neutron flux and fission source distribution mesh tallies to CSAS-Shift with visualization support in Fulcrum
- Code updates for the next production release SCALE 6.2.4
  - Updates to thermal scattering kernel interpolation to improve robustness
  - Updates to AMPX/ZEST to correct MAT, MF, and MT numbers emitted in TAB1 file

AM3 - AMPX Maintenance and Modernization

- Presented the AMPX status report at the annual CSEWG meeting
- Reported on covariance issues in ENDF/B-VIII.0 at the annual CSEWG meeting
- Worked on a Format proposal for External R-Matrix parameters. The Proposal was reported on at the annual CSEWG meeting and implemented in AMPX.

	• Work continued on generating the low level GNDS access classes from the JSON files that define the GNDS format. The code was changed to respect name spaces used in the JSON files. The initial code was tested via generating and comparing point-wise data. • Covariance data are corrected before use in SCALE. We changed the code to apply these correction in PUFF on the super-grid . This allows to preserve more of the ENDF covariance data even if the data contain unreasonable correlation. • Work continued to support HDF5 formatted CE libraries in SCALE. **AM6 – Slide Rule Application** • No report. Awaiting input from IRSN. **AM9 - Sensitivity / Uncertainty Comparison Study with a Focus on Upper Subcritical Limits** • Presented paper at Winter ANS meeting in November 2019 (paper and presentation attached) • Meeting held at Winter ANS meeting (with LANL and IRSN co-participants) to discuss progress to date and future activities, with follow at the TPR in February 2020 **AM10 - Proposed Benchmark Intercomparison Study** • No effort required from ONRL at this time, IRSN presented results at Winter ANS meeting **AM15 - The Effects of Temperature on the Propagation of Nuclear Data Uncertainty in Nuclear Criticality Safety Calculations** • Nothing to report. **AM16 - Technical Data for the Pitzer Formulation of Solution Compositions to Include Uranium/Plutonium Solutions with Selected Admixed Absorbers** • A report has been issued, Density Calculations of Actinide Solutions using the Pitzer Method, ORNL/TM-2019/1427, documenting all work conducted during the year. It includes a listing of all data obtained and describes efforts to regress model parameters using the data. Deficiencies in model capability are noted, and additional data is recommended, including that for solutions heretofore not considered.

NCSP Quarterly Progress Report (FY-2020 Q1)

ORNL AM Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	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, AM15, AM16, AM20)		
Q2	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, AM15, AM16, AM20)		

	Issue an annual SCALE maintenance report to the NCSP Manager. (AM2)		
Q3	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, AM15, AM16, AM20)		
Q4	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, AM15, AM16, AM20)		
	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)		

NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	OECD/NEA Paris, France Oct-19 TS1, IE, AM2 ICSBEP and IRPhE Technical Review Meetings (Bowen, Marshall) Provide oversight of NCSP IE tasks as ICSBEP tasks are the end product of the NCSP IE process.	**Yes**	
Q2			
Q3	Cambridge, England Apr-20 AM2 Attend PHYSOR 2020 meeting of the ANS. (Bowen, Greene) Present papers for ANS subcritical limits and progress on GA Tech NCSP tasks.		
	Paris, France TBD – date AM, IE, IP&D, ND1, TS7 IRSN Meetings (Sobes, Wiarda, Holcomb) 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.		
Q4	OECD/NEA Paris, France TBD – date TS1, IE, AM2 WPNCS Meetings (Marshall, Bowen, Clarity, Wieselquist) AM collaboration; provide relationship between IAEA and ISO with respect to NCS standards.		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	Dorothea Wiarda, Andrew Holcomb, Friederike Bostelmann, "Current Status of AMPX", November 2019 William Wieselquist, Brad Rearden, “Recent Developments in SCALE”, November 2019	**Yes**	

	B.J. Marshall, "Energy-dependent Bias between ENDF/B-VII.1 and ENDF/B-VIII.0 for LCT Benchmarks, CSEWG, November 2019 B.J. Marshall, "Energy-dependent Bias between ENDF/B-VII.1 and ENDF/B-VIII.0 for LCT Benchmarks, ANS, November 2019 W.J. Marshall, "Bias between ENDF/B-VIII.0 and ENDF/B=VII.1 for LEU Pin Array System"		
Q2			
Q3			
Q4			

Task Titles:

AM1 Radiation Safety Information Computational Center (RSICC)

AM2 SCALE/KENO/TSUNAMI Maintenance and Support/Cross-Section and Generation/Modernization

AM3 AMPX Maintenance and Modernization

AM6 Slide Rule Application

AM9 Sensitivity/Uncertainty Comparison Study with a Focus on Upper Subcritical Limits

AM10 Proposed Benchmark Intercomparison Study

AM11 Proposed 1-D Multipoint Analytical Benchmark Intercomparison

AM15 The Effects of Temperature on the Propagation of Nuclear Data Uncertainty in Nuclear Criticality Safety Calculations

AM16 Technical Data for the Pitzer Formulation of Solution Compositions to Include Uranium/Plutonium Solutions with Selected Admixed Absorbers

AM20 Nuclear Data and Cross Section Testing Using ENDF/B-VIII.0

ORNL/TM-2019/1427

Density Calculations of Actinide Solutions using the Pitzer Method

Charles F. Weber
Jason M. Hite
Jennifer L. Alwin

January 2020

Draft. Not for public release.

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE US DEPARTMENT OF ENERGY

ORNL/TM-2019/1427

Nuclear Nonproliferation Division

DENSITY CALCULATIONS OF ACTINIDE SOLUTIONS USING THE PITZER METHOD

Charles F. Weber
Jason M. Hite
Jennifer L. Alwin*

*Los Alamos National Laboratory

January 2020

Prepared by
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managed by
UT-BATTELLE, LLC
for the
US DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

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ABSTRACT

This report summarizes an exhaustive literature search for density data of actinide solutions in support of the Nuclear Criticality Safety Program (NCSP). This work comprises an extension of work originally begun in 2003 that implemented an advanced density calculation scheme in the SCALE material input processor. This method demonstrated improved criticality calculations for aqueous systems of $UO_2(NO_3)_2$ and $Pu(NO_3)_4$ in excess acid over a considerable range of concentrations and temperatures. It also provided for UO_2F_2 in acid at room temperature, although with higher uncertainty. The current study was intended to search all available sources for additional data on uranium and plutonium solutions, including the open literature, reports with limited distribution, and unpublished sources such as laboratory notebooks. Data for some of the systems has been regressed to obtain model parameters for the Pitzer formalism of modeling electrolyte solutions.

1. INTRODUCTION

To assess the criticality conditions of actinide solutions, an accurate calculation of the solution density is essential. In 2003, the input processor of the SCALE code system [1] was updated to use the ion-interaction method developed by Pitzer [2], [3] for such calculations. This approach was immediately applicable to systems of uranyl nitrate, $UO_2(NO_3)_2$, in acid because of the plethora of data that was available over a wide range of temperatures [4]. The revised density calculations produced immediate improvements in nuclear criticality calculations [5].

Additional systems were also modeled, including $Pu(NO_3)_4$, $Th(NO_3)_4$, and UO_2F_2, although considerably less data was available for these systems. For $Pu(NO_3)_4$, there was noticeable scatter in some of the data, raising questions that could only be answered by additional high-fidelity experiments. In the case of fluoride systems, data were quite sparse and somewhat questionable because of scatter in available data.

Rather than immediately fund additional density experiments, the NCSP decided to conduct a thorough and up-to-date examination of available data and to assess its integrity and usefulness in further developing the Pitzer method for use in criticality calculations. This report represents an evaluation of some additional data, and an assessment of gaps where additional data would be necessary. In Section 2, we review an exhaustive search through published and unpublished sources for additional density measurements of actinide solutions. In Section 3, we describe the regression of these data to obtain the parameters needed in the Pitzer method. Finally, in Section 4 we describe additional data and analyses that would be needed to provide a comprehensive and robust model of densities in a variety of actinide solutions.

2. DENSITY DATA

A number of sources for density data have been located through painstaking searches of unpublished sources and follow-up of references listed in existing sources. Many of the unpublished sources are old laboratory notebooks for criticality experiments at ORNL made during the 1950s, 1960s, and 1970s. Some of the published sources are found in obscure references that are old, brief, and quite possibly in languages other than English. Thus, although these sources represent a potential treasure of additional data, they must be used soberly, recognizing that the integrity of the final result hinges on the consistency of the data used. The data described herein involve solutions of uranyl fluoride and uranyl sulfate, each with excess acid.

2.1 DATA FOR UO_2F_2

A number of individual data points are available at temperatures 17°C–30°C and are listed in Appendix A. A few of the references are published in open literature, but most of these measurements represent a single record in a laboratory notebook. In general, the data appear to be fairly consistent with each other, as shown in Figure 1 for UO_2F_2 data at 25°C, although there is a little scatter at very high concentrations near 4.3 molal for the logbook data. Unpublished measurements are quite consistent with the smoothed values of Söhnel and Novotny [6] and Johnson and Kraus [7].

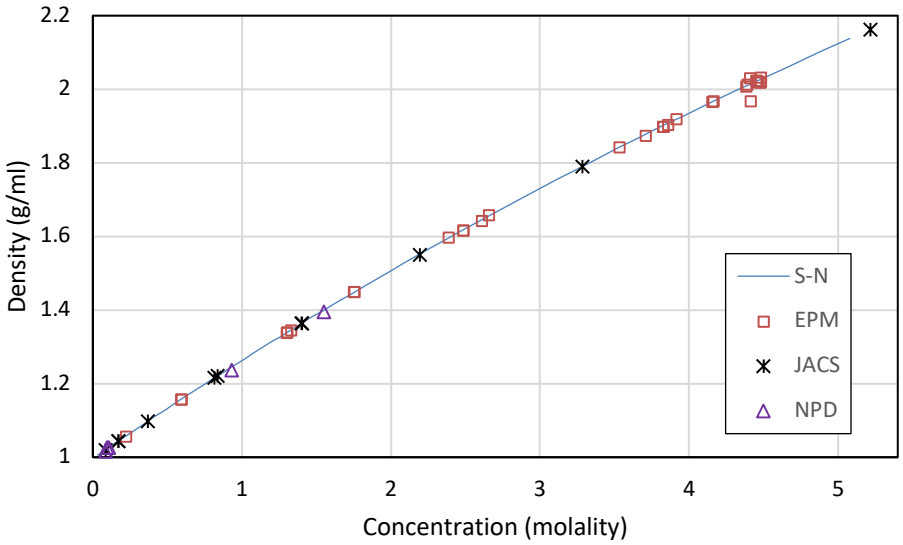

Figure 1. Density of UO_2F_2 Solutions at 25°C. Data from Ref. [6] (S-N), Ref. [7] (JACS), and two unpublished sources from ORNL: Ref. [8] (EPM) and Ref. [9] (NPD).

When multiple temperatures are plotted together (Figure 2), it becomes apparent that there is very little change due to temperature. In fact, any discernable temperature effect is probably within the margin of error for the measurements themselves. Consequently, it is likely that we will not be able to obtain temperature coefficients for the parameter regressions.

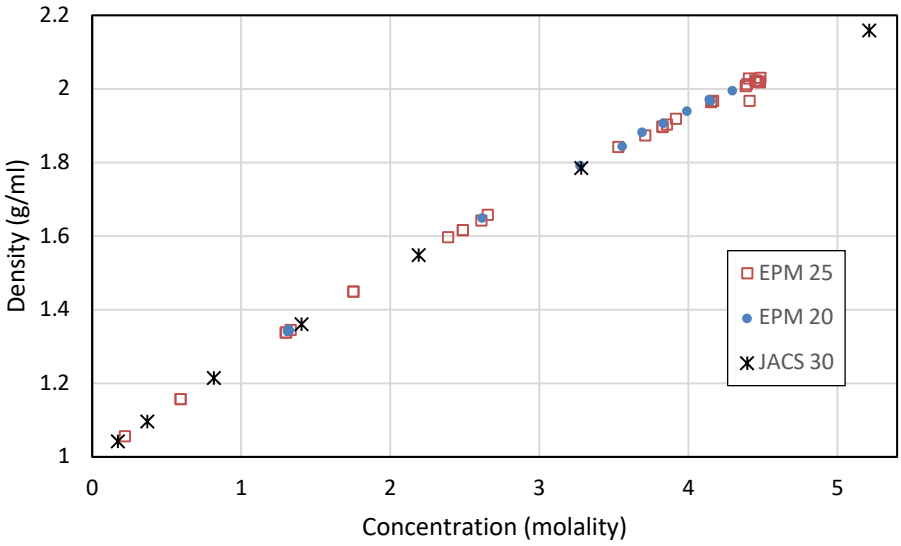

Figure 2. Density of UO_2F_2 at three temperatures. Data from Ref. [8] (EPM) at 20°C and 25°C, and Ref. [7] (JACS) at 30°C.

2.2 DATA FOR HF

Because systems of UO_2F_2 often occur with excess acid, having data for hydrofluoric acid alone is necessary. Painstaking evaluations of open literature data have yielded a number of obscure sources. A plot in a marketing brochure from Honeywell Corporation (one of the largest US industrial producers of HF) shows specific gravity for temperatures 0°C, 15.6°C, 26.7°C, 37.8°C, and 48.9°C (32°F, 60°F, 80°F, 100°F, and 120°F, respectively). Queries to obtain raw data behind the plot were not successful but did identify a few additional open literature sources. Open sources only span the temperature range 0°C–25°C, although a few points taken from the Honeywell plots represent higher temperatures. All available data are provided in Appendix B.

Data at 15°C are shown in Figure 3 and demonstrate good consistency except at very high concentrations. (As mentioned, our primary concern is for concentrations below 10 molal.) Similar results hold at 0°C. However, at 20°C and 25°C, we notice a distinct conflict, as several data sets deviate wildly from each other (Figure 4). The three sets at 20°C all are consistent, and in fact only the data of Winteler [15] represent original experiments. However, the two data sets at 25°C are in direct conflict—one shows an upward shift with increasing temperature [16], whereas the three points from Ref. [12] indicate a downward shift. The difficulty is further illustrated in Figure 5, where smoothed lines describe data at different temperatures. There is a clear decrease from 0°C to 15°C, but data at 20°C are virtually unchanged from those at 15°C. As temperature rises to 26.6°C and above, densities continue to decrease in a consistent manner. However, these curves represent only the Honeywell data [12].

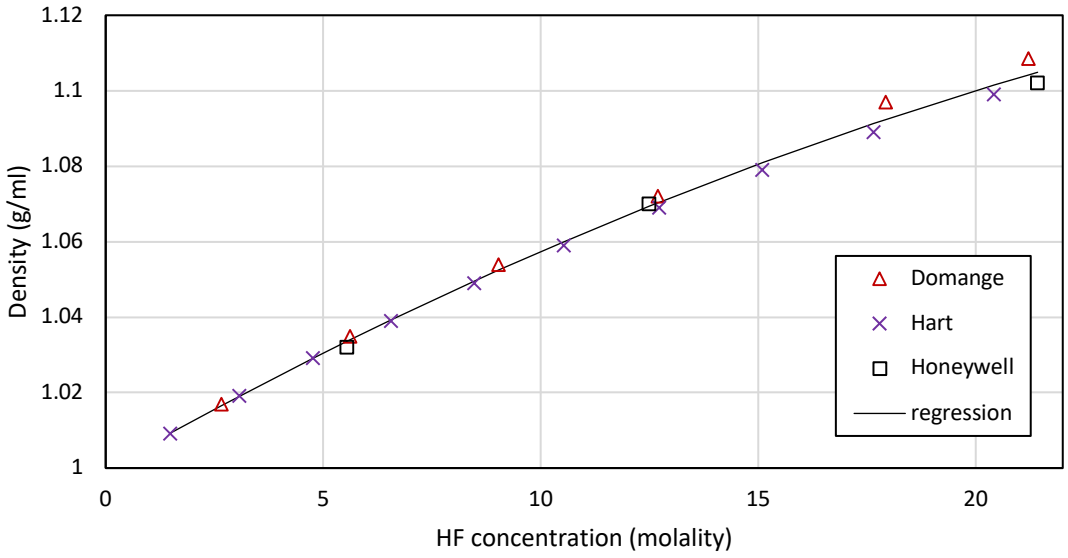

Figure 3. Hydrofluoric acid density at 15°C (Honeywell data at 15.6°C). Data from Domange [10], Hart [11], and Honeywell [12].

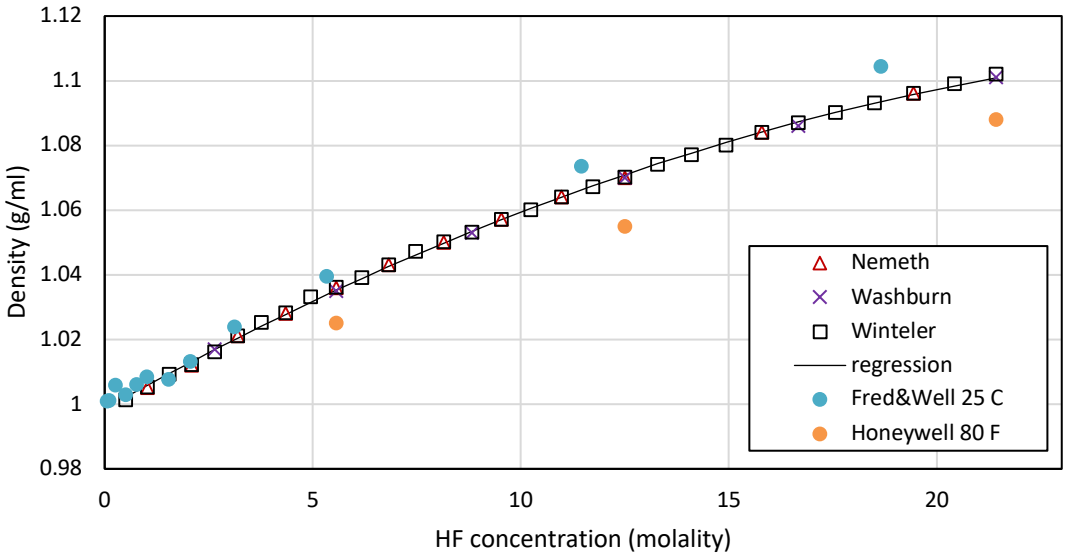

Figure 4. Hydrofluoric acid density at different temperatures. Data at 20°C (Nemeth [13], Washburn [14], Winteler [15]), 25° (Fredenhagen [16]) and 26.6°C C (Honeywell [12]).

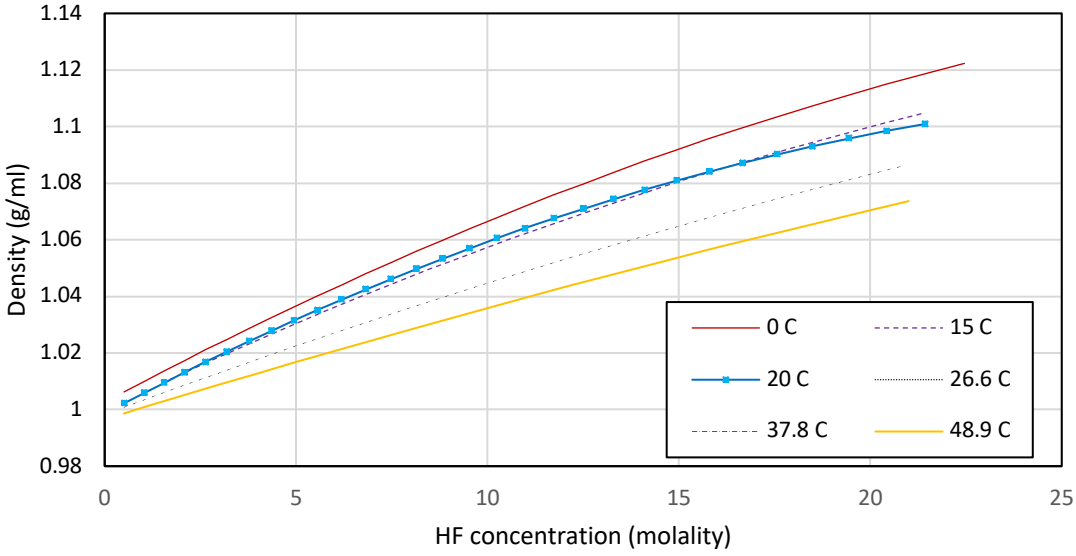

Figure 5. Hydrofluoric acid density at multiple temperatures. Data from ref. 17 (0°C), Refs. 10, 11, 12 (15°C), Refs. 13, 14, 15 (20°C) and Ref. 12 (26.6, 37.8, and 48.9°C).

2.3 DATA FOR UO_2F_2 IN HF

There are very few data for this ternary system involving the common ion F^-. Ferris [18] measured densities of saturated solutions, along with solubilities and solids formed. Since these measurements were made at the solubility limit, they are quite concentrated, as shown in Table 1. Hence, only the first few points will be useful in the concentration range of this work.

Table 1. Densities of saturated solutions of UO_2F_2 and HF.

Density	Molality (mol/kg H_2O)		
(g/mL)	H^+	UO_2^{2+}	F^-
2.2969	0	4.19	8.39
1.6879	1.32	2.28	5.87
1.5494	3.45	1.82	7.10
1.5029	5.37	1.70	8.77
1.4715	7.24	1.60	10.43
1.432	10.38	1.45	13.29
1.375	14.70	1.25	17.20
1.357	16.09	1.14	18.37
1.327	19.51	0.999	21.50
1.277	23.12	0.784	24.68
1.225	31.06	0.486	32.03
1.2103	46.82	0.246	47.31

2.4 DENSITIES OF UO_2SO_4 SOLUTIONS

Smoothed densities between 20°C and 90°C are presented by Söhnel and Novotny [6]. These do not represent original measurements but rather are derived from regressions of earlier published data. Nevertheless, they were used in lieu of the original measurements. An old ORNL report [19] presents data at 25°C and 30°C, which are highly consistent at lower concentrations with the data of Söhnel and Novotny. However, deviation is noticeable at higher concentrations, as shown in Figure 6. From Figure 7, there is a clear trend of decreasing density with increasing temperature. All data for all temperatures are listed in Appendix C.

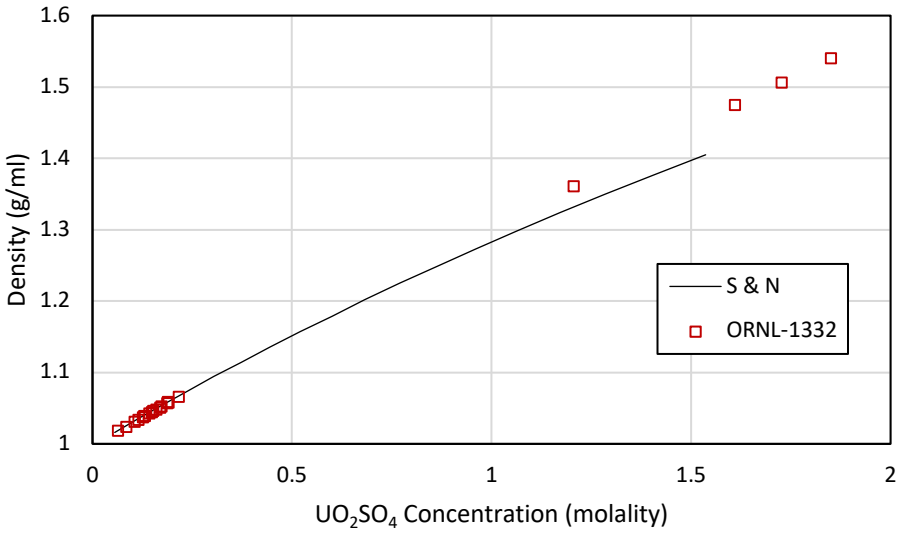

Figure 6. Density of UO_2SO_4 solutions at 25°C. Data taken from Refs. [6] (S & N) and [19] (ORNL-1332).

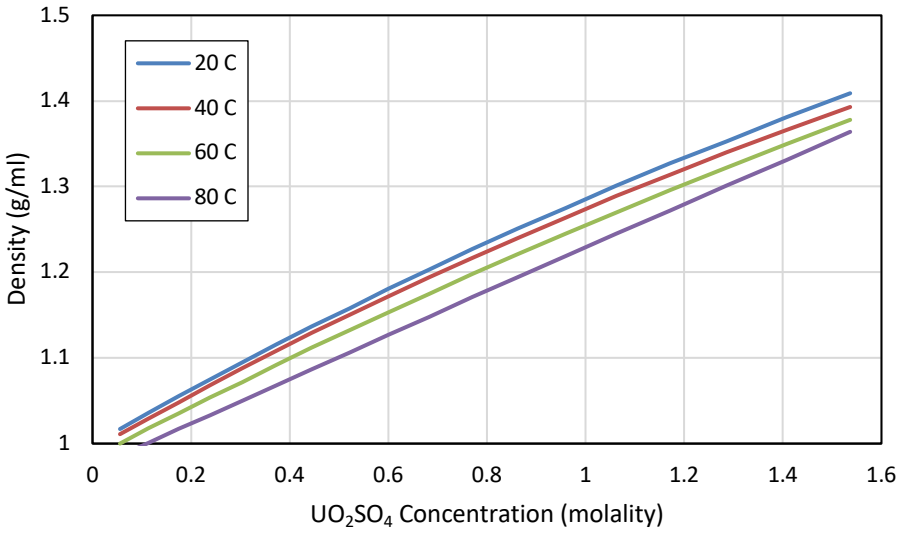

Figure 7. UO_2SO_4 density at different temperatures. Data taken from Ref. [6].

2.5 DENSITIES OF H_2SO_4 SOLUTIONS

Again, the primary source of data are the smoothed densities between 0°C and 100°C presented by Söhnel and Novotny [6]. As with the UO_2SO_4 values, these are used directly instead of the original published measurements from which they were derived. Values at 20°C given in the CRC Handbook [29] are identical to those of Ref. [6], and likely were derived from the same source; because they are redundant, they will not be included in our data set. There are a number of more recent measurements summarized in Oca et al. [20], but these have not been pursued. One recent report from Los Alamos National Laboratory also measured densities between 7°C and 25°C [21], and these compare favorably with the other data at two temperatures in Figure 8. As expected, there is a clear trend of decreasing density with increasing temperature. All data for all temperatures are listed in Appendix D.

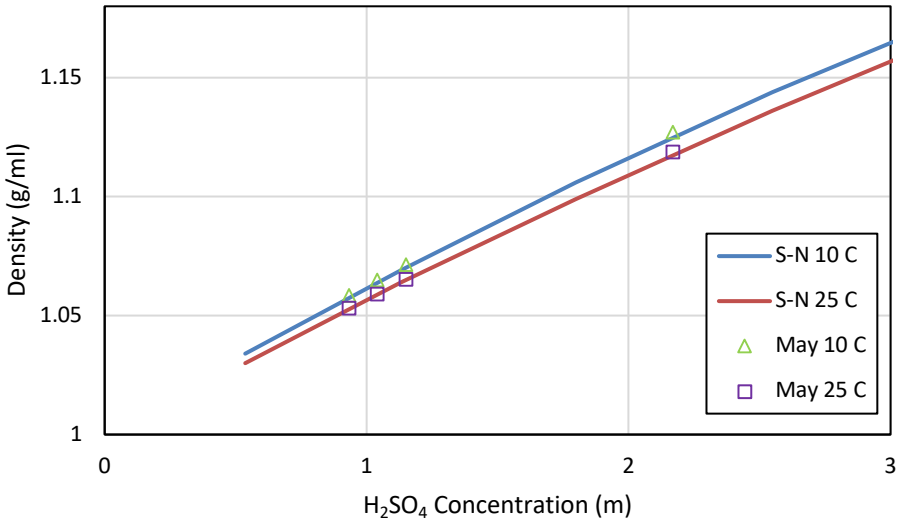

Figure 8. H_2SO_4 Densities at 10°C and 25°C. Data taken from Refs. [6] (S-N) and [21] (May).

2.6 TERNARY SYSTEM UO_2SO_4–H_2SO_4–H_2O

As was done in Section 2.3 for the fluoride system, we now examine the system involving uranyl ion in excess acid with a common sulfate ion. Two data sets are available from Refs. [19] and [21]. The latter does not fully explain concentrations in solution and will not be useful without additional follow-up. Data from Ref. [19] at 30°C are given in Table 2.

Table 2. Densities in ternary sulfate system at 30°C.

Density	Molarity (mol/L)		Molality (mol/kg H_2O)		
(g/mL)	UO_2SO_4	H_2SO_4	UO_2^{2+}	H^+	SO_4^{2-}
1.0312	0.105029	0	0.105796	0	0.105796
1.0279	0.126035	0	0.128377	0	0.128377
1.0452	0.147041	0	0.148321	0	0.148321
1.0518	0.168047	0	0.169696	0	0.169696
1.0585	0.189053	0	0.191099	0	0.191099
1.0653	0.210059	0	0.212524	0	0.212524
1.0318	0.105029	0.02	0.105942	0.040347	0.126115
1.0384	0.126035	0.02	0.12727	0.040392	0.147466
1.0457	0.147041	0.02	0.14854	0.040408	0.168744
1.0515	0.168047	0.02	0.170085	0.040485	0.190327
1.0591	0.189053	0.02	0.191363	0.040489	0.211607
1.0659	0.210059	0.02	0.212817	0.040525	0.23308
1.0332	0.105029	0.1	0.106635	0.203058	0.208164
1.0399	0.126035	0.1	0.128091	0.203262	0.229722
1.0468	0.147041	0.1	0.149559	0.203425	0.251272
1.0532	0.168047	0.1	0.171149	0.203693	0.272996
1.0604	0.189053	0.1	0.192639	0.203794	0.294536
1.0672	0.210059	0.1	0.214238	0.203979	0.316228
1.0348	0.105029	0.2	0.107531	0.409528	0.312295
1.0416	0.126035	0.2	0.129155	0.409902	0.334106
1.0483	0.147041	0.2	0.150834	0.410318	0.355993
1.0551	0.168047	0.2	0.172539	0.410693	0.377886
1.062	0.189053	0.2	0.194264	0.411026	0.399777
1.0688	0.210059	0.2	0.216047	0.411403	0.421748
1.0376	0.105029	0.4	0.109415	0.833405	0.526117
1.0448	0.126035	0.4	0.131365	0.83383	0.54828
1.0515	0.147041	0.4	0.153417	0.834692	0.570763
1.0581	0.168047	0.4	0.175534	0.835642	0.593355
1.0648	0.189053	0.4	0.19768	0.836507	0.615933
1.0713	0.210059	0.4	0.219918	0.837549	0.638693

3. PARAMETER ESTIMATION

In this section, we evaluate the data from Section 2 to develop the parameters needed to implement the Pitzer formalism for fluoride and sulfate systems involving the uranyl ion in acid. The calculational approach is identical to that undertaken previously in earlier work [4] and will only be summarized here.

The Pitzer model for calculating densities of electrolyte solutions is based on a theoretical development that uses empirical parameters to describe ion interactions. The model is described in detail in Appendix E, but here we identify only the parameters that will be determined from density data:

$\beta_{ca}^{v(0)}$, $\beta_{ca}^{v(1)}$, C_{ca}^{v} = parameters describing interaction of cation c and anion a
$\theta_{cc'}^{v}$ = parameter describing interaction of cations c and c'
$\psi_{cc'a}^{v}$ = parameter describing interaction of cations c and c' and anion a
$\bar{V}_i^o$ = partial molar volume (at infinite dilution) of individual salts (cation–anion pairs)

In this report, we only have cations UO_2^{2+} and H^+, and we consider systems with a single anion (either F^- or SO_4^{2-}, considered separately, but not together). Note, that the general formulation [2]–[4] would also include interactions of multiple anions, but we do not consider such systems in this report.

Each of these parameters could vary with temperature, so we consider a general dependence of the form:

$$h(T) = A + B(T - T_0) + C\left[\frac{1}{T} - \frac{1}{T_0}\right] + D\ln\left[\frac{T}{T_0}\right] + E\left[\frac{1}{T^2} - \frac{1}{T_0^2}\right], \qquad T_0 = 298.15\ \text{K}. \tag{1}$$

Note that we only report the parameters that were included in the regression. Parameters that are not mentioned are assumed to be zero except where noted.

Importantly, both the fluoride and sulfate systems are notoriously ill-behaved primarily because of ion association and secondary reactions [22], [23]. In the fluoride system, the acid dissociation may only be 10%–15%, and we have the additional reaction:

$$HF + F^- \leftrightarrow HF_2^- . \tag{2}$$

For the sulfate system, both dissociation reactions must be considered:

$$H_2SO_4 \leftrightarrow H^+ + HSO_4^- \tag{3a}$$

$$HSO_4^- \leftrightarrow H^+ + SO_4^{2-} . \tag{3b}$$

In both cases, multiple anions are introduced for the binary system of acid alone, and this complication affects the ternary system that includes both acid and uranyl ions. This behavior is in contrast to nitrate systems, where the ions dissociate almost completely upon dissolution in water. Thus, any model of the fluoride and sulfate systems will be difficult to implement without special treatment that includes the additional aqueous species.

3.1 FLUORIDE SYSTEM

The data available for UO_2F_2 covers temperatures from approximately 17°C to 30°C and includes a total of 196 samples and solute concentrations from 0.0063 to 5.21 *m* UO_2F_2. Of the 196 samples, 108 were at 25°C. Within our limited temperature range, the data shows almost no variation with respect to temperature; hence, we performed the fit using all 196 data points disregarding temperature. The fit parameters are reported in Table 3, and the fit model is plotted against the data in Figure 9.

Table 3. Fit parameters for UO_2F_2.

Parameter	*A* [cf. Eq. (1)]
β_{ca}^{v0}	1.438E-3
β_{ca}^{v1}	1.429E-2
C_{ca}^{v}	-9.430E-5
$\overline{V}_i^0$	5.787E1

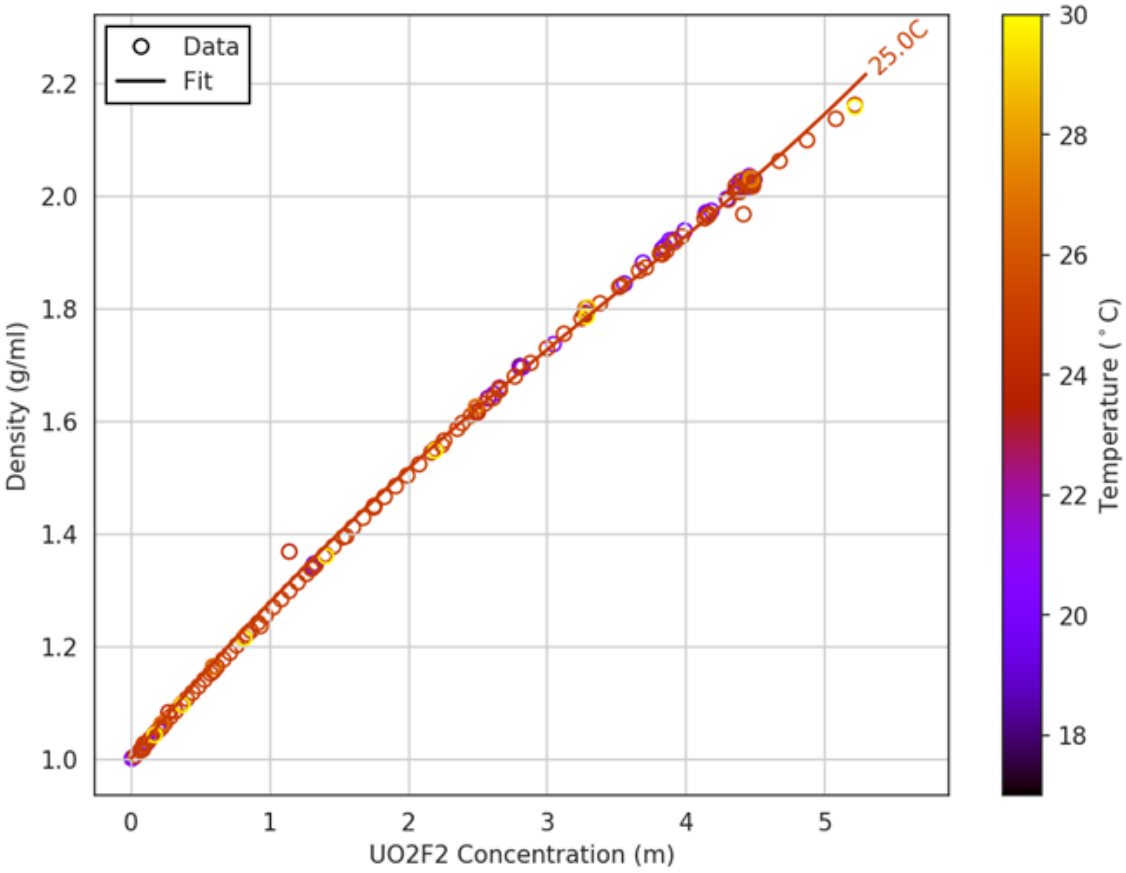

Figure 9. Plot of data and model fit for UO_2F_2.

Figure 9 shows that most of the data follows a smooth trend, which the model tracks well up to approximately 4.5 *m* UO_2F_2. The model begins to diverge for concentrations in excess of 4.5 *m*, and its use is discouraged outside this range. We were unable to find a fit that performed better in this region and provided a good fit at lower concentrations. Additionally, the fit tracks well for temperatures between 17°C and 30°C, and the very weak dependence on temperature suggests that this fit is valid over the entire temperature range and possibly beyond.

A total of 77 measurements were provided for HF with concentrations from 0.050 to 7.95 *m*. Temperatures range from 0°C to 50°C, and 10 are at 25°C. There appears to be some dependence on temperature, but we were unable to find good fits for the temperature-dependent parameters. We suspect the temperature dependence is obscured by measurement error and the need to model the additional species in Eq. (2). The fit parameters are given in Table 4, with the model and data plotted in Figure 10.

Table 4. Fit parameters for HF.

Parameter	A [cf. Eq. (1)]
β_{ca}^{v0}	-5.041E-4
β_{ca}^{v1}	9.5473E-3
C_{ca}^{v}	2.430E-5
$\bar{V}_{i}^{0}$	5.000E1

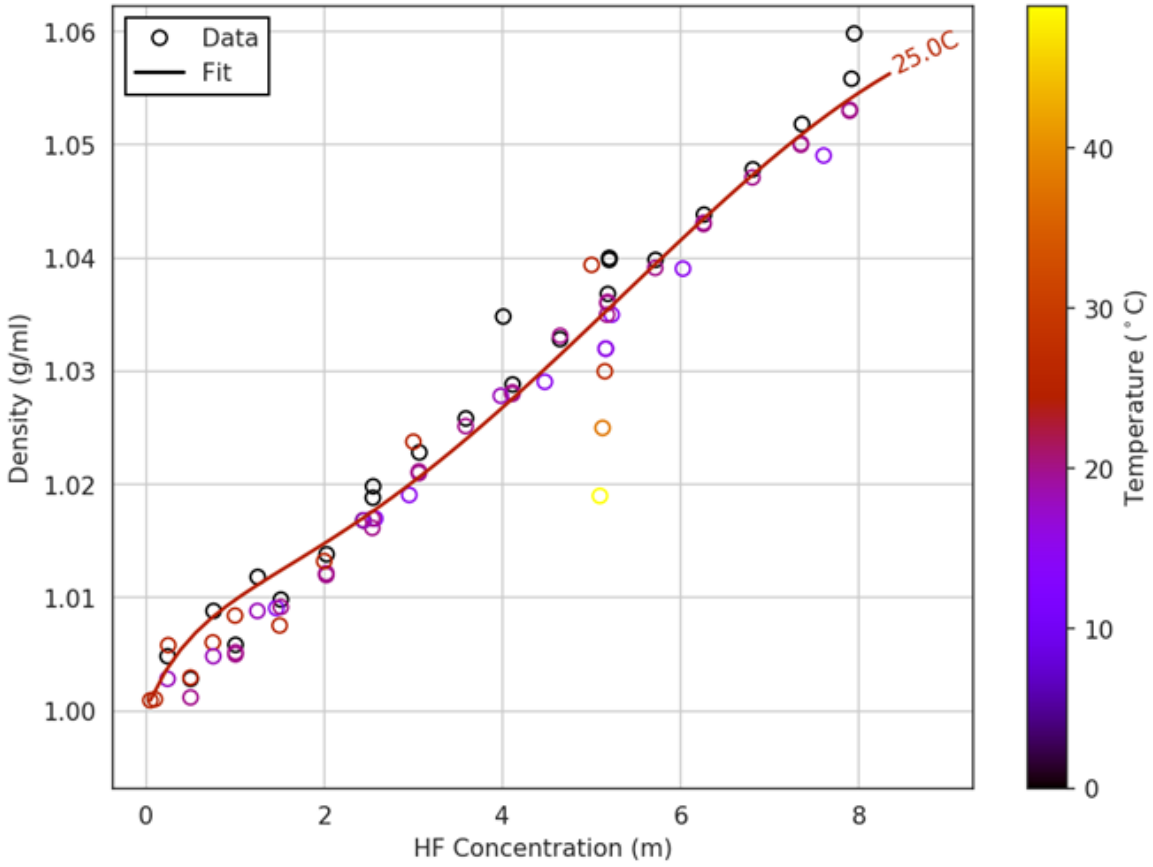

Figure 10. Plot of data and model fit for HF.

Fits for the temperature-independent coefficients were performed using the data at 25°C and agree with the data for concentrations up to 4–5 *m* and possibly even as high as 7–8 *m*. However, the unusual curvature of the model is cause for concern and reflects the difficulties of modeling this solution that have been noted by others [2]. Note that several of the measurements with temperatures in excess of 40°C appear to have considerable variation in temperature, but there were very few data points at higher temperatures, and we were unable to find a fit that agreed with the reported densities for these samples. This is likely due to the small number of samples at these higher temperatures and the high amount of variation in the reported densities.

3.2 SULFATE SYSTEM

Data for the UO_2SO_4 solutions totaled 293 samples at temperatures between 20°C and 90°C, with solute concentrations from 0.050 to 1.39 *m*. Of the 293 samples, 35 were recorded at 25°C. The data varies smoothly with concentration and contains significant variations in temperature, but we were again not able to find a fit for the temperature-dependent coefficients in Eq. 1. This indicates a potential inconsistency of the data with the model that requires additional modeling effort. Table 5 gives the fit parameters, while Figure 11 plots the fit and data. Note that the UO_2^{2+} and SO_4^{2-} ions are both doubly charged and use the special form of the model described in Appendix E.

Table 5. Fit parameters for UO_2SO_4.

Parameter	*A*
$\boldsymbol{\beta_{ca}^{v0}}$	3.8663E-3
$\boldsymbol{\beta_{ca}^{v1}}$	-4.0519E-2
$\boldsymbol{\beta_{ca}^{v2}}$	4.6874E0
$\boldsymbol{C_{ca}^{v}}$	2.7632E-4
$\boldsymbol{\overline{V}_i^0}$	3.7153E0

Figure 11 shows that the fit follows the data for UO_2SO_4 across the whole range of concentrations, though this range only extends to approximately 1.4 *m* UO_2SO_4. We see that the fit at 25°C is highly consistent with the corresponding data and reasonably accurate from 20°C to 35°C but diverges from reported densities at higher temperatures.

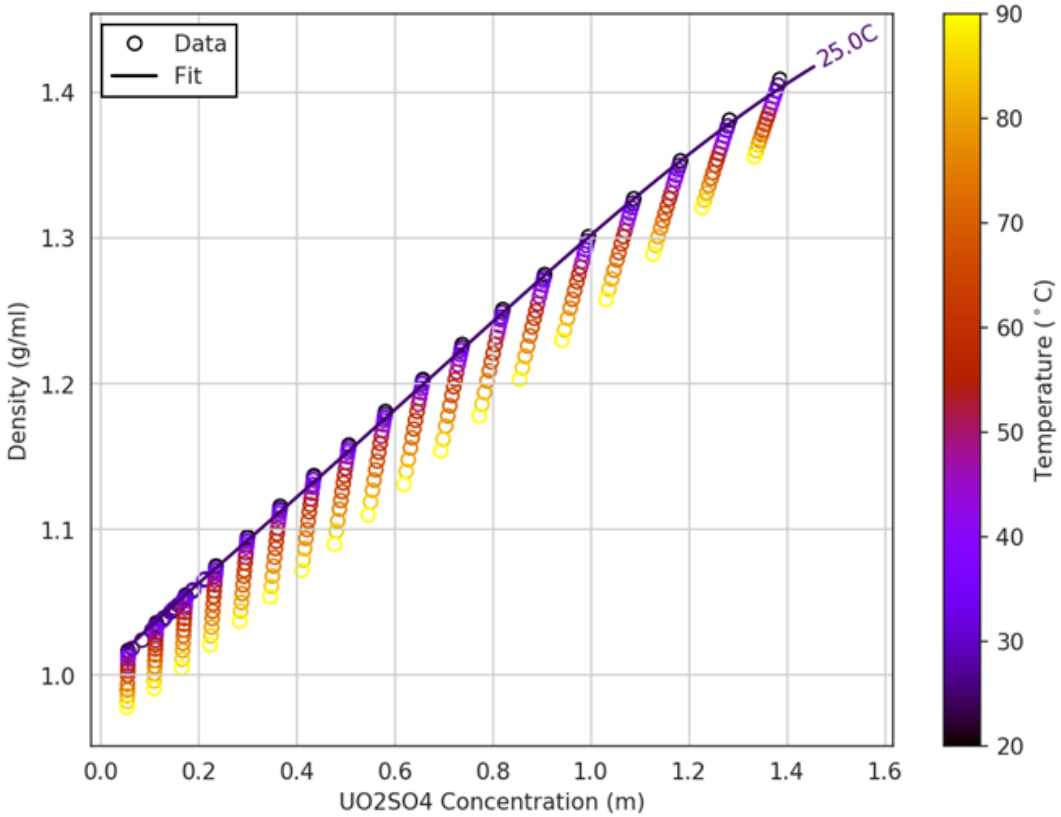

Figure 11. Plot of data and model fit for UO_2SO_4.

For sulfuric acid, 72 measurements were available at temperatures from 0°C to 100°C, and 6 were at 25°C. Concentrations varied from 0.53 to 4.37 *m* H_2SO_4. Fits suffer from the same problem as those for UO_2SO_4, where we were able to identify a good fit to the data at 25°C but were unable to find temperature-dependent parameters that agree with the data at other temperatures. Parameter values are listed in Table 6, and the fit is plotted with the data in Figure 12.

Table 6. Fit parameters for H_2SO_4.

Parameter	A
$\boldsymbol{\beta_{ca}^{v0}}$	-6.4000E-4
$\boldsymbol{\beta_{ca}^{v1}}$	3.8120E-2
$\boldsymbol{C_{ca}^{v}}$	4.7482E-5
$\boldsymbol{\bar{V}_{i}^{0}}$	4.3693E1

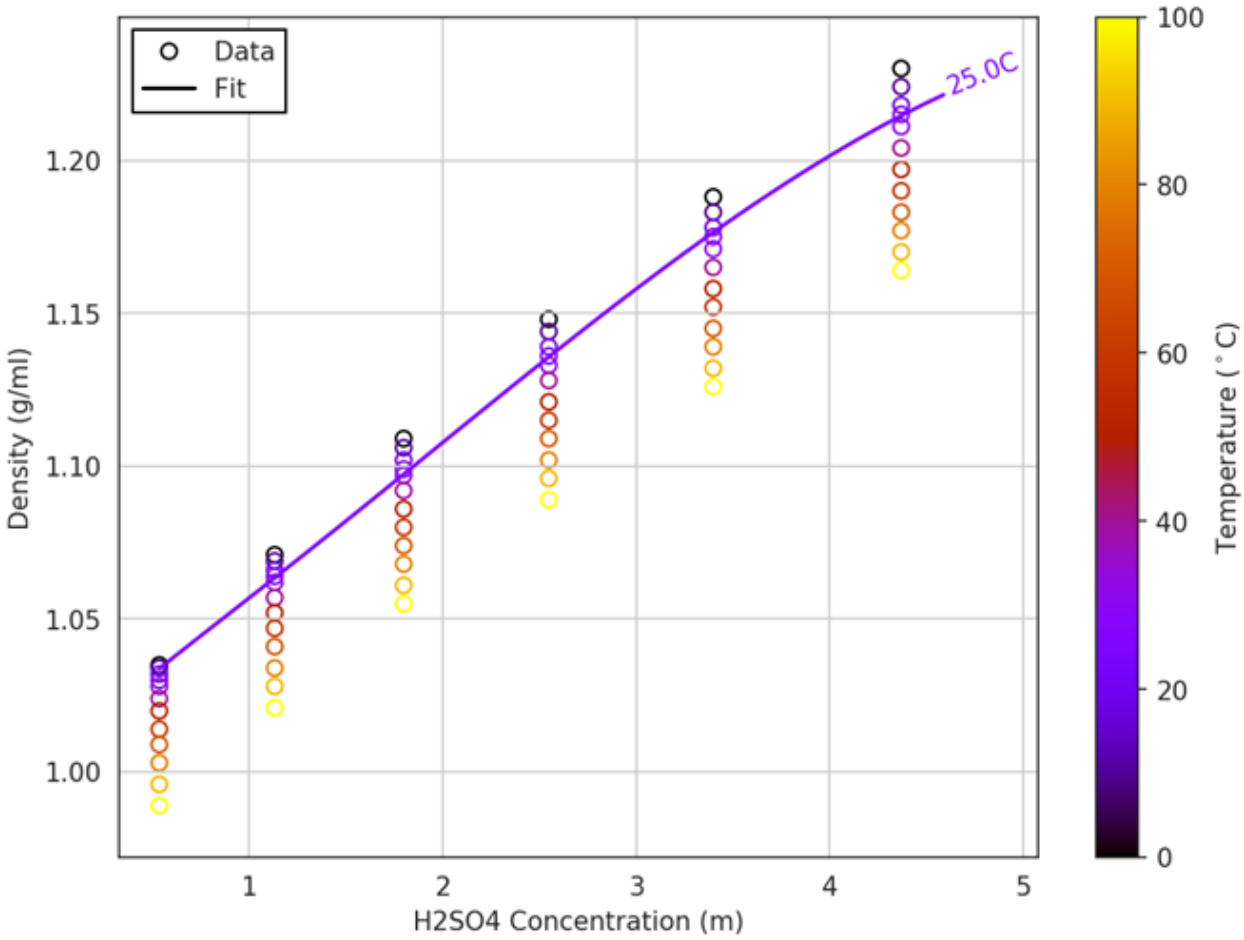

Figure 12. Plot of data and model fit for H_2SO_4.

As with the previous case, Figure 12 shows that the fit is highly consistent with the data at 25°C for all concentrations and reasonably describes the data between 15°C and 30°C.

3.3 TWO SPECIES SYSTEM

A total of 12 measurements were available for two species solutions containing UO_2F_2 and HF; however, the majority of these solutions were at concentrations well in excess of the concentrations for the corresponding binary solutions. We limited our analysis to measurements at concentrations that are consistent with the corresponding single species solution data, leaving only three measurements suitable for analysis. All of these measurements were recorded at 25°C, and no attempt was made to fit temperature-dependent coefficients. The parameters from fitting these three measurements are given in Table 7, and a comparison to the fit model predictions is listed in Table 8. Note that values for $\bar{V}_i^0$, β_{ca}^{v0}, β_{ca}^{v1}, and C_{ca}^{v} determined from the previous fits for binary solutions were fixed at the values given in Tables 3 and 4.

Table 7. Fit parameters for combined ternary fluoride solutions.

Parameter	A
$\theta^v[\mathbf{H^+}, \mathbf{UO_2^{2+}}]$	-1.4560E-2
$\psi^v[\mathbf{H^+}, \mathbf{UO_2^{2+}}, \mathbf{F^-}]$	2.6780E-3

Table 8. Measured and predicted densities for ternary fluoride solutions.

HF (m)	UO_2F_2 (m)	Meas. Density (g/mL)	Calc. Density (g/mL)	Difference (%)
1.319316	2.2762853	1.6879	1.6535	2.04%
3.454064	1.8240561	1.5494	1.5788	-1.90%
5.373435	1.7005814	1.5029	1.4933	0.64%

Data for solutions containing both UO_2SO_4 and H_2SO_4 consisted of a total of 29 measurements, all recorded at 30°C. Concentrations of UO_2SO_4 varied from 0.100 to 0.220 m UO_2SO_4, whereas acid concentrations ranged from 0.0200 to 0.4188 m H_2SO_4. As with the fluoride solutions, binary system parameter values were fixed at the values given in Tables 5 and 6. Unfortunately, we were not able to find values for θ^v and ψ^v that produce fits that agree with the data for the mixed UO_2SO_4–H_2SO_4–H_2O solutions. This is likely due to the dissociation behavior of H_2SO_4 as mentioned previously.

4. SUMMARY OF DATA AND MODELING NEEDS

4.1 UO_2F_2

As demonstrated in Section 3.1, data for this system are adequate for a reasonable model at room temperature (20°C–30°C). Model applications outside this range are unknown because no data exist. Potential applications may extend to near boiling because some reprocessing operations use mixtures of HF and HNO_3 to dissolve nuclear fuel at temperatures near 100°C. However, the complications of this system will also require more robust model development, especially if it is to be extended to a greater temperature range.

4.2 UO_2SO_4

Data appear to be adequate, unless systems of multiple acids (e.g., H_2SO_4 + HNO_3) are encountered. However, the difficulty in modeling this system may require additional verification data, especially for systems including excess acid. As noted in Section 3, this system is quite difficult to model, and additional work is required. The model in Sections 3.2 and 3.3 indicates that a model at room temperature could be constructed but could not reliably be extended to other temperatures.

This system is the active solution in the SHINE Medical Technologies process for production of ^{99}Mo. [24]. It is also important for other processes, and therefore additional data and modeling effort is warranted.

4.3 $PuCl_3$

There is a need for density prediction of plutonium chloride solutions so that systems that are more realistic than the fictitious metal-water system may be modeled in criticality calculations. Current methods are conservative and do not take into account any chloride. Los Alamos is pursuing data for this system and has installed equipment for density measurements. They plan to obtain data at room temperature over the next year. It would be helpful for the NCSP program to contribute to experiments and to be able to model results.

4.4 UCl_3

As with the plutonium system, density prediction for uranium chloride solutions would allow systems that are more realistic than the fictitious metal-water system to be modeled in criticality calculations. There are active needs for data and calculational support at several U.S. facilities.

4.5 MIXED ACTINIDES

There is one data set for U–Th systems in acid [4], but no data have been evaluated for mixed U–Pu systems in acid. There is also a need for data for mixed Pu-Am systems. Although there have been discussions of future work to obtain such measurements for chloride systems at Los Alamos, efforts are not currently funded.

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APPENDIX A. DATA FOR UO_2F_2 SOLUTIONS

Temp. (°C)	Density (g/mL)	Molarity (mol/L)	Molality (mol/kg-H_2O)	Reference
17	1.6979	2.554	2.802	[8] Book 48
18	1.6976	2.553	2.802	[8] Book 48
18	1.6976	2.553	2.802	[8] Book 48
19	1.7921	2.921	3.274	[8] Book 48
19	2.0176	3.789	4.455	[8] Book 96
19	2.0298	3.826	4.490	[25]
18	2.0200	3.789	4.438	[26]
18	2.0300	3.825	4.486	[26]
18.5	1.7921	2.921	3.274	[8] Book 48
19.5	2.0255	3.804	4.455	[8] Book 96
19.5	1.3474	1.268	1.325	[8] Book 99
20	1.3420	1.253	1.311	[8] Book 48
20	1.3467	1.262	1.317	[8] Book 95
20	1.3442	1.262	1.321	[8] Book 95
20	1.6491	2.390	2.617	[8] Book 95
20	1.7917	2.921	3.274	[8] Book 95
20	1.8451	3.131	3.555	[8] Book 96
20	1.8823	3.250	3.688	[8] Book 96
20	1.9067	3.350	3.829	[8] Book 96
20	1.9392	3.471	3.988	[8] Book 96
20	1.9683	3.584	4.146	[8] Book 99
20	1.9712	3.587	4.142	[8] Book 99
20	1.9958	3.689	4.293	[8] Book 99
20.3	2.0100	3.739	4.356	[8] Book 48
20.5	1.9059	3.347	3.825	[8] Book 95
20.5	1.9112	3.364	3.845	[8] Book 95
20.5	1.9220	3.397	3.879	[8] Book 95
20.5	1.9744	3.608	4.181	[8] Book 96
20.5	2.0167	3.760	4.380	[8] Book 96
20.5	2.0266	3.780	4.384	[8] Book 96
20.5	2.0280	3.800	4.431	[8] Book 96
20.8	2.0361	3.824	4.455	[8] Book 96
21	1.0011	0.006	0.006	[8] Book 3
21	1.0030	0.016	0.016	[8] Book 3
21	1.0298	0.118	0.119	[8] Book 3
21	1.0511	0.195	0.196	[8] Book 3
21	1.6966	2.552	2.816	[8] Book 48
21	1.6966	2.552	2.816	[8] Book 48

Temp. (°C)	Density (g/mL)	Molarity (mol/L)	Molality (mol/kg-H_2O)	Reference
21	1.6966	2.552	2.816	[8] Book 48
21	1.6966	2.552	2.816	[8] Book 48
21	1.6966	2.552	2.816	[8] Book 48
21	1.7374	2.729	3.043	[8] Book 95
21	1.9229	3.409	3.906	[8] Book 96
21	2.0096	3.738	4.356	[8] Book 48
21.5	2.0288	3.807	4.448	[8] Book 95
22	1.6412	2.350	2.573	[8] Book 48
22	1.6412	2.350	2.573	[8] Book 48
22	1.6412	2.350	2.573	[8] Book 48
22	1.6412	2.350	2.573	[8] Book 48
22	1.6593	2.423	2.655	[8] Book 48
22	1.6593	2.423	2.655	[8] Book 48
22	1.6593	2.423	2.655	[8] Book 48
22	1.6962	2.551	2.802	[8] Book 48
22	2.0091	3.737	4.356	[8] Book 48
22.2	2.0091	3.737	4.356	[8] Book 48
22.5	2.0091	3.737	4.356	[8] Book 48
22.5	2.0091	3.737	4.356	[8] Book 48
23	1.6165	2.276	2.486	[8] Book 48
23	1.6165	2.276	2.486	[8] Book 48
23	1.6185	2.284	2.496	[8] Book 48
23	1.7905	2.919	3.274	[8] Book 48
23	1.7905	2.919	3.274	[8] Book 48
23	1.7905	2.919	3.274	[8] Book 48
23.3	2.0086	3.736	4.356	[8] Book 48
24	1.0830	0.270	0.270	[8] Book 48
24	1.3687	1.512	1.140	[8] Book 48
24	1.6161	2.281	2.498	[8] Book 97
24	1.7901	2.918	3.274	[8] Book 97
24.2	2.0082	3.736	4.356	[8] Book 48
24.4	2.0191	3.756	4.356	[8] Book 48
24.5	1.6249	2.288	2.486	[8] Book 48
24.5	1.6249	2.288	2.486	[8] Book 48
24.5	1.0626	0.223	0.225	[8] Book 48
25	1.0060	0.033	0.033	[6]
25	1.0150	0.066	0.066	[6]
25	1.0250	0.100	0.100	[6]
25	1.0350	0.134	0.135	[6]

Temp. (°C)	Density (g/mL)	Molarity (mol/L)	Molality (mol/kg-H_2O)	Reference
25	1.0440	0.169	0.171	[6]
25	1.0540	0.205	0.207	[6]
25	1.0640	0.242	0.244	[6]
25	1.0750	0.279	0.282	[6]
25	1.0850	0.317	0.321	[6]
25	1.0960	0.356	0.361	[6]
25	1.1070	0.395	0.401	[6]
25	1.1180	0.436	0.443	[6]
25	1.1290	0.476	0.485	[6]
25	1.1410	0.519	0.528	[6]
25	1.1520	0.561	0.573	[6]
25	1.1640	0.605	0.618	[6]
25	1.1770	0.650	0.665	[6]
25	1.1890	0.695	0.713	[6]
25	1.2020	0.741	0.762	[6]
25	1.2150	0.789	0.812	[6]
25	1.2280	0.837	0.863	[6]
25	1.2420	0.887	0.916	[6]
25	1.2550	0.937	0.970	[6]
25	1.2700	0.990	1.025	[6]
25	1.2840	1.042	1.082	[6]
25	1.2990	1.096	1.141	[6]
25	1.3140	1.152	1.201	[6]
25	1.3290	1.208	1.263	[6]
25	1.3450	1.266	1.326	[6]
25	1.3610	1.326	1.391	[6]
25	1.3780	1.387	1.459	[6]
25	1.3940	1.448	1.528	[6]
25	1.4120	1.513	1.599	[6]
25	1.4290	1.577	1.672	[6]
25	1.4470	1.644	1.748	[6]
25	1.4660	1.713	1.826	[6]
25	1.4850	1.784	1.907	[6]
25	1.5040	1.855	1.990	[6]
25	1.5240	1.930	2.076	[6]
25	1.5450	2.006	2.164	[6]
25	1.5660	2.084	2.256	[6]
25	1.5870	2.164	2.351	[6]
25	1.6100	2.248	2.449	[6]
25	1.6320	2.331	2.551	[6]
25	1.6560	2.419	2.656	[6]

Temp. (°C)	Density (g/mL)	Molarity (mol/L)	Molality (mol/kg-H_2O)	Reference
25	1.6800	2.509	2.766	[6]
25	1.7040	2.600	2.879	[6]
25	1.7300	2.696	2.997	[6]
25	1.7560	2.793	3.119	[6]
25	1.7830	2.894	3.246	[6]
25	1.8100	2.997	3.379	[6]
25	1.8390	3.105	3.517	[6]
25	1.8680	3.214	3.661	[6]
25	1.8980	3.327	3.811	[6]
25	1.9290	3.444	3.968	[6]
25	1.9610	3.565	4.132	[6]
25	1.9940	3.690	4.303	[6]
25	2.0280	3.819	4.483	[6]
25	2.0630	3.952	4.672	[6]
25	2.1000	4.091	4.870	[6]
25	2.1380	4.234	5.078	[6]
25	1.0565	0.218	0.221	[8] Book 48
25	1.1566	0.579	0.592	[8] Book 48
25	1.1565	0.580	0.594	[8] Book 48
25	1.6157	2.275	2.486	[8] Book 48
25	1.6157	2.275	2.486	[8] Book 48
25	1.6581	2.422	2.655	[8] Book 48
25	2.0077	3.735	4.384	[8] Book 48
25	1.5971	2.196	2.386	[8] Book 89
25	1.8736	3.243	3.709	[8] Book 95
25	1.8976	3.332	3.824	[8] Book 95
25	1.8972	3.333	3.828	[8] Book 95
25	1.9037	3.356	3.857	[8] Book 95
25	2.0198	3.797	4.466	[8] Book 95
25	2.0312	3.824	4.482	[8] Book 95
25	1.3390	1.245	1.303	[8] Book 96
25	1.4499	1.649	1.750	[8] Book 96
25	1.4489	1.650	1.754	[8] Book 96
25	1.6418	2.375	2.610	[8] Book 96
25	1.8420	3.116	3.532	[8] Book 96
25	1.9187	3.405	3.915	[8] Book 96
25	1.9650	3.581	4.154	[8] Book 96
25	1.9682	3.591	4.165	[8] Book 96
25	1.9683	3.681	4.412	[8] Book 96
25	2.0130	3.758	4.393	[8] Book 96
25	2.0227	3.797	4.450	[8] Book 96

Temp. (°C)	Density (g/mL)	Molarity (mol/L)	Molality (mol/kg-H_2O)	Reference
25	2.0223	3.797	4.452	[8] Book 96
25	2.0293	3.794	4.408	[8] Book 98
25	2.0207	3.796	4.460	[8] Book 98
25	2.0181	3.799	4.479	[8] Book 98
25	2.0199	3.803	4.481	[8] Book 98
25	1.3386	1.242	1.299	[8] Book 99
25	1.3453	1.269	1.330	[8] Book 99
25	1.0202	0.083	0.083	[7]
25	1.0443	0.169	0.170	[7]
25	1.0448	0.170	0.172	[7]
25	1.0983	0.364	0.369	[7]
25	1.2164	0.793	0.816	[7]
25	1.2219	0.812	0.836	[7]
25	1.3632	1.332	1.398	[7]
25	1.3632	1.336	1.403	[7]
25	1.5509	2.029	2.192	[7]
25	1.7893	2.920	3.282	[7]
25	2.1627	4.327	5.215	[7]
25	1.0270	0.105	0.106	[9]
25	1.0170	0.084	0.085	[9]
25	1.3959	1.460	1.550	[9]
25	1.2363	0.893	0.933	[9]
25	1.0270	0.092	0.093	[9]
25.6	1.5580	2.065	2.239	[8] Book 2
26	1.8007	2.935	3.274	[8] Book 48
26.2	1.6257	2.289	2.486	[8] Book 48
26.6	1.1644	0.583	0.592	[8] Book 48
26.6	1.1644	0.583	0.592	[8] Book 48
26.6	1.0622	0.220	0.222	[8] Book 48
26.6	1.0622	0.220	0.222	[8] Book 48
26.8	2.0335	3.821	4.462	[8] Book 98
27	1.6262	2.289	2.486	[8] Book 48
27.4	2.0295	3.817	4.470	[8] Book 98
29	1.8023	2.938	3.292	[8] Book 48
30	1.0429	0.169	0.170	[7]
30	1.0967	0.363	0.369	[7]
30	1.2146	0.792	0.816	[7]
30	1.3607	1.333	1.403	[7]
30	1.5481	2.025	2.192	[7]

Temp. (°C)	Density (g/mL)	Molarity (mol/L)	Molality (mol/kg-H_2O)	Reference
30	1.7859	2.915	3.282	[7]
30	2.1589	4.320	5.215	[7]

APPENDIX B. DATA FOR HF

Temp (°C)	Density (g/mL)	Molality (mol/kg-H_2O)	Molarity (mol/L)	Reference
0	1.002842	0.504899035	0.501262	[17]
0	1.005842	1.020102133	1.005523	[17]
0	1.009841	1.545927974	1.514281	[17]
0	1.01384	2.082708521	2.027038	[17]
0	1.01884	2.63078971	2.546291	[17]
0	1.022839	3.190532202	3.067544	[17]
0	1.025839	3.762312167	3.589296	[17]
0	1.028838	4.34652213	4.114047	[17]
0	1.032837	4.943571873	4.646295	[17]
0	1.036837	5.553889389	5.18254	[17]
0	1.039836	6.177921904	5.717286	[17]
0	1.043836	6.816136977	6.261028	[17]
0	1.047835	7.469023661	6.808768	[17]
0	1.051834	8.137093756	7.360506	[17]
0	1.055834	8.820883147	7.916243	[17]
0	1.059833	9.520953238	8.475977	[17]
0	1.063833	10.23789249	9.039709	[17]
0	1.068832	10.97231806	9.616436	[17]
0	1.072831	11.7248776	10.18866	[17]
0	1.07683	12.49625112	10.76489	[17]
0	1.08283	13.28715309	11.36611	[17]
0	1.085829	14.0983346	11.94033	[17]
0	1.089828	14.93058576	12.52905	[17]
0	1.092828	15.78473826	13.10978	[17]
0	1.096827	16.66166817	13.70599	[17]
0	1.099827	17.56229888	14.29322	[17]
0	1.103826	18.4876044	14.89693	[17]
0	1.106826	19.43861286	15.49065	[17]
0	1.110825	20.41641029	16.10186	[17]
0	1.113825	21.42214479	16.70207	[17]
0	1.117824	22.45703101	17.32078	[17]
0	1.004842	0.243104045	0.243095	[27]
0	1.008841	0.763253805	0.758408	[27]
0	1.011841	1.271152698	1.254285	[27]
0	1.01684	2.520252328	2.439642	[27]
0	1.034837	4.199282221	4.008722	[27]
0	1.064832	9.414882012	8.436121	[27]
0	1.096827	16.19400318	13.41543	[27]

Temp (°C)	Density (g/mL)	Molality (mol/kg-H_2O)	Molarity (mol/L)	Reference
0	1.109825	19.90454318	15.7989	[27]
0	1.119824	21.24914756	16.69688	[27]
0	1.019839	2.63078971	2.54879	[14]
0	1.039836	5.553889389	5.197533	[14]
0	1.059833	8.820883147	7.946228	[14]
0	1.07983	12.49625112	10.79488	[14]
0	1.098827	16.66166817	13.73098	[14]
0	1.118824	21.42214479	16.77704	[14]
0	1.04	5.553889389	5.19844	[12]
0	1.08	12.49625112	10.79676	[12]
0	1.12	21.42214479	16.79496	[12]
15	1.017	2.66404174	2.572194	[10]
15	1.035	5.615667914	5.225093	[10]
15	1.054	9.029168463	8.060544	[10]
15	1.072	12.69211713	10.85056	[10]
15	1.097	17.92940379	14.47581	[10]
15	1.1085	21.21870561	16.51141	[10]
15	1.009093	1.492858013	1.46272	[11]
15	1.019084	3.077632973	2.954406	[11]
15	1.029075	4.763083671	4.475055	[11]
15	1.039066	6.559118237	6.02467	[11]
15	1.049057	8.476989067	7.603249	[11]
15	1.059048	10.52952879	9.210794	[11]
15	1.069039	12.73143778	10.8473	[11]
15	1.07903	15.09963678	12.51278	[11]
15	1.089021	17.65370254	14.20721	[11]
15	1.099012	20.41641029	15.93062	[11]
15.6	1.032	5.553889389	5.158452	[12]
15.6	1.07	12.49625112	10.69679	[12]
15.6	1.102	21.42214479	16.52504	[12]
18	1.002842	0.243104045	0.242611	[27]
18	1.004842	0.763253805	0.755401	[27]
18	1.008841	1.271152698	1.250566	[27]
18	1.01684	2.520252328	2.439642	[27]
18	1.027838	4.199282221	3.98161	[27]
18	1.057833	9.414882012	8.380672	[27]
18	1.086829	16.19400318	13.29314	[27]
18	1.102826	21.24914756	16.69688	[27]
20	1.005	1.020102133	1.004681	[13]
20	1.012	2.082708521	2.023358	[13]

Temp (°C)	Density (g/mL)	Molality (mol/kg-H_2O)	Molarity (mol/L)	Reference
20	1.021	3.190532202	3.062029	[13]
20	1.028	4.34652213	4.110696	[13]
20	1.036	5.553889389	5.178358	[13]
20	1.043	6.816136977	6.256016	[13]
20	1.05	8.137093756	7.34767	[13]
20	1.057	9.520953238	8.453319	[13]
20	1.064	10.97231806	9.572964	[13]
20	1.07	12.49625112	10.69661	[13]
20	1.084	15.78473826	13.00388	[13]
20	1.096	19.43861286	15.33914	[13]
20	1.017	2.63078971	2.541694	[14]
20	1.035	5.553889389	5.173359	[14]
20	1.053	8.820883147	7.894996	[14]
20	1.07	12.49625112	10.69661	[14]
20	1.086	16.66166817	13.5707	[14]
20	1.101	21.42214479	16.50976	[14]
20	1.001201	0.504899035	0.500442	[15]
20	1.005194	1.020102133	1.004875	[15]
20	1.009187	1.545927974	1.5133	[15]
20	1.012181	2.082708521	2.023721	[15]
20	1.016174	2.63078971	2.53963	[15]
20	1.021165	3.190532202	3.062524	[15]
20	1.025158	3.762312167	3.586915	[15]
20	1.028152	4.34652213	4.111306	[15]
20	1.033144	4.943571873	4.647672	[15]
20	1.036138	5.553889389	5.179048	[15]
20	1.039133	6.177921904	5.713418	[15]
20	1.043126	6.816136977	6.256769	[15]
20	1.047118	7.469023661	6.804112	[15]
20	1.050113	8.137093756	7.348461	[15]
20	1.053108	8.820883147	7.895803	[15]
20	1.0571	9.520953238	8.454122	[15]
20	1.060095	10.23789249	9.007951	[15]
20	1.064088	10.97231806	9.573755	[15]
20	1.067083	11.7248776	10.13407	[15]
20	1.070077	12.49625112	10.69738	[15]
20	1.07407	13.28715309	11.27416	[15]
20	1.077065	14.0983346	11.84395	[15]
20	1.080059	14.93058576	12.41674	[15]
20	1.084052	15.78473826	13.0045	[15]
20	1.087047	16.66166817	13.58378	[15]

Temp (°C)	Density (g/mL)	Molality (mol/kg-H_2O)	Molarity (mol/L)	Reference
20	1.090041	17.56229888	14.16604	[15]
20	1.093036	18.4876044	14.75131	[15]
20	1.096031	19.43861286	15.33956	[15]
20	1.099025	20.41641029	15.93081	[15]
20	1.10202	21.42214479	16.52506	[15]
25	1.000948	0.050002594	0.05	[16]
25	1.001048	0.100095355	0.1	[16]
25	1.005815	0.249796879	0.25	[16]
25	1.002958	0.503547725	0.5	[16]
25	1.006063	0.756766967	0.75	[16]
25	1.008431	1.011710607	1	[16]
25	1.007556	1.534453708	1.5	[16]
25	1.013241	2.055015173	2	[16]
25	1.023785	3.112786885	3	[16]
25	1.039398	5.32272665	5	[16]
25	1.073432	11.4498702	10	[16]
25	1.104331	18.65113082	15	[16]
25	1.13165	27.33997548	20	[16]
25	1.159083	37.94010881	25	[16]
25	1.232083	47.47567451	30	[16]
25	1.210887	97.40736401	40	[16]
26.7	1.03	5.553889389	5.148455	[12]
26.7	1.065	12.49625112	10.64681	[12]
26.7	1.097	21.42214479	16.45006	[12]
37.8	1.025	5.553889389	5.123463	[12]
37.8	1.055	12.49625112	10.54684	[12]
37.8	1.088	21.42214479	16.31511	[12]
48.9	1.019	5.553889389	5.093472	[12]
48.9	1.045	12.49625112	10.44687	[12]
48.9	1.075	21.42214479	16.12016	[12]

APPENDIX C. DATA FOR UO_2SO_4 SOLUTIONS

Temp (°C)	Density (g/mL)	Molarity (mol U/L)	Molality (mol/kg-H_2O)	Reference
20	1.017	0.05556	0.055746	[6]
20	1.036	0.113196	0.113815	[6]
20	1.055	0.172908	0.174355	[6]
20	1.075	0.234914	0.237527	[6]
20	1.095	0.299106	0.303507	[6]
20	1.116	0.36581	0.372485	[6]
20	1.137	0.43481	0.444672	[6]
20	1.158	0.506103	0.520297	[6]
20	1.181	0.580675	0.59961	[6]
20	1.203	0.657213	0.68289	[6]
20	1.227	0.737357	0.77044	[6]
20	1.251	0.820123	0.862598	[6]
20	1.275	0.905512	0.959737	[6]
20	1.301	0.995052	1.062273	[6]
20	1.327	1.087434	1.170668	[6]
20	1.353	1.182656	1.285439	[6]
20	1.381	1.282576	1.407167	[6]
20	1.409	1.385556	1.536502	[6]
24.8	1.126166	0.470637		[28]
24.9	1.262961	0.941481		[28]
24.9	1.396087	1.410522		[28]
24.8	1.525314	1.881869		[28]
25	1.656117	2.351785		[28]
25	1.720905	2.586666		[28]
25.2	1.794098	2.821788		[28]
25	1.851797	3.057215		[28]
25	1.901969	3.29237		[28]
25	2.042403	3.763061		[28]
25	1.016	0.055505	0.055746	[6]
25	1.035	0.113087	0.113815	[6]
25	1.054	0.172744	0.174355	[6]
25	1.074	0.234696	0.237527	[6]
25	1.094	0.298833	0.303507	[6]
25	1.114	0.365155	0.372485	[6]
25	1.136	0.434427	0.444672	[6]
25	1.157	0.505666	0.520297	[6]
25	1.179	0.579691	0.59961	[6]
25	1.202	0.656667	0.68289	[6]
25	1.225	0.736155	0.77044	[6]

Temp (°C)	Density (g/mL)	Molarity (mol U/L)	Molality (mol/kg-H_2O)	Reference
25	1.249	0.818812	0.862598	[6]
25	1.273	0.904091	0.959737	[6]
25	1.298	0.992758	1.062273	[6]
25	1.324	1.084975	1.170668	[6]
25	1.35	1.180033	1.285439	[6]
25	1.377	1.278861	1.407167	[6]
25	1.405	1.381623	1.536502	[6]
25	1.0184	0.063858	0.064177	[19]
25	1.0241	0.084023	0.084587	[19]
25	1.031	0.104189	0.104939	[19]
25	1.0342	0.114692	0.115592	[19]
25	1.0378	0.125615	0.126652	[19]
25	1.0395	0.128976	0.129979	[19]
25	1.0393	0.129816	0.130893	[19]
25	1.0433	0.142	0.143244	[19]
25	1.0443	0.147461	0.148903	[19]
25	1.0461	0.150402	0.151762	[19]
25	1.0482	0.157964	0.1595	[19]
25	1.0511	0.168467	0.170267	[19]
25	1.0526	0.171408	0.173166	[19]
25	1.0576	0.186112	0.188093	[19]
25	1.0586	0.187792	0.189718	[19]
25	1.058	0.188212	0.190287	[19]
25	1.0661	0.212999	0.21556	[19]
25	1.3613	1.138517	1.205419	[19]
25	1.4746	1.493558	1.609747	[19]
25	1.5063	1.593504	1.726567	[19]
25	1.5404	1.698953	1.849849	[19]
30	1.014	0.055396	0.055746	[6]
30	1.033	0.112868	0.113815	[6]
30	1.053	0.17258	0.174355	[6]
30	1.072	0.234258	0.237527	[6]
30	1.092	0.298286	0.303507	[6]
30	1.113	0.364827	0.372485	[6]
30	1.134	0.433662	0.444672	[6]
30	1.155	0.504792	0.520297	[6]
30	1.177	0.578708	0.59961	[6]
30	1.2	0.655574	0.68289	[6]
30	1.223	0.734953	0.77044	[6]
30	1.246	0.816845	0.862598	[6]
30	1.271	0.902671	0.959737	[6]

Temp (°C)	Density (g/mL)	Molarity (mol U/L)	Molality (mol/kg-H_2O)	Reference
30	1.295	0.990463	1.062273	[6]
30	1.321	1.082517	1.170668	[6]
30	1.347	1.177411	1.285439	[6]
30	1.374	1.276075	1.407167	[6]
30	1.401	1.377689	1.536502	[6]
30	1.0312	0.105029	0.105796	[19]
30	1.0379	0.126035	0.127082	[19]
30	1.0452	0.147041	0.148321	[19]
30	1.0518	0.168047	0.169696	[19]
30	1.0585	0.189053	0.191099	[19]
30	1.0653	0.210059	0.212524	[19]
35	1.013	0.055341	0.055746	[6]
35	1.032	0.112759	0.113815	[6]
35	1.051	0.172252	0.174355	[6]
35	1.07	0.233821	0.237527	[6]
35	1.09	0.29774	0.303507	[6]
35	1.111	0.364171	0.372485	[6]
35	1.131	0.432515	0.444672	[6]
35	1.153	0.503918	0.520297	[6]
35	1.175	0.577725	0.59961	[6]
35	1.197	0.653935	0.68289	[6]
35	1.22	0.73315	0.77044	[6]
35	1.244	0.815534	0.862598	[6]
35	1.268	0.90054	0.959737	[6]
35	1.292	0.988169	1.062273	[6]
35	1.317	1.079239	1.170668	[6]
35	1.343	1.173915	1.285439	[6]
35	1.37	1.27236	1.407167	[6]
35	1.397	1.373756	1.536502	[6]
40	1.011	0.055232	0.055746	[6]
40	1.029	0.112431	0.113815	[6]
40	1.048	0.17176	0.174355	[6]
40	1.068	0.233384	0.237527	[6]
40	1.088	0.297194	0.303507	[6]
40	1.108	0.363188	0.372485	[6]
40	1.129	0.43175	0.444672	[6]
40	1.15	0.502607	0.520297	[6]
40	1.172	0.57625	0.59961	[6]
40	1.194	0.652296	0.68289	[6]
40	1.217	0.731348	0.77044	[6]

Temp (°C)	Density (g/mL)	Molarity (mol U/L)	Molality (mol/kg-H_2O)	Reference
40	1.24	0.812912	0.862598	[6]
40	1.264	0.8977	0.959737	[6]
40	1.289	0.985874	1.062273	[6]
40	1.314	1.076781	1.170668	[6]
40	1.34	1.171292	1.285439	[6]
40	1.366	1.268645	1.407167	[6]
40	1.393	1.369822	1.536502	[6]
45	1.008	0.055068	0.055746	[6]
45	1.027	0.112212	0.113815	[6]
45	1.046	0.171433	0.174355	[6]
45	1.065	0.232729	0.237527	[6]
45	1.084	0.296101	0.303507	[6]
45	1.105	0.362205	0.372485	[6]
45	1.125	0.430221	0.444672	[6]
45	1.146	0.500859	0.520297	[6]
45	1.168	0.574283	0.59961	[6]
45	1.19	0.650111	0.68289	[6]
45	1.213	0.728944	0.77044	[6]
45	1.236	0.81029	0.862598	[6]
45	1.26	0.894859	0.959737	[6]
45	1.284	0.98205	1.062273	[6]
45	1.31	1.073503	1.170668	[6]
45	1.336	1.167796	1.285439	[6]
45	1.362	1.26493	1.407167	[6]
45	1.389	1.365889	1.536502	[6]
50	1.006	0.054959	0.055746	[6]
50	1.024	0.111885	0.113815	[6]
50	1.043	0.170941	0.174355	[6]
50	1.062	0.232073	0.237527	[6]
50	1.081	0.295282	0.303507	[6]
50	1.101	0.360894	0.372485	[6]
50	1.121	0.428691	0.444672	[6]
50	1.142	0.49911	0.520297	[6]
50	1.164	0.572316	0.59961	[6]
50	1.186	0.647926	0.68289	[6]
50	1.208	0.725939	0.77044	[6]
50	1.232	0.807667	0.862598	[6]
50	1.255	0.891308	0.959737	[6]
50	1.28	0.978991	1.062273	[6]
50	1.305	1.069405	1.170668	[6]

Temp (°C)	Density (g/mL)	Molarity (mol U/L)	Molality (mol/kg-H_2O)	Reference
50	1.331	1.163426	1.285439	[6]
50	1.358	1.261215	1.407167	[6]
50	1.385	1.361955	1.536502	[6]
55	1.003	0.054795	0.055746	[6]
55	1.021	0.111557	0.113815	[6]
55	1.039	0.170285	0.174355	[6]
55	1.058	0.231199	0.237527	[6]
55	1.077	0.294189	0.303507	[6]
55	1.097	0.359582	0.372485	[6]
55	1.117	0.427161	0.444672	[6]
55	1.137	0.496925	0.520297	[6]
55	1.159	0.569858	0.59961	[6]
55	1.181	0.645194	0.68289	[6]
55	1.203	0.722934	0.77044	[6]
55	1.227	0.804389	0.862598	[6]
55	1.25	0.887757	0.959737	[6]
55	1.275	0.975167	1.062273	[6]
55	1.301	1.066127	1.170668	[6]
55	1.327	1.159929	1.285439	[6]
55	1.354	1.2575	1.407167	[6]
55	1.382	1.359005	1.536502	[6]
60	1	0.054631	0.055746	[6]
60	1.018	0.111229	0.113815	[6]
60	1.035	0.16963	0.174355	[6]
60	1.054	0.230325	0.237527	[6]
60	1.072	0.292823	0.303507	[6]
60	1.092	0.357943	0.372485	[6]
60	1.112	0.425249	0.444672	[6]
60	1.132	0.49474	0.520297	[6]
60	1.153	0.566908	0.59961	[6]
60	1.175	0.641916	0.68289	[6]
60	1.198	0.71993	0.77044	[6]
60	1.221	0.800456	0.862598	[6]
60	1.245	0.884206	0.959737	[6]
60	1.27	0.971342	1.062273	[6]
60	1.296	1.06203	1.170668	[6]
60	1.322	1.155559	1.285439	[6]
60	1.35	1.253786	1.407167	[6]
60	1.378	1.355072	1.536502	[6]

Temp (°C)	Density (g/mL)	Molarity (mol U/L)	Molality (mol/kg-H_2O)	Reference
65	0.99	0.054085	0.055746	[6]
65	1.014	0.110792	0.113815	[6]
65	1.031	0.168974	0.174355	[6]
65	1.049	0.229232	0.237527	[6]
65	1.068	0.29173	0.303507	[6]
65	1.087	0.356305	0.372485	[6]
65	1.106	0.422955	0.444672	[6]
65	1.126	0.492118	0.520297	[6]
65	1.147	0.563958	0.59961	[6]
65	1.169	0.638638	0.68289	[6]
65	1.192	0.716324	0.77044	[6]
65	1.215	0.796523	0.862598	[6]
65	1.239	0.879944	0.959737	[6]
65	1.264	0.966753	1.062273	[6]
65	1.29	1.057113	1.170668	[6]
65	1.317	1.151188	1.285439	[6]
65	1.345	1.249142	1.407167	[6]
65	1.374	1.351138	1.536502	[6]
70	0.994	0.054303	0.055746	[6]
70	1.01	0.110355	0.113815	[6]
70	1.027	0.168319	0.174355	[6]
70	1.044	0.22814	0.237527	[6]
70	1.062	0.290092	0.303507	[6]
70	1.081	0.354338	0.372485	[6]
70	1.1	0.42066	0.444672	[6]
70	1.12	0.489495	0.520297	[6]
70	1.141	0.561008	0.59961	[6]
70	1.163	0.635361	0.68289	[6]
70	1.185	0.712117	0.77044	[6]
70	1.209	0.792589	0.862598	[6]
70	1.233	0.875683	0.959737	[6]
70	1.258	0.962164	1.062273	[6]
70	1.285	1.053016	1.170668	[6]
70	1.312	1.146818	1.285439	[6]
70	1.341	1.245427	1.407167	[6]
70	1.371	1.348188	1.536502	[6]
75	0.99	0.054085	0.055746	[6]
75	1.006	0.109918	0.113815	[6]
75	1.022	0.167499	0.174355	[6]
75	1.039	0.227047	0.237527	[6]
75	1.056	0.288453	0.303507	[6]

Temp (°C)	Density (g/mL)	Molarity (mol U/L)	Molality (mol/kg-H_2O)	Reference
75	1.075	0.352371	0.372485	[6]
75	1.094	0.418366	0.444672	[6]
75	1.114	0.486873	0.520297	[6]
75	1.134	0.557566	0.59961	[6]
75	1.156	0.631536	0.68289	[6]
75	1.178	0.707911	0.77044	[6]
75	1.202	0.788	0.862598	[6]
75	1.226	0.870712	0.959737	[6]
75	1.252	0.957575	1.062273	[6]
75	1.278	1.04728	1.170668	[6]
75	1.307	1.142447	1.285439	[6]
75	1.336	1.240783	1.407167	[6]
75	1.367	1.344255	1.536502	[6]
80	0.986	0.053866	0.055746	[6]
80	1.001	0.109372	0.113815	[6]
80	1.017	0.16668	0.174355	[6]
80	1.033	0.225736	0.237527	[6]
80	1.05	0.286814	0.303507	[6]
80	1.068	0.350077	0.372485	[6]
80	1.087	0.415689	0.444672	[6]
80	1.106	0.483377	0.520297	[6]
80	1.127	0.554124	0.59961	[6]
80	1.148	0.627166	0.68289	[6]
80	1.171	0.703704	0.77044	[6]
80	1.194	0.782756	0.862598	[6]
80	1.219	0.86574	0.959737	[6]
80	1.245	0.952221	1.062273	[6]
80	1.272	1.042363	1.170668	[6]
80	1.301	1.137203	1.285439	[6]
80	1.331	1.23614	1.407167	[6]
80	1.364	1.341305	1.536502	[6]
85	0.982	0.053648	0.055746	[6]
85	0.996	0.108825	0.113815	[6]
85	1.011	0.165696	0.174355	[6]
85	1.027	0.224425	0.237527	[6]
85	1.044	0.285175	0.303507	[6]
85	1.061	0.347782	0.372485	[6]
85	1.079	0.412629	0.444672	[6]
85	1.099	0.480317	0.520297	[6]
85	1.119	0.550191	0.59961	[6]
85	1.14	0.622795	0.68289	[6]

Temp (°C)	Density (g/mL)	Molarity (mol U/L)	Molality (mol/kg-H_2O)	Reference
85	1.162	0.698296	0.77044	[6]
85	1.186	0.777511	0.862598	[6]
85	1.211	0.860059	0.959737	[6]
85	1.237	0.946103	1.062273	[6]
85	1.265	1.036627	1.170668	[6]
85	1.295	1.131958	1.285439	[6]
85	1.326	1.231496	1.407167	[6]
85	1.36	1.337371	1.536502	[6]
90	0.978	0.053429	0.055746	[6]
90	0.991	0.108279	0.113815	[6]
90	1.005	0.164713	0.174355	[6]
90	1.021	0.223114	0.237527	[6]
90	1.037	0.283263	0.303507	[6]
90	1.054	0.345488	0.372485	[6]
90	1.072	0.409952	0.444672	[6]
90	1.09	0.476384	0.520297	[6]
90	1.11	0.545765	0.59961	[6]
90	1.131	0.617879	0.68289	[6]
90	1.154	0.693488	0.77044	[6]
90	1.178	0.772266	0.862598	[6]
90	1.203	0.854377	0.959737	[6]
90	1.23	0.940749	1.062273	[6]
90	1.258	1.03089	1.170668	[6]
90	1.289	1.126713	1.285439	[6]
90	1.321	1.226852	1.407167	[6]
90	1.356	1.333438	1.536502	[6]

APPENDIX D. H_2SO_4 DATA

Temp (°C)	Density g/mL	Molarity mol/L	Molality mol/kg-H_2O	Reference
7.01	1.05953	0.9	0.933043	[21]
7.01	1.06594	1	1.040852	[21]
7.01	1.07239	1.1	1.149634	[21]
7.01	1.1286	2	2.169043	[21]
10.01	1.0586	0.9	0.933043	[21]
10.01	1.06494	1	1.040852	[21]
10.01	1.07131	1.1	1.149634	[21]
10.01	1.127	2	2.169043	[21]
13.01	1.05759	0.9	0.933043	[21]
13.01	1.06387	1	1.040852	[21]
13.01	1.07017	1.1	1.149634	[21]
13.01	1.12536	2	2.169043	[21]
16	1.05652	0.9	0.933043	[21]
16	1.06274	1	1.040852	[21]
16	1.06896	1.1	1.149634	[21]
16	1.12372	2	2.169043	[21]
19.01	1.05536	0.9	0.933043	[21]
19.01	1.06158	1	1.040852	[21]
19.01	1.06773	1.1	1.149634	[21]
19.01	1.12208	2	2.169043	[21]
22	1.05421	0.9	0.933043	[21]
22	1.06034	1	1.040852	[21]
22	1.06646	1.1	1.149634	[21]
22	1.12043	2	2.169043	[21]
25	1.05299	0.9	0.933043	[21]
25	1.05907	1	1.040852	[21]
25	1.06516	1.1	1.149634	[21]
25	1.11875	2	2.169043	[21]
0	1.035	0.527633	0.536622	[6]
0	1.071	1.091972	1.132868	[6]
0	1.109	1.696073	1.799261	[6]
0	1.148	2.340959	2.548953	[6]
0	1.188	3.028156	3.398604	[6]
0	1.23	3.762255	4.369634	[6]
10	1.034	0.527124	0.536622	[6]
10	1.069	1.089932	1.132868	[6]
10	1.106	1.691485	1.799261	[6]
10	1.144	2.332802	2.548953	[6]
10	1.183	3.015412	3.398604	[6]

Temp (°C)	Density g/mL	Molarity mol/L	Molality mol/kg-H_2O	Reference
10	1.224	3.743902	4.369634	[6]
20	1.032	0.526104	0.536622	[6]
20	1.066	1.086874	1.132868	[6]
20	1.102	1.685368	1.799261	[6]
20	1.139	2.322606	2.548953	[6]
20	1.178	3.002667	3.398604	[6]
20	1.218	3.72555	4.369634	[6]
25	1.03	0.525084	0.536622	[6]
25	1.064	1.084834	1.132868	[6]
25	1.099	1.68078	1.799261	[6]
25	1.136	2.316489	2.548953	[6]
25	1.175	2.99502	3.398604	[6]
25	1.215	3.716374	4.369634	[6]
30	1.028	0.524065	0.536622	[6]
30	1.062	1.082795	1.132868	[6]
30	1.097	1.677721	1.799261	[6]
30	1.133	2.310371	2.548953	[6]
30	1.171	2.984824	3.398604	[6]
30	1.211	3.704139	4.369634	[6]
40	1.024	0.522026	0.536622	[6]
40	1.057	1.077697	1.132868	[6]
40	1.092	1.670074	1.799261	[6]
40	1.128	2.300175	2.548953	[6]
40	1.165	2.96953	3.398604	[6]
40	1.204	3.682728	4.369634	[6]
50	1.02	0.519986	0.536622	[6]
50	1.052	1.072599	1.132868	[6]
50	1.086	1.660898	1.799261	[6]
50	1.121	2.285901	2.548953	[6]
50	1.158	2.951688	3.398604	[6]
50	1.197	3.661316	4.369634	[6]
60	1.014	0.516928	0.536622	[6]
60	1.047	1.067502	1.132868	[6]
60	1.08	1.651722	1.799261	[6]
60	1.115	2.273666	2.548953	[6]
60	1.152	2.936394	3.398604	[6]
60	1.19	3.639905	4.369634	[6]
70	1.009	0.514379	0.536622	[6]
70	1.041	1.061384	1.132868	[6]
70	1.074	1.642545	1.799261	[6]
70	1.109	2.261431	2.548953	[6]

Temp (°C)	Density g/mL	Molarity mol/L	Molality mol/kg-H_2O	Reference
70	1.145	2.918551	3.398604	[6]
70	1.183	3.618494	4.369634	[6]
80	1.003	0.51132	0.536622	[6]
80	1.034	1.054247	1.132868	[6]
80	1.068	1.633369	1.799261	[6]
80	1.102	2.247157	2.548953	[6]
80	1.139	2.903258	3.398604	[6]
80	1.177	3.600141	4.369634	[6]
90	0.996	0.507751	0.536622	[6]
90	1.028	1.04813	1.132868	[6]
90	1.061	1.622664	1.799261	[6]
90	1.096	2.234922	2.548953	[6]
90	1.132	2.885415	3.398604	[6]
90	1.17	3.57873	4.369634	[6]
100	0.989	0.504183	0.536622	[6]
100	1.021	1.040992	1.132868	[6]
100	1.055	1.613487	1.799261	[6]
100	1.089	2.220648	2.548953	[6]
100	1.126	2.870121	3.398604	[6]
100	1.164	3.560378	4.369634	[6]

APPENDIX E. EQUATIONS OF THE PITZER METHOD

For a solution, the apparent molar volume (L/mol) is defined as

$$\varphi_v = \frac{1}{n}V - \frac{n_1}{n}\bar{V}_1^0 \ , \tag{E.1}$$

where $n =$ total inventory of dissolved species (mol),
$V =$ total solution volume (L),
$n_1, \bar{V}_1^0 =$ inventory (mol) and partial molar volume at infinite dilution (L/mol) of solvent.

Throughout this study, the solvent is water, and so $\bar{V}_1^0$ is just the molar volume of pure water, which is readily available [2]. The density can be calculated from these quantities as

$$d = \left(10^{-3}\ \frac{\text{L}}{\text{mL}}\right)\frac{n_1 M_1 + nM}{n_1\bar{V}_1^0 + n\varphi_v} \ , \tag{E.2}$$

where $d =$ total solution density (g/mL),
$M = \frac{1}{n}\sum_{i=2}^{N} n_i M_i =$ average molecular weight of all solutes (g/mol),
$M_i =$ molecular weight of component i (g/mol); $i = 1$ denotes water.

Note that in this definition, components refer to dissolved salts (ion pairs) and the solvent (water). The Pitzer method derives a representation of the apparent molar volume based on empirical coefficients and the inventories of all solution components:

$$\varphi_v = \sum_{i=2}^{N} x_i\bar{V}_i^0 + \frac{RT}{m}\left\{\frac{\partial f}{\partial P} + 2\sum_c\sum_a m_c m_a\left(B_{ca}^v + ZC_{ca}^v\right) + \sum_{c<c'} m_c m_{c'}\left(2\Phi_{cc'}^v + \sum_a m_a\,\psi_{cc'a}^v\right)\right\} \ , \tag{E.3}$$

where $x_i, \bar{V}_i^0 =$ mole fraction and partial molar volume at infinite dilution (L/mol) of components,
$m_c, m_a =$ Concentrations of cations and anions, respectively (molality),
$m = m_c + m_a =$ total moles in solution per kg H_2O (molality),
$R =$ universal gas constant,
$T =$ absolute temperature (K),
$f =$ Debye–Huckel term (see below),
$Z =$ total charge in solution, calculated below,
$B_{ca}^v, C_{ca}^v, \Phi_{cc'}^v, \psi_{cc'a}^v =$ ion-interaction parameters, determined empirically as described below.

The concentrations (*molality* = mol solute per kg water, abbreviated with lower-case "*m*") should not be confused with *molarity* (mol solute per liter of solution, abbreviated with upper-case "*M*"), which is often the measured quantity. The pressure derivative of the Debye–Huckel term appearing in Eq. (E.3) has been calculated and can be found in tables [2]:

$$RT\frac{\partial f}{\partial P}. \tag{E.4}$$

The total charge from all ions in solution is calculated as:

$$Z = \frac{1}{2}\sum m_i|z_i| = \sum_{\text{cations}} m_i z_i = -\sum_{\text{anions}} m_i z_i \,, \tag{E.5}$$

where z_i = charge on individual ion, listed in Table E.1.

Table E.1. Ionic charges.

Ion	Charge
UO_2^{2+}	+2
H^+	+1
F^-	-1
SO_4^{2-}	-2

Of the ion-interaction parameters, B_{ca}^{v} and C_{ca}^{v} are termed "binary" parameters because they are determined from solutions of a single salt. The C_{ca}^{v} are determined directly from regressions, but the B_{ca}^{v} have the representation:

$$B_{ca}^{v} = \beta_{ca}^{v0} + \beta_{ca}^{v1} g\left(\alpha\sqrt{I}\right), \tag{E.6}$$

where $I = \frac{1}{2}\sum m_i z_i^2$ = ionic strength,
$\alpha = 2$ = an empirically determined constant,
$\beta_{ca}^{v0}, \beta_{ca}^{v1}$ = parameters to be obtained through regressions,
$g(x)$ = an empirically determined function given below.

$$g(x) = \frac{2}{x^2}\left[1 - (1+x)e^{-x}\right]. \tag{E.7}$$

For the special case of doubly charged cation and anion, Eq. (E.6) takes the special form [2]

$$B_{ca}^{v} = \beta_{ca}^{v0} + \beta_{ca}^{v1} g\left(\alpha_1\sqrt{I}\right) + \beta_{ca}^{v2} g\left(\alpha_2\sqrt{I}\right), \tag{E.6a}$$

where β_{ca}^{v2} = additional parameter to be regressed,
$\alpha_1 = 1.4$ and $\alpha_2 = 12$ are empirical constants.

In our present study, Eq. (E.6a) is only relevant for the UO_2SO_4 binary system because upon dissolution this results in the doubly charged ions UO_2^{2+} and SO_4^{2-}.

The last term in Eq. (E.3) involves "ternary" parameters $\Phi_{cc'}^{v}$ and $\psi_{cc'a}^{v}$, so named because they only arise when three or more components are present (the solvent H_2O being one of them). The parameters $\psi_{cc'a}^{v}$ are determined directly from regressions, whereas the terms $\Phi_{cc'}^{v}$ are defined by the function:

$$\Phi_{cc'}^{v} = \theta_{cc'}^{v} + {}^{E}\theta_{cc'}^{v}(I), \tag{E.8}$$

where $\theta_{cc'}^{v}$ = parameter obtained through regression of systems involving the cations c and c',
${}^{E}\theta_{cc'}^{v}(I)$ = a function arising from statistical mechanics that must be calculated.

We note that Eq. (E.3) only involves ternary systems involving multiple cations c and c', together with a single anion a. The theory is applicable to multiple anions (e.g., NO_3^- and F^-) in the same solution, but this study has not involved any such systems. Hence, the appropriate terms have not been included in Eq. (E.3).

In summary, the terms listed in Table E.2 must be determined by empirical regression involving density data with known temperatures and concentrations. All other variables in Eqs. (E.1)–(E.8) can be calculated using methods or published data from open literature.

Table E.2. Parameters determined from density data.

Parameter	Symbol	Equation
Binary ion-interaction	β_{ca}^{v0}	E.6
Binary ion-interaction	β_{ca}^{v1}	E.6 or E.6a
Binary ion-interaction	β_{ca}^{v2}	E.6a
Binary ion-interaction	C_{ca}^{v}	E.3
Like-charged ion-interaction	$\theta_{cc'}^{v}$	E.8
Triple ion-interaction	$\psi_{cc'a}^{v}$	E.3
Partial molar volume at infinite dilution	$\bar{V}_i^0$	E.3

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtasks: IPD1, 2, 4, 5, 6

Task Titles:

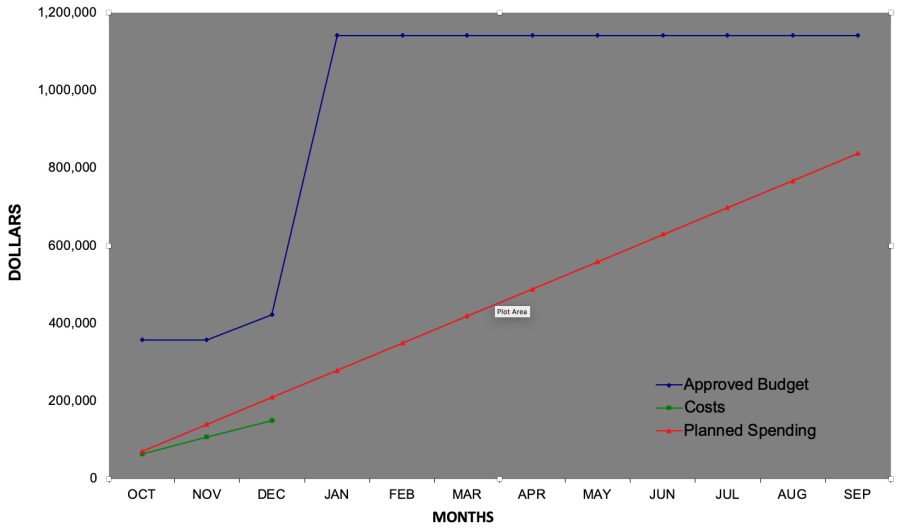
IPD1-Conduct ICSBEP for Benchmarks listed in Appendix C of the 5-Year Plan and publish annual revision to the Handbook
IPD2-Maintain the NCSP Website and Systems
IPD4-Benchmark Evaluation of Hot Box, LLNL Historical Critical Configurations at High Temperature
IPD5-IT Support at NNSS
IPD6-Benchmark Evaluation of LLNL 'Pulsed Spheres'

M&O Contractor Name: Lawrence Livermore National Laboratory

Point of Contact Name: David Heinrichs
Point of Contact Phone: (925) 424-5679

Reference: B&R DP0909010
Date of Report: January 31, 2020

BUDGET



1. **Carryover into FY 2020** = $230,063
2. **Approved FY 2020 Budget** = $1,141,063 (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $147,416
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021 =** $91,285 (8%)

MAJOR ACCOMPLISHMENTS

1. ICSBEP (IPD1).

Two NCSP evaluations were approved at the ICSBEP TRG meeting 'pending resolution of the review comments' as reported in LLNL-MI-796017:

- **IER-209**, LCT101, 7uPCX, 0.855 cm pitch, variable water height (SNL)
- **IER-184**, TEX baseline experiments with PANN plates moderated by polyethylene (LLNL)

LANL continues to evaluate **IER-299**, HMF101, KRUSTY cold/warm critical experiments. IRSN revised **PST041**, Pu nitrate solution in annular cylinders, and LLNL provided revised sample COG calculations for all 40 cases.

2. Website and Systems (IPD2).

Provided NCSP website updates as requested by NCSP Management including development and deployment of new webpages for the NCSP TPR. Deployed https://nda.llnl.gov publicly and added it as a focus area of https://ncsp.llnl.gov.

3. Hot Box (IPD4).

Formal evaluation of "Hot Box" is in progress. The benchmark model (Section 3) continues to be refined and specific cases are now being analyzed for completeness.

4. IT Support at NNSS (IPD5)

- Maintained & updated iSRD and NTS-SLAN/NCERC networks. Renewed 7 NTS-SLAN accounts. Completed classified network expansion at DAF-East. Performed continuous monitoring and authenticated scans of NCERC network devices.
- Terminated classified network computing at NSF for construction/upgrade of current PTS and relocation of infrastructure to IARC vault. Network reactivation pending CSP approval.
- Provided equipment inspections, certifications and data transfers (IPD2) supporting LANL IER-462, 465, 466, 494, and 508.

5. Benchmark Evaluation of LLNL 'Pulsed Spheres' (IPD6).

LLNL developed two models of the target assembly and a polyethylene sphere with point detectors and compared a COG simulation to that of a published MCNP simulation using the experimentally determined neutron 'source spectrum.' COG and MCNP results are in excellent agreement. LLNL also completed a first principles COG simulation starting with the incident deuteron beam impinging on the Ti-T target assembly. This coupled deuteron-fusion-neutron simulation yields superior results in comparison to experimental data. Including the collimator and room details in the model commences next quarter.

NCSP Quarterly Progress Report (FY-2020 Q1)

LLNL IP&D Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone
			

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	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, and the benchmark evaluation of LLNL 'Pulsed Spheres.' (IPD5, IPD6).		
Q2	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 and the benchmark evaluation of LLNL ‘Pulsed Spheres.’ (IPD5, IPD6).		
Q3	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, and the benchmark evaluation of LLNL ‘Pulsed Spheres.’ (IPD5, IPD6).		
Q4	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, and the benchmark evaluation of LLNL 'Pulsed Spheres.' (IPD5, IPD6).		

NCSP Quarterly Progress Report (FY-2020 Q1)

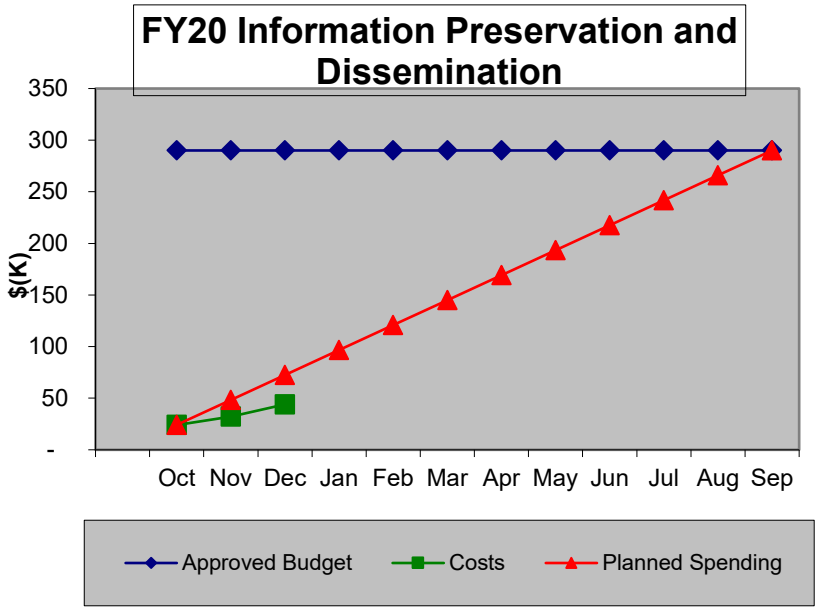
Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	Paris, France October 21-25, 2019 AM, IE, IP&D, ND, TS5 ICSBEP, IRPhE, and SINBAD Technical Review Meetings (Heinrichs, Kim, Percher) Conduct ICSBEP for benchmarks listed in Appendix C of the Five-Year Execution Plan.	**Yes** (LLNL-MI-796017)	
Q2	**N/A**		
Q3	**N/A**		
Q4	OECD/NEA Paris, France Jun-20 IPD1 TS5 WPNCS Meeting (Percher, Scorby) Participate in activities of the Working Party on Nuclear Criticality Safety and expert group meetings on MC methods and excursion analyses.		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	Catherine Percher, Jesse Norris, "PU-MET-MIX-002: TEX Plutonium Baseline Assemblies: Plutonium/ Aluminum Metal Alloy Plates with Varying Thicknesses of Polyethylene Modera-tor and a Thin Polyethylene Reflector", LLNL-TR-785164-DRAFT, October 19, 2019	**No**	Final report to be uploaded into IER-184 CEdT webpage.
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: ORNL – IPD5, 6
Task Titles:
IPD5-Oak Ridge Health Physics Research Reactor CAAS Benchmark Evaluation
IPD7- Preserving the "Howard Dyer" Library at ORNL
M&O Contractor Name: ORNL
Point of Contact Name: Doug Bowen
Point of Contact Phone: (865) 576-0315

Reference: DP0909010/ORNL
Date of Report: January, 2020

BUDGET



1. **Carryover into FY 2020** = $15K
2. **Approved FY 2020 Budget** = $290K (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $44K
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021** = $

MAJOR ACCOMPLISHMENTS

IPD 5 – Oak Ridge Health Physics Research Reactor CAAS Benchmark Evaluation

- Memo drafted to fulfill Milestone 1 in review that documents the literature review that was completed in FY19. The memo will document gaps for further literature review of HPRR report information and the information compiled to support the benchmark work for this task. Calvin Hopper has been providing expert support to this task.
- Available information is now being organized for inclusion into the format needed for the benchmark report due in Q4 (Shielding benchmark).

IPD 7 - Preserving the "Howard Dyer" Library at ORNL

- Library contents have been boxed and picked up by ACS Document Imaging. Scanning in progress.
- Digital product/media expected end of January/beginning of February 2020.
- The scanned documents will be QA-checked and will be ready to be shared to the NCS community via the NCSP website.

NCSP Quarterly Progress Report (FY-2020 Q1)

ORNL ND Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

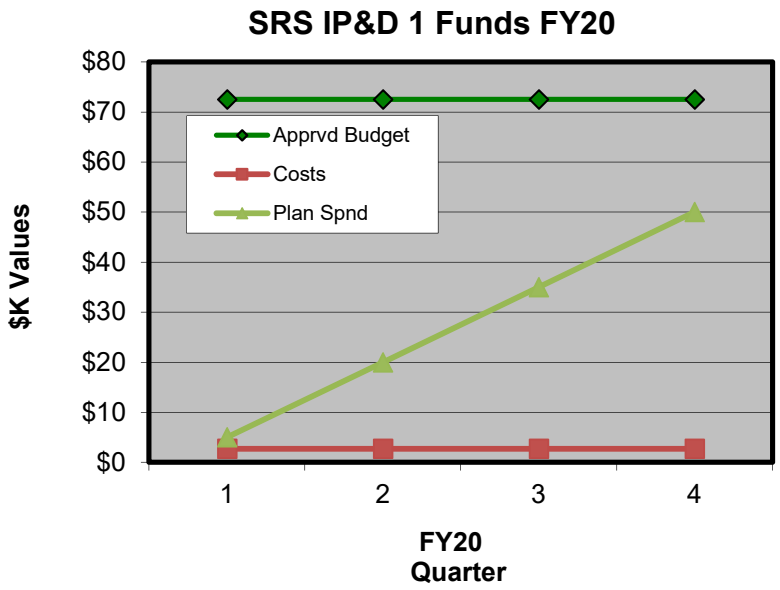
Complete	On Schedule	Behind Schedule	Missed Milestone
			

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	Provide a status report on progress made on IPD tasks. (IPD5, IPD7)		
Q2	Provide a status report on progress made on IPD tasks. (IPD5, IPD7)		
Q3	Provide a status report on progress made on IPD tasks. (IPD5, IPD7)		
Q4	Provide a status report on progress made on IPD tasks. (IPD5, IPD7)		

NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**(example)** J.L. Alwin, F.B. Brown, M.E. Rising, "Excluding Benchmark Statistical Outliers in Nuclear Criticality Safety Validation: A Comparison Study of Upper Subcritical Limits for Plutonium Systems using Whisper-1.1", LA-UR-18-27731, October 1, 2019	No	Publications will be submitted in Quarter 2
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: SRS IPD1 **Task Title:** ARH-600 Reissue **M&O Contractor Name(s):** SRNS **Point of Contact Name:** David Erickson **Point of Contact Phone:** 803-557-9445	**Reference: B&R DP 0909010** **Date of Report: February 17, 2020**
BUDGET	**MAJOR ACCOMPLISHMENTS**
 1. **Carryover into FY 2020** = $41,243 2. **Approved FY 2020 Budget** = $72,524 (includes carryover) 3. **Actual spending for 1st Quarter FY 2020** = $2,727 4. **Actual spending for 2nd Quarter FY 2020** = $ 5. **Actual spending for 3rd Quarter FY 2020** = $ 6. **Actual spending for 4rd Quarter FY 2020** = $ 7. **Projected carryover into FY 2021** = ~$22,000	Slow progress being made on achieving SRNS release of code to NCSP.

NCSP Quarterly Progress Report (FY-2020 Q1)

SRS IP&D Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone
			

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	Provide status reports on SRS progress with CritView. (IPD1)		
Q2	Provide status reports on SRS progress with CritView. (IPD1)		
	Develop QA documents for current version to meet current SRS/DOE requirements. (IPD1)		
Q3	Provide status reports on SRS progress with CritView. (IPD1)		
Q4	Provide status reports on SRS progress with CritView. (IPD1)		
	Issue Preliminary (updated) CritView version for internal testing. (IPD1)		
	Issue Preliminary User Guide to support internal testing. (IPD1		

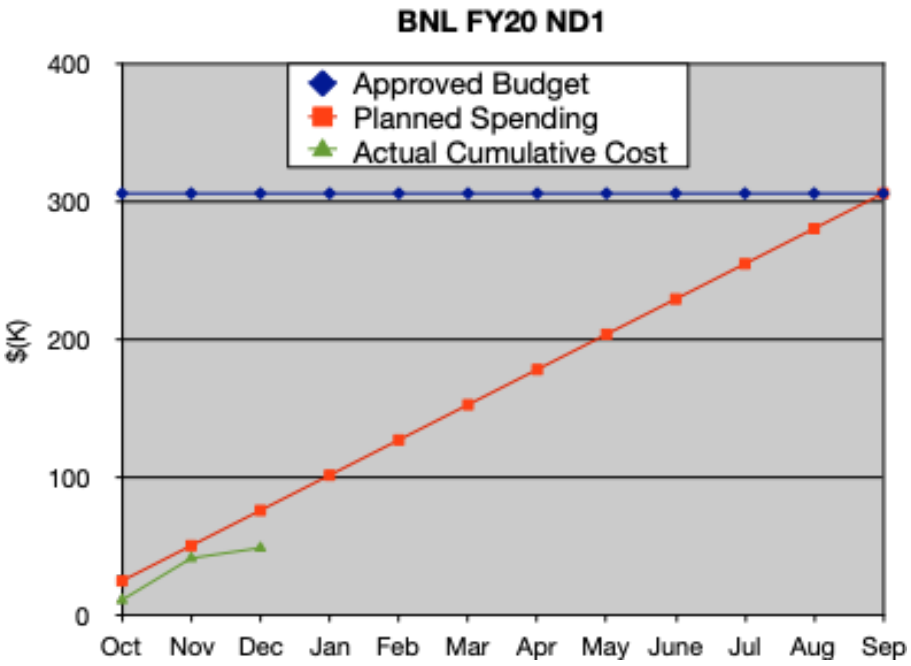
NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**(example)** J.L. Alwin, F.B. Brown, M.E. Rising, "Excluding Benchmark Statistical Outliers in Nuclear Criticality Safety Validation: A Comparison Study of Upper Subcritical Limits for Plutonium Systems using Whisper-1.1", LA-UR-18-27731, October 1, 2019	No	Publications will be submitted in Quarter 2
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: Nuclear Data ND1 Task Title: National Nuclear Data Center (NNDC) Support to the NCSP M&O Contractor Name: BNL Point of Contact Name: David Brown Point of Contact Phone: 631-344-2814	Reference: DP 0902000 Date of Report: Jan. 24, 2020

BUDGET



1. **Carryover into FY 2020** = $35,688
2. **Approved FY 2020 Budget** = $306,688
3. **Actual spending for 1st Quarter FY 2020** = $49,500
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021** = $

MAJOR ACCOMPLISHMENTS

The source code and data files for all ENDF related projects on the NNDC GForge server have been moved to a new GitLab instance at git.nndc.bnl.gov. We are moving over the outstanding ENDF tracker items by hand and it is quite time consuming.

ADVANCE and git.nndc.bnl.gov are communicating and GitLab is triggering builds on ADVANCE which are being posted on the NNDC website.

NCSP Quarterly Progress Report (FY-2020 Q1)

BNL ND Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	MILESTONE	STATUS	ISSUES/PATH FORWARD
Q1	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)		**With the new ADVANCE/GitLab system, we are revising how we will review new evaluation. More information will become available as we figure out the proper review criteria for new/revised evaluations.**
Q2	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)		
Q3	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)		
	If mandated by CSEWG, release new ENDF library. (ND1)		
Q4	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)		

NCSP Quarterly Progress Report (FY-2020 Q1)

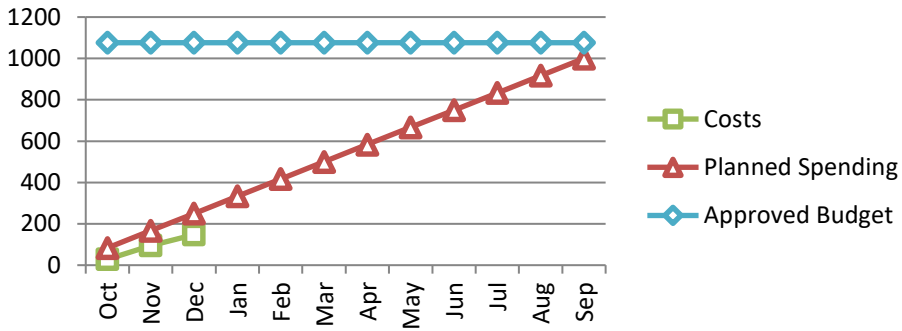
Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**	**no**	
Q2	**N/A**	**no**	
Q3	**N/A**	**no**	
Q4	**N/A**	**no**	
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**	No	
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: ND1, 2, 3
Task Title:
ND1: Nuclear Data Evaluation and Testing
ND2: Prompt Fission Neutron Spectra (PFNS) Measurement of Plutonium-240
ND3: Unresolved and Fast Measurements of Uraunium-233 (n,gamma)
M&O Contractor Name: LANL
Point of Contact Name: Brian Bluhm / Bob Little
Point of Contact Phone: 505-667-2440 / 505-665-3487

Reference: DP0902000
Date of Report: January 21, 2020

BUDGET

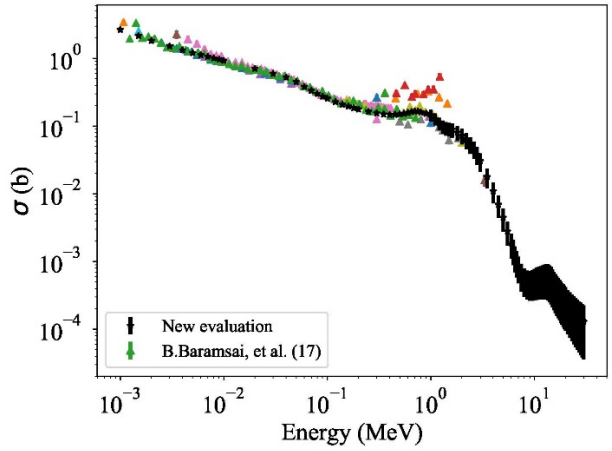


1. **Carryover into FY 2020 = $0**
2. **Approved FY 2020 Budget = $1,076,000 (includes carryover)**
3. **Actual spending for 1st Quarter FY 2020 = $147,361**
4. **Actual spending for 2nd Quarter FY 2020 = $**
5. **Actual spending for 3rd Quarter FY 2020 = $**
6. **Actual spending for 4rd Quarter FY 2020 = $**
7. **Projected carryover into FY 2021 = $76,000**

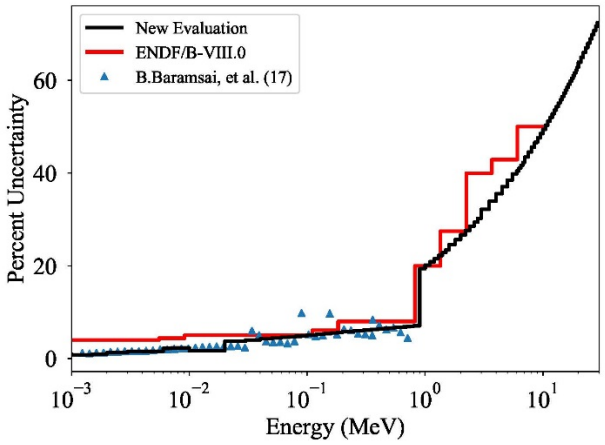
MAJOR ACCOMPLISHMENTS

- Los Alamos scientists led three sessions at the annual CSEWG meeting during the week of November 4 and contributed over 15 presentations. Several LANL scientists also participated in the NDAG meeting held during the week.
- ND-2 "Prompt fission neutron spectra (PFNS) measurement of Pu-240" is a new start in FY20. It will build on recent Chi-Nu work that has greatly improved the measured PFNS for ^{235}U and ^{239}Pu(n,f). In FY20 we will use an existing ^{240}Pu sample for a ^{240}Pu(sf) PFNS measurement and procure ^{240}Pu samples needed for ^{240}Pu(n,f) measurements.
- ND-3 "Unresolved and fast measurements of U-233(n,g)" is a new start in FY20. It will build on recent DANCE work that has demonstrated improved precision above 1 keV for capture on ^{235}U and ^{239}Pu, by measuring the capture / fission ratio to minimize uncertainties from sample, beam overlap, etc. In FY20, we will assess earlier ^{233}U data taken with DANCE and procure ^{233}U samples needed for measurement.
- We updated the evaluation of the covariance for 236U(n,g) reaction, based on available experimental information from the DANCE experiment using a Kalman approach; we are working with our experimental colleagues on updated values for their uncertainties. Based on the latest capture measurement for 236U, we have reduced the evaluated uncertainties below 20 keV. See the attached figures for the evaluated cross section compared with available experimental data, as well as a comparison of the relative uncertainty with the previous evaluation and DANCE data.
- Our experimental colleague Marian Jandel (formerly at LANSCE, now at UMass Lowell) has promised us his analysis of capture data for 234U so that we can complete our evaluation of 234U.
- More data has been added to our 10Be evaluation (differential cross section and polarization data for incident neutron energy below 3 MeV) enabling progression on our updated R-matrix evaluation of n+9Be. See the figure below showing the status of our current n+9Be evaluation.

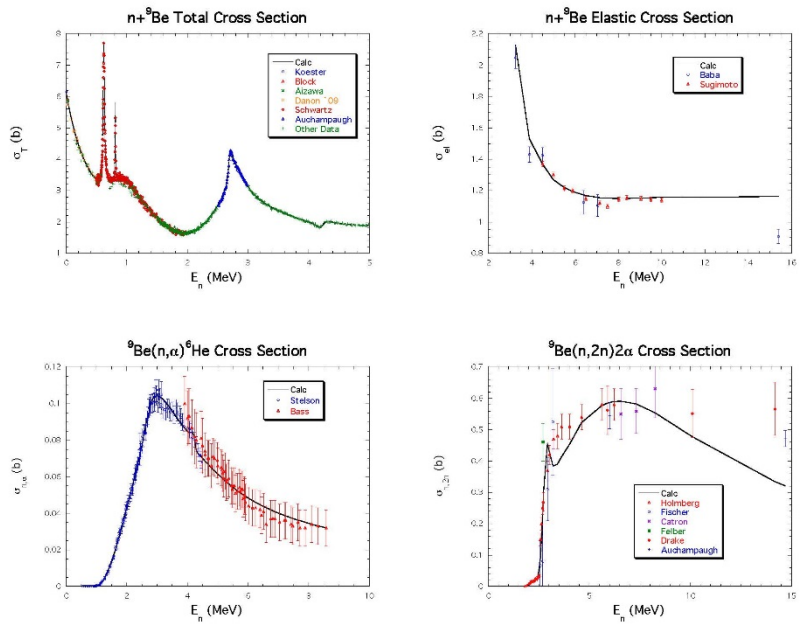
- As part of our Nuclear Data Machine Learning project, we adapted the FAUST software package to analyze k_eff bias in function of dissimilarity for sets of similar experiments.



236U(n,g) evaluated cross section compared with experimental data.



236U(n,g) relative uncertainty compared with experiment and ENDF/B-VIII.0.


n+9Be Total Cross Section
Calc
Koester
Block
Aizawa
Danon '09
Schwartz
Auchampaugh
Other Data
σT (b)
En (MeV)
n+9Be Elastic Cross Section
Calc
Baba
Sugimoto
σel (b)
En (MeV)
9Be(n,α)6He Cross Section
Calc
Stetson
Bass
σn,α (b)
En (MeV)
9Be(n,2n)2α Cross Section
Calc
Holmberg
Fischer
Catron
Feiber
Drake
Auchampaugh
σn,2n (b)
En (MeV)

NCSP Quarterly Progress Report (FY-2020 Q1)

LANL ND Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone
			

QUARTER	MILESTONE	STATUS	COMMENTS
Q1	Provide status reports on LANL participation in US and International Nuclear Data collaborations. (ND1)		
	Conduct CSEWG Data Evaluation Committee session. (ND1)		
	Report data testing results with ENDF/B-VIII.0 and additional beta release cross sections. (ND1)		
Q2	Provide status reports on LANL participation in US and International Nuclear Data collaborations. (ND1)		
Q3	Provide status reports on LANL participation in US and International Nuclear Data collaborations. (ND1)		
	Complete review of previous "thin" target U233 measurements and finalize specifications for new "thick" U233 target. (ND3)		
Q4	Provide status reports on LANL participation in US and International Nuclear Data collaborations. (ND1)		
	Acquire Pu240 PPAC target (ND2)		
	Deliver nuclear data evaluations as indicated in Appendix B of this document. (ND1)		

NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	OECD/NEA Paris, France TBD-date ND1 The NEA/WPEC Subgroup 38 is developing a modern nuclear database (XML) structure. (Paris) Contributor to multiple sub-groups-Paris co-leads SG38.		
	OECD/NEA Paris, France TBD-date ND1 The NEA/WPEC Subgroup 45 is "Validation of Nuclear Data Libraries (VaNDaL) Project." (Herman) Contributor to multiple sub-groups-Herman co-leads SG45.		
	OECD/NEA Paris, France TBD-date ND1 The NEA/WPEC Subgroup 46 is "Efficient and Effective Use of Integral Experiments for Nuclear Data Validation." (Herman) Contributor to multiple sub-groups-Herman co-leads SG46.		
Q4	**N/A**		

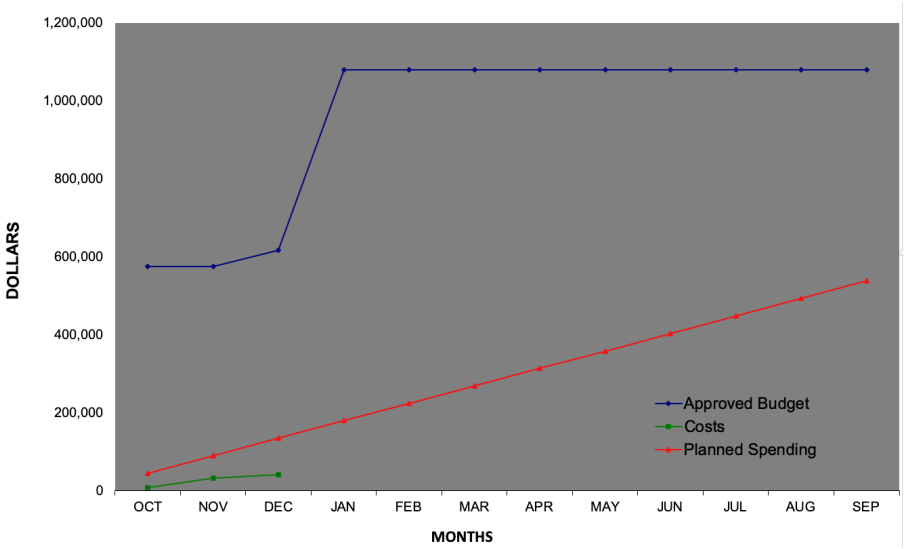
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: ND1, 2, 3, 5, 6, 7
Task Titles: See last page
M&O Contractor Name: Lawrence Livermore National Laboratory
Point of Contact Name: David Heinrichs
Point of Contact Phone: (925) 424-5679

Reference: B&R DP0909010
Date of Report: January 31, 2020

BUDGET



1. **Carryover into FY 2020** = $494,744
2. **Approved FY 2020 Budget** = $1,080,744 (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $42,353
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021 =** $86,500 (8%)

MAJOR ACCOMPLISHMENTS

1. Identified an issue in the current LLNL (COG) and NNL (MC21) algorithms used to calculate β_{eff} that may not properly account for fissions induced by prompt and delayed photoneutrons in assemblies with D_2O, Be, or BeO. A test problem or benchmark is needed to further investigate this issue. (ND1)
2. NCSU initiated testing of the LAMMPS molecular dynamics model (1000 molecules, NPT ensemble) of hydrofluoric acid (HF). The model is based on the use of an LJ potential with a Coulomb component for inter-molecular interactions and a harmonic component for intra-molecular interactions. Temperature and pressure dependent density data was extracted from the report R. Caizergues et al., "Criticality of Liquid Mixtures of Highly ^{235}U Enriched Uranium Hexafluoride and Hydrofluoric Acid," Union Carbide Corporation Report Y-CDC-9 (May 1971), and used to parameterize and validate the model. The density data as predicted by the model is in reasonable agreement with experimental data. Further verification of the model is underway. (ND2)
3. NCSU continued development of *FLASSH*. This includes adding a means of using an effective (with a weighted average) DOS, as opposed to a single atom site DOS, a more exact estimate of the full width at half maximum (FWHM) for the free gas diffusive model was added and tested giving faster grid convergence than the previous FWHM estimate, and several notable changes have been made to the GUI to include Liquid Physics capabilities. Some of these, along with the associated changes to *FLASSH*, allow the user to provide diffusive input lists of variable lengths. Various warnings have been added throughout the code to provide additional information and guidance to the user. (ND3)
4. NCSU introduced improved accuracy in the generalized Doppler routine as a function of β. Previous work showed reasonable agreement for the overall trend of data when compared with a cubic thermal scattering law. However, erroneous peaks were found. A correction was made to the generalized inelastic routine. Furthermore, the automatic β gridding over which the calculation is executed was improved. The non-cubic module is currently being tested using UO_2 which can be considered as having cubic symmetry. The results show the expected agreement between the two methods. (ND5)
5. LLNL received pre-publication radiative capture gamma production data in $^{113}Cd(n,\gamma)$ in EXFOR format courtesy of Michael Fleming (OECD NEA). Analysis of this data is in progress. (ND6)

NCSP Quarterly Progress Report (FY-2020 Q1)

LLNL ND Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone
			

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	Provide status on LLNL/NCSU nuclear data activities to NCSP Manager (ND1 {subtask 1 and 2}, ND2, ND3, ND5, ND6, ND7)		Costs include actual (LLNL) and estimated (NCSU) expenditures as LLNL has yet to receive invoices for Q1 from NCSU.
Q2	Provide status on LLNL/NCSU nuclear data activities to NCSP Manager (ND1 {subtask 1 and 2}, ND2, ND3, ND5, ND6, ND7)		
Q3	Provide status on LLNL/NCSU nuclear data activities to NCSP Manager (ND1 {subtask 1 and 2}, ND2, ND3, ND5, ND6, ND7)		
Q4	Provide status on LLNL/NCSU nuclear data activities to NCSP Manager (ND1 {subtask 1 and 2}, ND2, ND3, ND5, ND6, ND7)		
	Deliver thermal neutron scattering data evaluations as indicated in Appendix B of the 5-Year Plan. (ND2)		

NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	C. A. Manring, A. I. Hawari, "Development of Neural Thermal Scattering (NeTS) Modules for Reactor Physics Applications," Transactions of the American Nuclear Society: **121**, 1351-1353, November 2019	**Yes**	
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

Task Titles:

ND1 Subtasks 1 – Delayed Fission Gamma Multiplicity and Spectra – Data testing
ND1 Subtask 2 – Delayed Fission Gamma Multiplicity and Spectra – Document the technical basis of the method and data testing results

ND2 Generation and Benchmarking of Thermal Neutron Scattering Cross Sections in Support of Advanced Nuclear Reactor Concepts

ND3 Development and Implementation of an Advanced and Rigorous Computational Platform for Thermal Neutron Scattering Analysis

ND5 Development and Implementation of a Modern Doppler Broadening Approach Including Atomic Binding Effects

ND6 Evaluate Neutron Radiative Capture Gamma Production in Cadmium

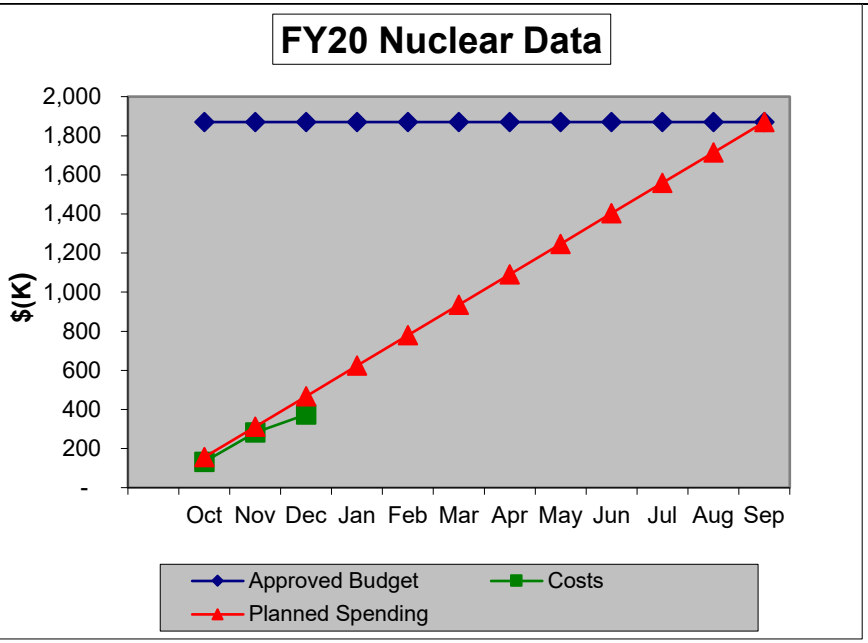
ND7 'Alpha-N' Benchmark Measurements

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: ORNL – ND1, 3, 4, 6, 10
Task Title: see last page
M&O Contractor Name: ORNL
Point of Contact Name: Doug Bowen
Point of Contact Phone: (865) 576-0315

Reference: DP0909010/ORNL
Date of Report: January, 2020

BUDGET



1. **Carryover into FY 2020** = $95K
2. **Approved FY 2020 Budget** = $1870K (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $374K
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021 = $**

MAJOR ACCOMPLISHMENTS

ND1 – Nuclear Data Measurement and Evaluation

- **Status report on all nuclear data support activities.**
  - Participate in the CSEWG meeting in November at BNL.
  - Participate in the NDAG meeting.
  - Mentor new staff member for the NCSP.
  - 239Pu evaluation (Pigni): work to extend the Resolved Resonance Evaluation is in progress. Preliminary results were presented at the INDEN meeting and CSWEG (see presentation IDs 1344366 or 133818). In additional work is in progress in the thermal region were the fit of the thermal constants and the first few resonances are being coupled to newly evaluated prompt fission neutron spectrum to improve the agreement with the benchmarks
  - 233U evaluation (Pigni): the fit of the nTOF and GELINA fission cross section and consequent adjustment of the capture cross section was complete. The test of the evaluation with newly normalized fission and capture cross sections is the next step to test the benchmark performance
  - 181Ta evaluation (Barry/Pigni): work on supporting the 181Ta evaluation work with RPI is in progress. The generation of set of resonance parameters consistent with the fitted thermal cross sections and experimental data (transmission and capture) was completed and the work on generating the covariance information is in progress
  - 54,56,57Fe (Pigni/Chapman): the work on the iron evaluations was initiated by sorting available experimental data and nuclear data evaluation released in different libraries
  - 140,142Cerium evaluation (Chapman/Pigni) : there was a presentation of the preliminary results at the ICNC conference (ID 131118) and related proceeding paper (ID 126323). (Not sure if these fall within this quarter or mentioned earlier)
- **Complete cross-section measurement and evaluation deliverables per the nuclear data schedule in Appendix B of the 5-year plan.**
  - Travel to JRC-Geel to finalized Ce-142 capture experiments (green)
  - The sorted Ce-142 capture TOF-spectra were reduced to cross section. (green)

NCSP Element and Subtask: ORNL – ND1, 3, 4, 6, 10 **Task Title:** see last page **M&O Contractor Name:** ORNL **Point of Contact Name:** Doug Bowen **Point of Contact Phone:** (865) 576-0315	**Reference:** DP0909010/ORNL **Date of Report:** January, 2020
BUDGET	**MAJOR ACCOMPLISHMENTS**
	○ Transmission experiment for Ce-142 with better neutron beam collimation were performed. (green) ○ Transmission data sorted into TOF-spectra. (green) ○ However, due to lack of GELINA neutron beam in spring. Experiments are delayed until April/May. (delayed) **Y12 ND1 – GELINA depleted Uranium target cost estimate and construction** • No action. Target is in procurement process for outside production at MSC Inc. **ND3 – Isotopic Sample Lease to Support ND1 ND Measurements** • Ce-142 sample lease will be extended for additional experiments at JRC. (green) • Started lease process for Zr-90 sample. • ORNL isotopes is to produce a metal sample after successful test with natural martial. **ND6 – SAMMY Nuclear Data Evaluation Code Modernization** • Gave the SAMMY status report at the annual CSEWG meeting • As there were inconsistencies reported by users in how covariance information for pup'ed parameters is reported, we started to move SAMMY covariance information into C++ in-memory structure. This will allow us to better manage the covariance information. This included writing some additional in-memory classes. The covariance information was written to temporary files for use during execution. The use of temporary files for covariance data for adjusted (but not for pup'ed parameters) has been eliminated. Work on this issue will continue, as there are still places were container array data is used to access the covariance information. • Changes in the SCALE continuous integration code made it necessary to update the SAMMY continuous integration code. • Work started on modernizing the multiple scattering code in SAMMY: Parameters needed to describe multiple scattering data have been moved to newly added C++ in-memory structures. • Fixed a production error where omitting spin groups from the fit did not work correctly if using reduced width In the parameter file written by SAMMY. **ND7 - Nuclear Data Evaluation and Testing for Nuclear Criticality Safety Applications** • Student (Alex Shaw) worked with B.J. Marshall to learn the VALID QA procedure by incorporating the Godiva benchmark, currently under review. Once it is

NCSP Element and Subtask: ORNL – ND1, 3, 4, 6, 10 Task Title: see last page M&O Contractor Name: ORNL Point of Contact Name: Doug Bowen Point of Contact Phone: (865) 576-0315	Reference: DP0909010/ORNL Date of Report: January, 2020
BUDGET	**MAJOR ACCOMPLISHMENTS**
	accepted into VALID, Alex will be able to follow the same procedure to incorporate the rest of his models to the validation suite. • Student continued to create models for benchmarks currently not in VALID that have sensitivities to nuclear data prioritized in Appendix B of the NCSP five-year plan. We not have 145 additional KENO models (and almost all of the same cases modeled in MCNP), run with both the ENDF-7.1 and ENDF-8.0 data libraries. • Student also used the ORNL developed isotope-swapping script to demonstrate the impact of individual isotopic evaluations of the CIELO nuclides on k-eff prediction for a select subset of cases from the LCT-010 benchmark: LCT-010-004, LCT-010-010, LCT-010-016, and LCT-010-020. In principle, the same methodology can be applied to any set of benchmark problems, but each base-case model generates 64 unique inputs, a substantial computational burden. • A PHYSOR-2020 paper demonstrating the ENDF-7.1 and ENDF-8.0 performance of Cu-63 and Cu-65 (isotopes referenced in Appendix B of the five-year plan) for 11 separate ICSBEP benchmark evaluations containing 32 individual configurations highly sensitive to copper was submitted and accepted for publication. **ND10 - Monte Carlo Evaluation of Differential and Integral Data** • We have continued to build on a proof of principle demonstration of this Monte Carlo method on the U-233 integral and differential data sets. • 1,000 randomly perturbed sets of U-233 resonance parameters were created by Monte Carlo sampling from ENDF U-233 resonance parameter covariance matrix. • Integral Data: o 1,000 randomly perturbed U-233 resonance parameters sets were used to compute 1,000 corresponding values of k_eff for U233-SOL-THERM-001-001 and U233-SOL-INTER-001-001 integral benchmark experiments using KENO o Variance of 1,000 values of k_eff for the 2 IBEs were found to significantly larger than the variance computed by the linear TSUNAMI method o This deviation was found to be particularly large for the thermal IBE U233-SOL-THERM-001-001, indicating that the effect of non-linearities is the largest in thermal neutron energy range • Differential Data: o 1,000 randomly perturbed U-233 resonance parameter sets were used to compute 1,000 total, fission, and capture differential cross section data using SAMMY

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: ORNL – ND1, 3, 4, 6, 10 **Task Title:** see last page **M&O Contractor Name:** ORNL **Point of Contact Name:** Doug Bowen **Point of Contact Phone:** (865) 576-0315	**Reference:** DP0909010/ORNL **Date of Report:** January, 2020
BUDGET	**MAJOR ACCOMPLISHMENTS**
	○ Variance of 1,000 total, fission, and capture differential cross section data were computed and found to be vastly larger than corresponding variance computed by the linear SAMMY method ○ In particular, the thermal neutron energy range, the variance computed by the Monte Carlo method was found to be significantly larger than the corresponding variance computed by the linear method in SAMMY ○ These large non-linearities in the thermal neutron energy range were interpreted as a consequence of a divergence of cross section as a resonance energy approaches zero energy in the theory of scattering • The method and the findings above were reported in a talk titled "Bayesian Monte-Carlo Evaluation Framework of Differential and Integral Data" at the Cross Section Evaluation Working Group Meeting of the Nuclear Data Week, BNL, November 4-8, 2019. • The next task is to implement Metropolis-Hastings Markov Chain method that is absolutely necessary for a Monte Carlo evaluation of a large number of R-matrix resonance parameters.

NCSP Quarterly Progress Report (FY-2020 Q1)

ORNL ND Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND1, ND3, ND4, ND6, ND7m 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).		
Q2	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND1, ND3, ND4, ND6, 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).		
Q3	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND1, ND3, ND4, ND6, 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).		
Q4	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND1, ND3, ND4, ND6, 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).		
	Document SAMMY modernization progress and report status annually to the NCSP Manager (ND6).		

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	IRMM Geel, Belgium Nov 2019 ND1, TS7 Perform resonance region nuclear data measurements using GELINA facility at IRNN in accordance with Appendix B of the Five-Year Plan Participate in WPEC and attend IAEA International Nuclear Data Evaluation Network (INDEN) meeting WPEC and INDEN Paris, France, Vienna, Austria Nov, 2019 Participate in WPEC annual meeting, coordinate international nuclear data collaborations for the NCSP, and present NCSP/ORNL nuclear data evalua-tion work. Attend IAEA International Nuclear Data Evaluation Network (INDEN) meeting ND1 INDEN Vienna, Austria Oct, 2019 ND1 Attend IAEA International Nuclear Data Evaluation Network (INDEN) meeting	**Yes**	
Q2	**N/A**		
Q3	OECD/NEA Paris, France Jun-20 ND1, TS Participate in WPEC annual meeting, coordinate international nuclear data collaborations for the NCSP, and present NCSP/ORNL nuclear data evaluation work (Sobes, Pigni, Wiarda) 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 – date ND1 Participate in IAEA working group meeting to improve nuclear data evaluations to support new evaluations of interest to the NCSP (Sobes, Pigni)		

	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.		
Q4	Tokyo, Japan Sep-20 ND10 Participate in the 5th International Workshop on Nuclear Data Covariances 2020, (CW2020) (Pigni). Present NCSP-funded project Bayesian Monte Carlo Evaluation of Differential and Integral Data (ND10, Arbanas). Present the progress on fission modeling and generation of covariance matrices for fission product yields with physical constraints.		
	IRMM Mol, Belgium Jan-19 Apr-19 Jun-19 Sep-19 ND, TS7 Perform resonance region nuclear data measurements using GELINA facility at IRMM in accordance with Appendix B of the Five-Year Plan (Guber) Continues cross-section measurements to support the production of new cross-section evaluations per the schedule in Appendix B of the Five-Year Plan.		

Publications (add each publication on an individual line)

Quarter	Publication Reference	Submitted yes/no	If no, state status of submittal
Q1	Dorothea Wiarda, "Issues in ENDF/B-VIII.0 GNDS Covariances", November, 2019 Dorothea Wiarda, Goran Arbanas, Andrew Holcomb, Marco Pigni, "Current Status of SAMMY", November 2019 Marco Pigni, "Updates to R-matrix Evaluations for Fissile Actinides: 233,235U, 239Pu", November 2019 Marco Pigni, "Status of the n+35Cl cross sections", November 2019Updates to R-matrix Evaluations of Fissile Actinides: 233,235U, 239Pu" Klaus Guber, ORNL, C. Paradela, S. Kopecky, J. Heyse, P. Schillebeeckx, EC-JRC, "ORNL neutron cross section measurements for the US Nuclear Criticality Safety Program", November 2019 Jesse Brown, Y. Danon RPI, D. Barry, B. Epping, M. Rapp, Naval Nuclear Laboratory, "Differential Transmission Benchmark Method to Validate		

	Resolved and Unresolved Resonance Parameter Evaluations", November 2019 Jesse Brown, Dorothea Wiarda, "Format proposal: R-external function", November 2019		
Q2			
Q3			
Q4			

Task Titles:

ND1 Nuclear Data Measurement and Evaluation

ND3 Isotopic Sample Leases to Support ND1 ND Measurements

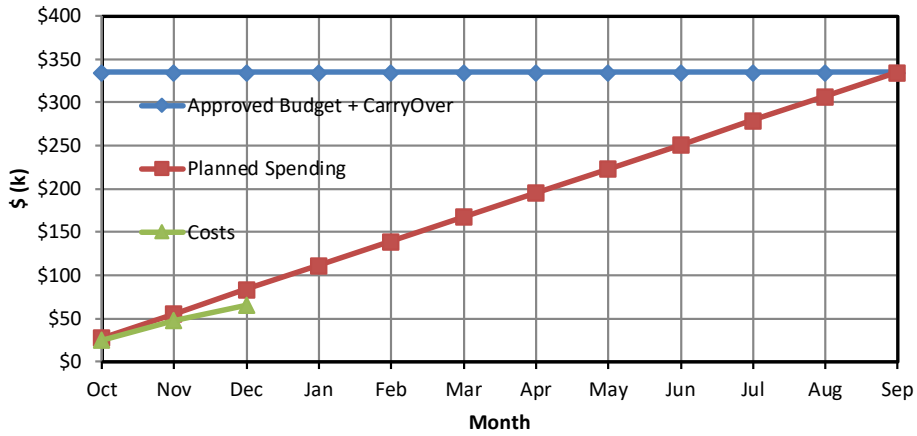
ND4 Thermal Neutron Total Cross Section Measurements for Improvement of Criticality Calculations and Propagation of Scattering Kernel Uncertainties

ND6 SAMMY Nuclear Data Evaluation Code Modernization

ND10 Monte Carlo Evaluation of Differential and Integral Data

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: ND1 **Task Title:** Resonance Region Nuclear Data Measurement Capability at RPI **M&O Contractor Name**: RPI **Point of Contact Name**: Yaron Danon ***Point of Contact Phone***: 518-276-4008	Reference: BNR Code 0909010 Date of Report: 1 15, 2020
BUDGET	**MAJOR ACCOMPLISHMENTS**



1. **Carryover into FY 2020** = $ -8,913
2. **Approved FY 2020 Budget** = $ 335,087 (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $ 65,388
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021 =** $

- Completed Cu scattering analysis, publication in progress.
- Fully assembled new detector system with seven total detectors and full control of detector positions.
- Designed a preliminary experiment for Cr-53 neutron capture measurement.
- Designed detector alignment mechanism to precisely determine detector locations relative to sample.

NCSP Quarterly Progress Report (FY-2020 Q1)

RPI ND1 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND1)		
	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)		
	Complete analysis of measurement from FY-18 (ND1)		
Q2	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND1)		
	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)		
Q3	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND1)		
	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)		
	Complete transmission measurement per the nuclear data schedule in Appendix B (ND1)		

	Complete capture measurement per the nuclear data schedule in Appendix B (ND1)		
Q4	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND1)		
	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)		
	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)		

NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	OECD/NEA Paris, France May-20 ND1 ND2 Participate in WPEC, and WPEC (Danon, Lui) 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.		
Q4	**N/A**		

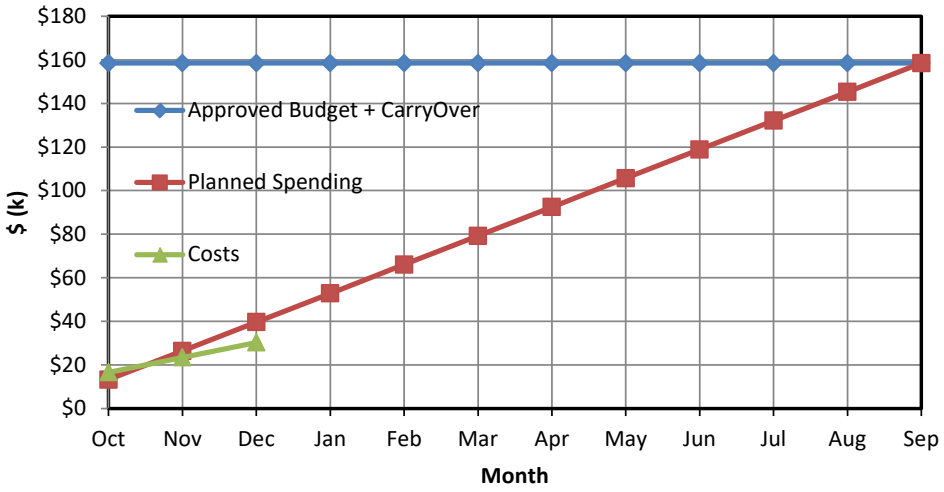
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1		No	
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: ND2
Task Title: Thermal Neutron Scattering Measurement for Improvement of Criticality Calculations and Propagation of Scattering Kernel Uncertainties
M&O Contractor Name: RPI
Point of Contact Name: Yaron Danon
Point of Contact Phone: 518-276-4008

Reference: BNR Code 0909010
Date of Report: January, 2020

BUDGET



1. **Carryover into FY 2020** = $ 116,888
2. **Approved FY 2020 Budget** = $ 266,888 (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $ 8,827
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021 =** $

MAJOR ACCOMPLISHMENTS

- Cryostat design drawings submitted to vendor. Anticipated date of shipment: 5/1/20
- Begun design of accessory components (i.e. table).
- Started investigation of non-cryogenic low-energy neutron gain improvements.

NCSP Quarterly Progress Report (FY-2020 Q1)

RPI ND2 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone
			

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND2)		
	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 (ND2)		
Q2	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND2)		
	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 (ND2)		
	Complete cold moderator preliminary design phase (ND2)		
Q3	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND2)		
	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 (ND2)		
Q4	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND2)		

	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 (ND2)		
	Complete cold moderator design (ND2)		

NCSP Quarterly Progress Report (FY-2020 Q1)

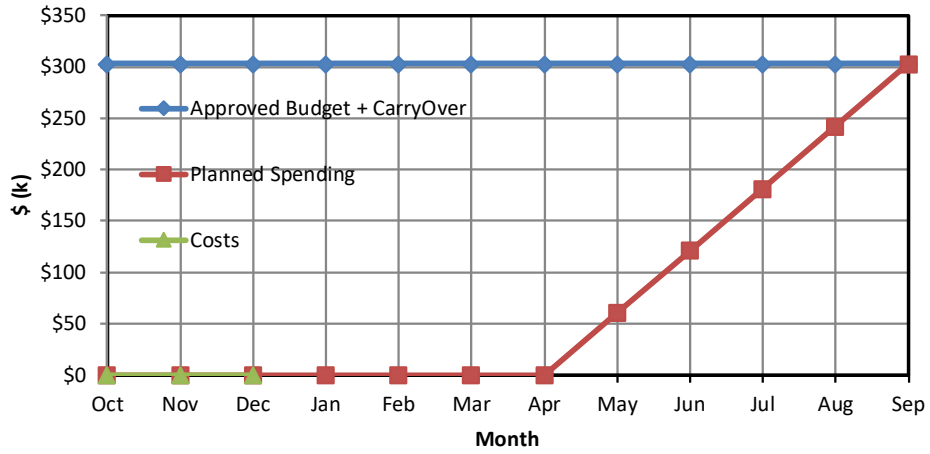
Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	OECD/NEA Paris, France May-20 ND1 ND2 Participate in WPEC, and WPEC (Danon, Lui) 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.		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1		No	
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: ND3
Task Title: RPI/ORNL: LINAC 2020 Nuclear Data Capabilities Maintenance Plan
M&O Contractor Name: RPI
Point of Contact Name: Yaron Danon
Point of Contact Phone: 518-276-4008

Reference: BNR Code 0909010
Date of Report: January, 2020

BUDGET



1. **Carryover into FY 2020** = $ 0
2. **Approved FY 2020 Budget** = $ 303K (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $ 0
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021 =** $ 0

MAJOR ACCOMPLISHMENTS

- Factory Acceptance test on modulators 2 and 3completed
- Completed setup of one modulator test infrastructure (water, electricity) at RPI.

NCSP Quarterly Progress Report (FY-2020 Q1)

RPI ND3 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND3)		
	Factory acceptance tests of RF Modulators 2 and 3 (ND3)		
Q2	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND3)		
	Delivery of RF Modulator 1 and Klystron 1 (ND3)		
	Factory acceptance tests of RF Modulators 4 and 5 (ND3)		
Q3	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND3)		
	Factory Acceptance test for Tapered Phase Velocity and Speed of Light #1 Accelerator Sections (ND3)		
Q4	Provide status reports on all nuclear data support activities in NCSP Quarterly Progress Reports (ND3)		
	Delivery and of TPV and SOL1 Accelerator Sections (ND3)		

NCSP Quarterly Progress Report (FY-2020 Q1)

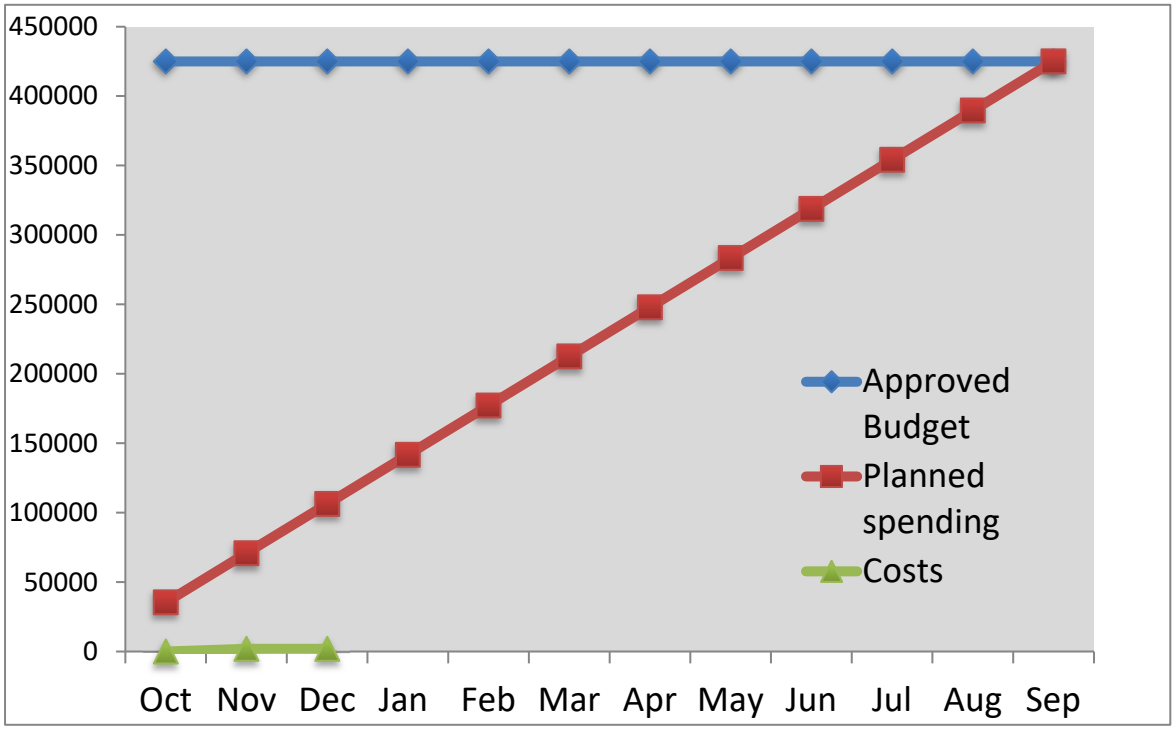
Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1		No	Publications will be submitted in Quarter 2
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element: LANL TE3
Task Title: Conduct Hands-On Criticality Safety Training Course at NCERC
M&O Contractor Name: Los Alamos National Laboratory (LANL)
Point of Contact Name: Brian Bluhm
Point of Contact Phone: (505) 667-2440

Reference: DP0909010
Date of Report: February 7, 2020

BUDGET



1. **Carryover into FY 2020 = $0K**
2. **Approved FY 2020 Budget = $425K**
3. **Actual spending for 1st Quarter FY 2020 = $2K**
4. **Actual spending for 2nd Quarter FY 2020 = $0K**
5. **Actual spending for 3rd Quarter FY 2020 = $0K**
6. **Actual spending for 4rd Quarter FY 2020 = $0K**
7. **Projected carryover into FY 2022 = $0K**

MAJOR ACCOMPLISHMENTS

- No major progress to report

NCSP Quarterly Progress Report (FY-2020 Q1)

LANL TE3 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	**TASK**	**STATUS**	**ISSUES/PATH FORWARD**
Q1	Provide status reports on all training activities to the NCSP Manager. (TE3)		
Q2	Provide status reports on all training activities to the NCSP Manager. (TE3)		
Q3	Provide status reports on all training activities to the NCSP Manager. (TE3)		
Q4	Provide status reports on all training activities to the NCSP Manager. (TE3)		

NCSP Quarterly Progress Report (FY-2020 Q1)

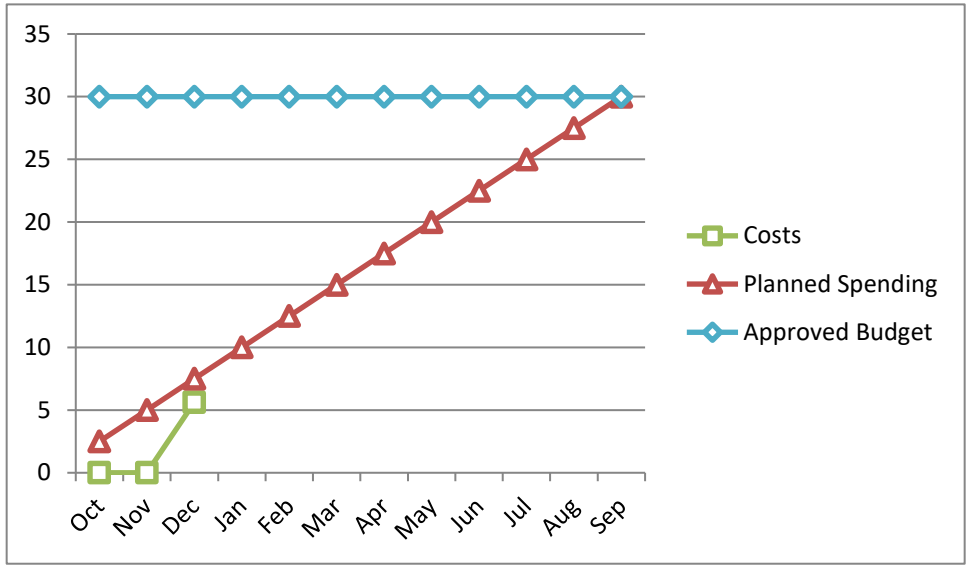
Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element: LANL TE4
Task Title: On-Site Introductory Training for the NCS Practitioner on Modern Approaches to Validation using Sensitivity and Uncertainty Analysis Tools
M&O Contractor Name: Los Alamos National Laboratory (LANL)
Point of Contact Name: Brian Bluhm / Bob Little
Point of Contact Phone: (505) 667-2440 / (505) 665-3487

Reference: B&R DP090200
Date of Report: January 21, 2020

BUDGET



1. **Carryover into FY 2020 = $0**
2. **Approved FY 2020 Budget = $30,000 (includes carryover)**
3. **Actual spending for 1st Quarter FY 2020 = $5,628**
4. **Actual spending for 2nd Quarter FY 2020 = $**
5. **Actual spending for 3rd Quarter FY 2020 = $**
6. **Actual spending for 4rd Quarter FY 2020 = $**
7. **Projected carryover into FY 2021 = $0**

MAJOR ACCOMPLISHMENTS

- Location / dates for joint S/U training still being determined for FY20

NCSP Quarterly Progress Report (FY-2020 Q1)

LANL TE4 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	MILESTONE	STATUS	ISSUES/PATH FORWARD
Q1	NONE		
Q2	NONE		
Q3	NONE		
Q4	In collaboration with ORNL, provide introductory 1-day S/U workshop training to one or more DOE sites in FY20. (TE4)		

NCSP Quarterly Progress Report (FY-2020 Q1)

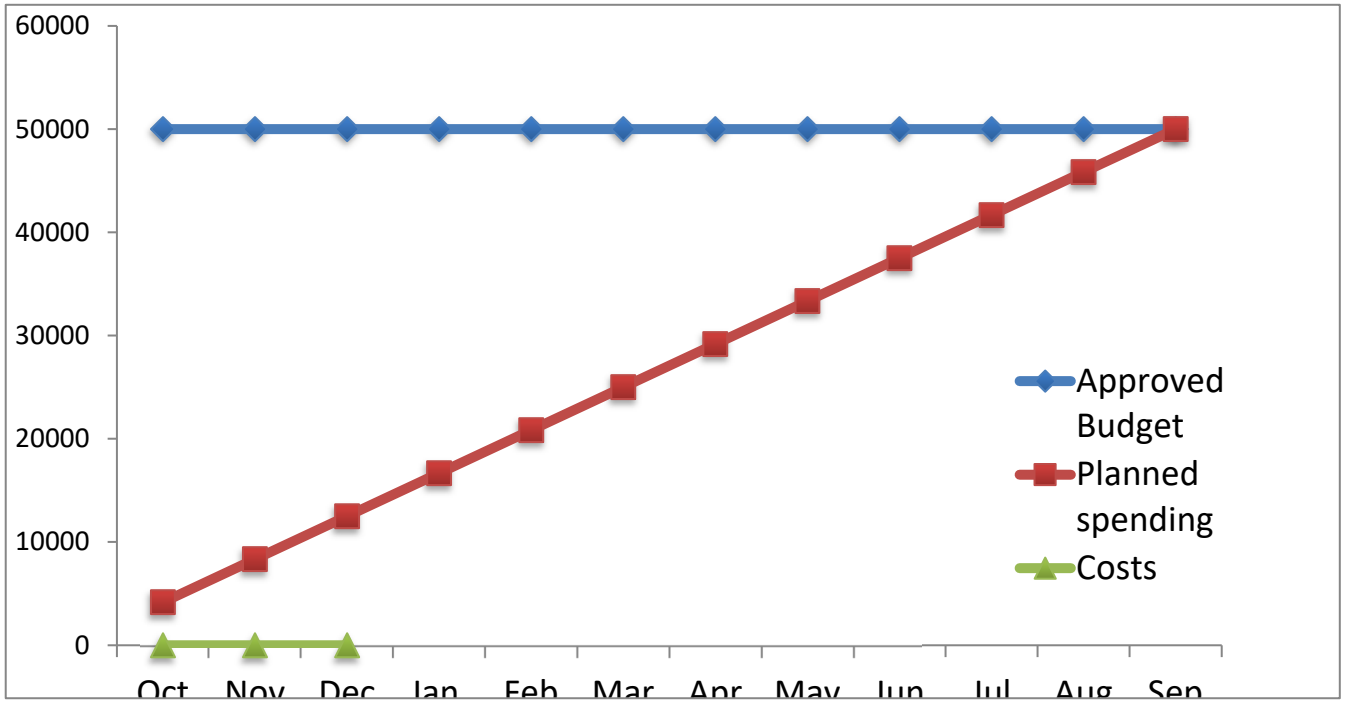
Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element: LANL TE6
Task Title: Development of University Pipeline for Criticality Safety Professionals
M&O Contractor Name: Los Alamos National Laboratory (LANL)
Point of Contact Name: Brian K. Bluhm
Point of Contact Phone: (505) 667-2440

Reference: B&R DP0909010
Date of Report: February 7, 2020

BUDGET



1. **Carryover into FY 2020 = $0K**
2. **Approved FY 2020 Budget = $50K**
3. **Actual spending for 1st Quarter FY 2020 = $0K**
4. **Actual spending for 2nd Quarter FY 2020 = $0K**
5. **Actual spending for 3rd Quarter FY 2020 = $0K**
6. **Actual spending for 4rd Quarter FY 2020 = $0K**
7. **Projected carryover into FY 2021 = $0K**

MAJOR ACCOMPLISHMENTS

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NCSP Quarterly Progress Report (FY-2020 Q1)

LANL TE6 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone
			

QUARTER	**TASK**	**STATUS**	**ISSUES/PATH FORWARD**
Q1	Provide status reports on all training activities to the NCSP Manager. (TE6)		
Q2	Provide status reports on all training activities to the NCSP Manager. (TE6)		
Q3	Provide status reports on all training activities to the NCSP Manager. (TE6)		
Q4	Provide status reports on all training activities to the NCSP Manager. (TE6)		

NCSP Quarterly Progress Report (FY-2020 Q1)

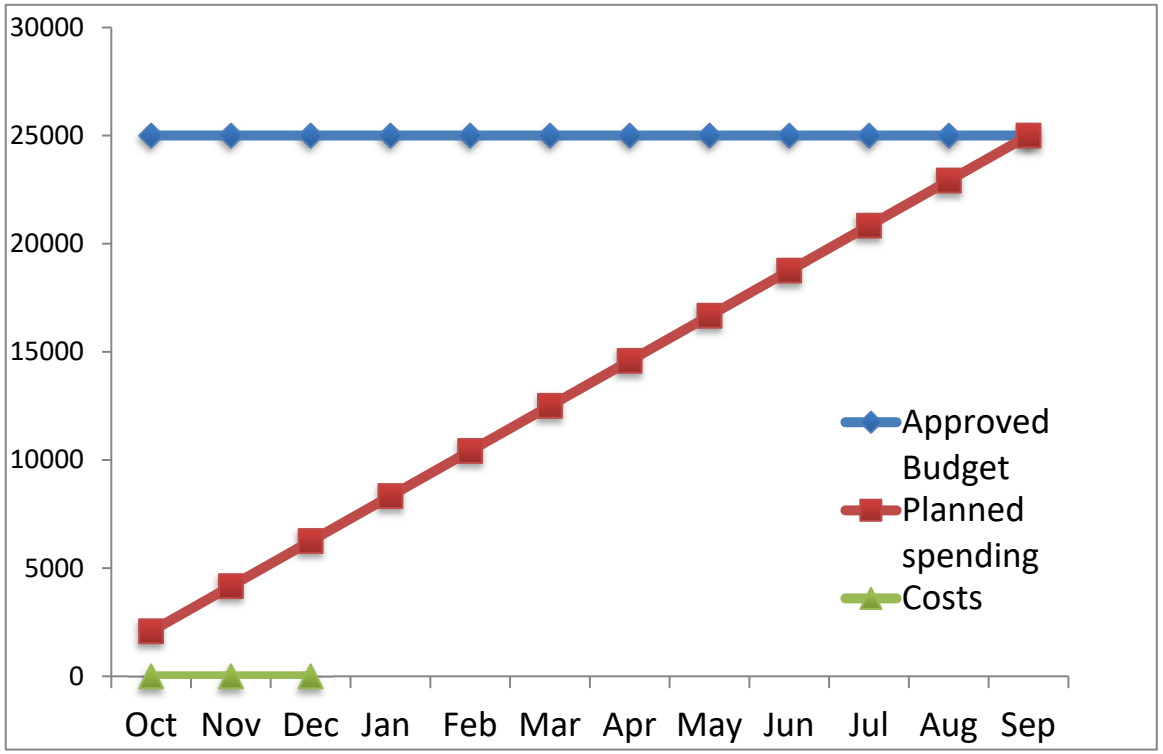
Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element: LANL TE7
Task Title: Design and Develop a New NCSP T&E Course Criticality Safety Officers at DOE/NNSA Nuclear Facilities
M&O Contractor Name: Los Alamos National Laboratory (LANL)
Point of Contact Name: Brian K. Bluhm
Point of Contact Phone: (505) 667-2440

Reference: B&R DP0909010
Date of Report: February 7, 2020

BUDGET



1. **Carryover into FY 2019 = $ 0K**
2. **Approved FY 2019 Budget = $25K**
3. **Actual spending for 1st Quarter FY 2019 = $0K**
4. **Actual spending for 2nd Quarter FY 2019 = $0K**
5. **Actual spending for 3rd Quarter FY 2019 = $0K**
6. **Actual spending for 4rd Quarter FY 2019 = $0K**
7. **Projected carryover into FY 2020 = $0K**

MAJOR ACCOMPLISHMENTS

- No Major Progress

NCSP Quarterly Progress Report (FY-2020 Q1)

LANL TE7 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	**TASK**	**STATUS**	**ISSUES/PATH FORWARD**
Q1	Provide status reports on all training activities to the NCSP Manager. (TE7)		
Q2	Provide status reports on all training activities to the NCSP Manager. (TE7)		
Q3	Provide status reports on all training activities to the NCSP Manager. (TE7)		
Q4	Provide status reports on all training activities to the NCSP Manager. (TE7)		

NCSP Quarterly Progress Report (FY-2020 Q1)

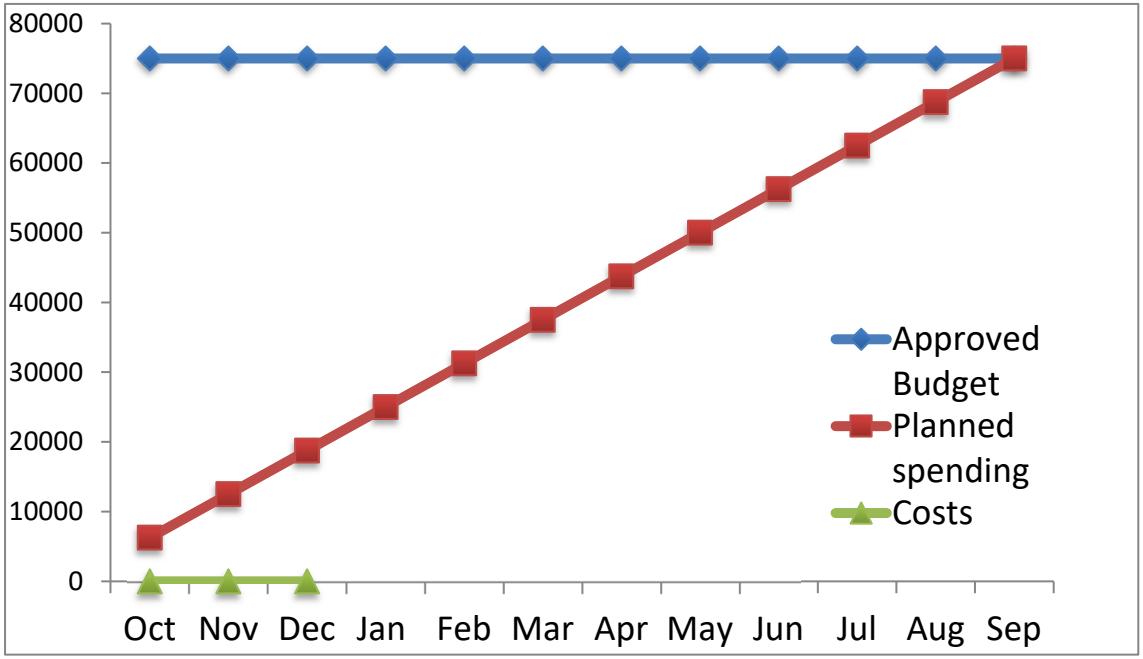
Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element: LANL TE8
Task Title: Reactivity Simulation Aids
M&O Contractor Name: Los Alamos National Laboratory (LANL)
Point of Contact Name: Brian K. Bluhm
Point of Contact Phone: (505) 667-2440

Reference: B&R DP0909010
Date of Report: February 7, 2020

BUDGET



1. **Carryover into FY 2020 = $0K**
2. **Approved FY 2020 Budget = $75K**
3. **Actual spending for 1st Quarter FY 2020 = $0K**
4. **Actual spending for 2nd Quarter FY 2020 = $0K**
5. **Actual spending for 3rd Quarter FY 2020 = $0K**
6. **Actual spending for 4rd Quarter FY 2020 = $0K**
7. **Projected carryover into FY 2021 = $0K**

MAJOR ACCOMPLISHMENTS

- Work expected to start in 2nd quarter on new simulation aid.

NCSP Quarterly Progress Report (FY-2020 Q1)

LANL TE8 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	**TASK**	**STATUS**	**ISSUES/PATH FORWARD**
Q1	Provide status reports on all training activities to the NCSP Manager. (TE8)		
Q2	Provide status reports on all training activities to the NCSP Manager. (TE8)		
Q3	Provide status reports on all training activities to the NCSP Manager. (TE8)		
Q4	Provide status reports on all training activities to the NCSP Manager. (TE8)		

NCSP Quarterly Progress Report (FY-2020 Q1)

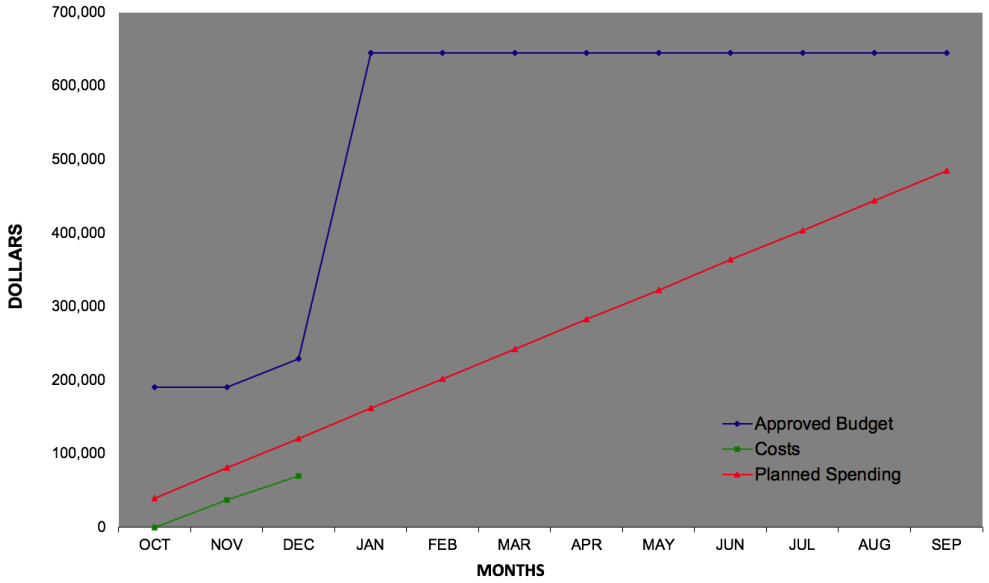
Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtasks: TE1, 3, 6, 7, 9
Task Titles: See last page
M&O Contractor Name: Lawrence Livermore National Laboratory
Point of Contact Name: David Heinrichs
Point of Contact Phone: (925) 424-5679

Reference: B&R DP0909010
Date of Report: January 31, 2020

BUDGET



1. **Carryover into FY 2020** = $118,004
2. **Approved FY 2020 Budget** = $645,004 (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $69,642
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021 =** $51,600 (8%)

MAJOR ACCOMPLISHMENTS

1. Provided registration and logistics support (TE1, TE3) for:
   - 2-week CSE course on Jan 27-Feb 7, 2020 at NATM/NCERC/SNL
   - 1-week Managers course on March 30-April 3, 2020 at SNL
   - 1-week Managers course on June 15-19, 2020 at NCERC
   - 2-week CSE course on Aug 10-21, 2020 at NATM/NCERC/SNL
2. CSE and work planning and control (WP&C) documents for TACS with beryllium shells are complete and are undergoing USQ review. First use of the shells by the instructors is scheduled next quarter (T1).
3. Participated in all T&E teleconferences (TE1, TE3, TE9).
4. Commenced consideration of preliminary design concepts for a mobile (Security Category III or IV) hands-on training assembly (TE6).
5. Commenced literature search for documentation on past criticality simulators (e.g., LLNL, RFP) (TE7).
6. Participated in the T&E CSO Course Development Meeting at SNL on December 10-11, 2019. The course contents are now finalized and will be deployed in the next Managers course (TE9).

NCSP Quarterly Progress Report (FY-2020 Q1)

LLNL T&E Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone
			

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	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)		
Q2	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)		
Q3	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)		
Q4	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)		

NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2			
Q3			
Q4			
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

Task Titles:

TE1 Conduct Hands-on Training at the DAF (TACS)

TE3 Classroom Criticality Safety Training

TE6 Mobile (CAT III or IV material) Hands on Critical or Near Critical Demonstration Capability

TE7 Criticality Simulator to Demonstrate Criticality Physics Fundamentals to Process Operators

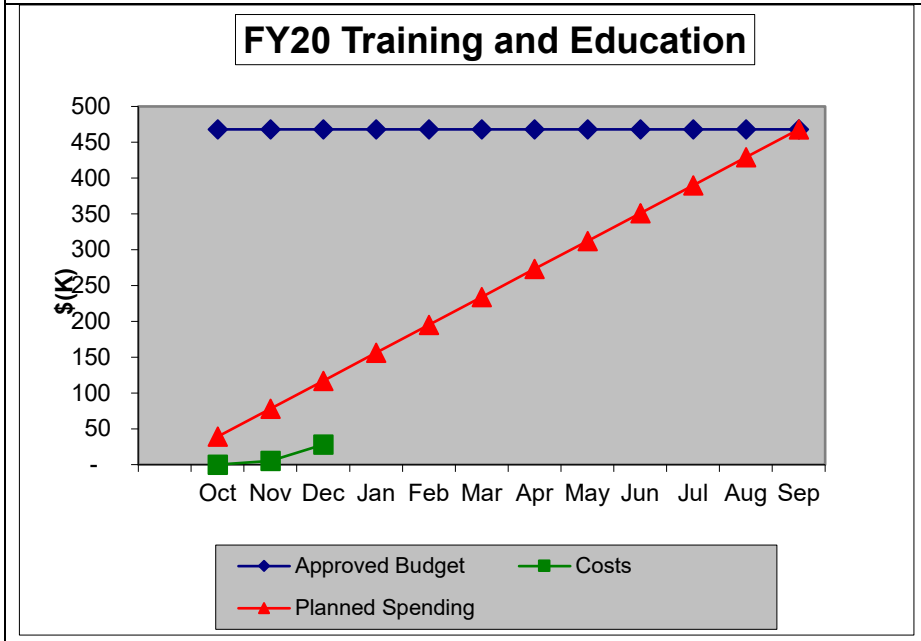
TE9 Design and Develop a New NCSP T&E Course for Criticality Safety Officers at DOE/NNSA Nuclear Facilities

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: TE1, 3, 5, 9, 10
Task Title: see last page
M&O Contractor Name: ORNL
Point of Contact Name: Doug Bowen
Point of Contact Phone: (865) 576-0315

Reference: DP0909010/ORNL
Date of Report: January, 2020

BUDGET



1. **Carryover into FY 2020 = $128K**
2. **Approved FY 2020 Budget** = **$468K** (includes carryover)
3. **Actual spending for 1st Quarter FY 2020 = $28K**
4. **Actual spending for 2nd Quarter FY 2020 = $**
5. **Actual spending for 3rd Quarter FY 2020 = $**
6. **Actual spending for 4th Quarter FY2020 = $**
7. **Projected carryover into FY 2021 = $**

MAJOR ACCOMPLISHMENTS

TE1 – Manage and Provide Instruction for the DOE Nuclear Criticality Safety Training & Education Program

- In FY2020 Q1, D. Bowen archived all the course materials, e.g., tests, student evaluations, etc., to the NCSP T&E SharePoint site at ORNL. In Dec. 2019, Doug held an FY20 T&E planning meeting for the lecture portion of the 2-week course at Sandia National Laboratory. All course instructors were present at this meeting making changes to content based on experience from the FY2019 courses. One preparatory telecon was held in Dec. 2019 to prepare for the 2-week hands-on course in Feb. 2020 at the National Atomic Testing Museum, SNL, and NCERC Jan. 27-Feb. 7, 2020.
- Lousteau - Tweaked the NDA module slightly this quarter and provided direction to the rest of the team for setting up the clickers.

TE3 - Hand-calculation Primer Expansion, LA-14244-M

- Dr. Robert Busch (UNM/Retired) was engaged on this project. ORNL is working to obtain his services via contract to support this work. Because of the lack of funding at this stage of the year, work has yet to begin, although the task has been outlined and plans have been made.

TE5 - On-Site Introductory Training for the NCS Practitioner on Modern Approaches to Validation using Sensitivity and Uncertainty Analysis Tools

- No activity yet planned for FY20

TE9 - Design and Develop a New NCSP T&E Course for Criticality Safety Officers at DOE/NNSA Nuclear Facilities

- In FY2020, little work has been done. Toward the end of FY2019, CSSG tasking 2018-01 was used to generate new course material for a CSO/Manager course. NCSP Manager course material was

NCSP Element and Subtask: TE1, 3, 5, 9, 10 **Task Title:** see last page **M&O Contractor Name:** ORNL **Point of Contact Name:** Doug Bowen **Point of Contact Phone:** (865) 576-0315	**Reference:** DP0909010/ORNL **Date of Report:** January, 2020
	used as a starting point and the recommended CSO content was added by the CSO course development team. A draft binder of course content was provided to the team and to the NCSP Manager by the end of FY2019, on schedule. No work has been performed beyond this in FY2020 Q1. A CSO table top meeting has been scheduled at LANL for the week of March 9th at LANL. **TE10 - Design of an Subcritical Assembly at ORNL for use with the CSO Courses** • This task was delayed due to issues at Y-12 locating AGN-201M reactor fuel in storage. In mid-FY2020 Q1, Y-12 did provide an MC&A listing of all AGN core pieces that were found. ORNL completed scoping computations for the feasibility of using these core pieces for a hands-on subcritical assembly to support operations, CSO, and manager training activities. D. Bowen walked down operations at the ORNL Manufacturing Demonstration Facility to determine if it would be possible to fabricate shielding materials for the assembly. A feasibility report will be submitted to the NCSP manager in FY2020 Q2.

NCSP Quarterly Progress Report (FY-2020 Q1)

ORNL TE Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	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)		Lack of funding in Q1 delayed this task.
	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)		
Q2	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)		

	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)		
Q3	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)		
Q4	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)		

NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**(example)** J.L. Alwin, F.B. Brown, M.E. Rising, "Excluding Benchmark Statistical Outliers in Nuclear Criticality Safety Validation: A Comparison Study of Upper Subcritical Limits for Plutonium Systems using Whisper-1.1", LA-UR-18-27731, October 1, 2019	No	Publications will be submitted in Quarter 2
Q2			
Q3			
Q4			

Task Title:

TE1 Manage and Provide Instruction for the DOE Nuclear Criticality Safety Training & Education Program

TE3 Hand-calculation Primer Expansion, LA-14244-M

TE5 On-Site Introductory Training for the NCS Practitioner on Modern Approaches to Validation using Sensitivity and Uncertainty Analysis Tools

TE9 Design and Develop a New NCSP T&E Course for Criticality Safety Officers at DOE/NNSA Nuclear Facilities

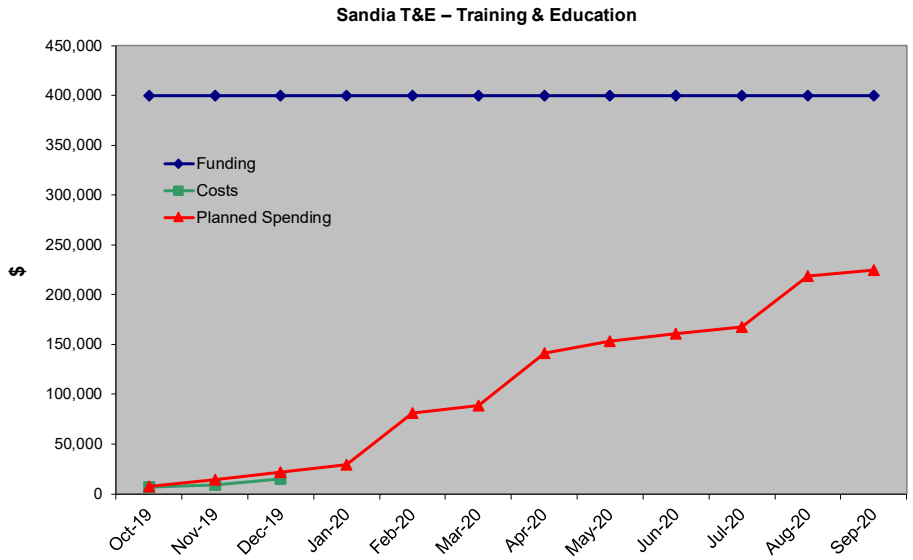
TE10 Design of a Subcritical Assembly at ORNL for use with the CSO/FMH Courses

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element: SNL TE1, 2
Task Titles:
TE1 Prepare for and Conduct Hands-on Criticality Safety Training at SNL
TE2 Design and Develop a New NCSP T&E Course Criticality Safety Officers at DOE/NNSA Nuclear Facilities
M&O Contractor Name: Sandia National Laboratories (SNL)
Point of Contact Name: Gary A. Harms
Point of Contact Phone: (505)845-3244

Reference: B&R DP 0909010
Date of Report: December 31, 2019

BUDGET



1. **Carryover into FY 2020** = $374,875
2. **Approved FY 2020 Budget** = $399,875 (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $15,052
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021 =** $

MAJOR ACCOMPLISHMENTS

- We are preparing to deliver the experimental portion of a Hands-On criticality safety course for NCSEs in February 2020.
- The presentation slide set was released as SAND2019-14993 TR.
- The new T&E course development is driven by ORNL. No activity has occurred at Sandia in the quarter.

NCSP Quarterly Progress Report (FY-2020 Q1)

SNL T&E Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone
			

QUARTER	MILESTONE	STATUS	ISSUES/PATH FORWARD
Q1	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)		
Q2	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)		
Q3	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)		
Q4	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)		

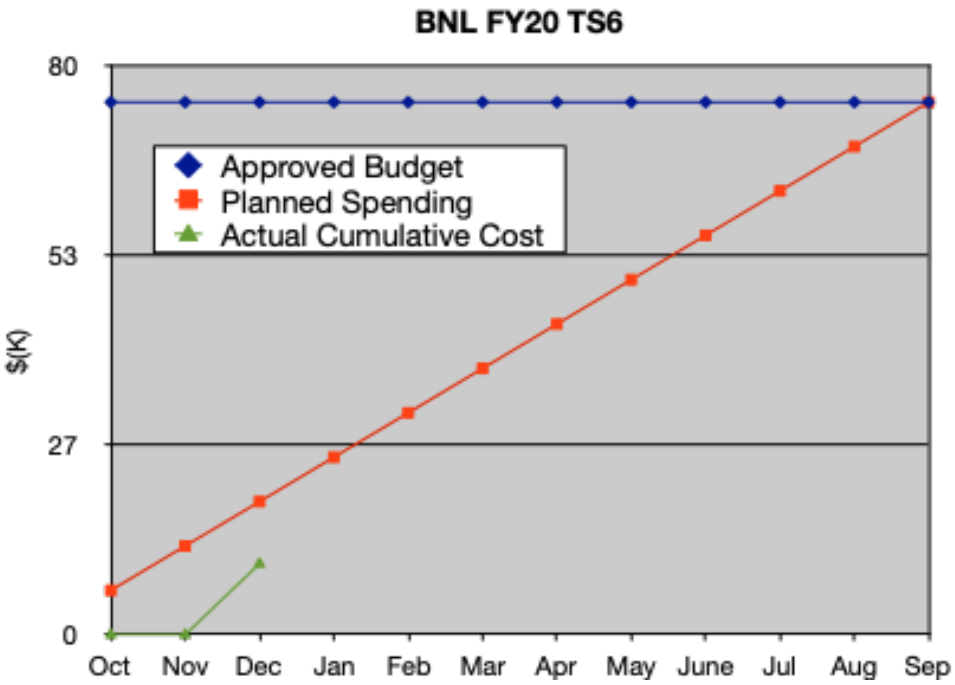
NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**(example)** Hands-On Training – Water Moderated Critical Experiments – Sandia National Laboratories, SAND2019-14993 TR, Sandia National Laboratories, 2019.	Yes	
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: NCSP Technical Support TS6 Task Title: ND Succession Planning M&O Contractor Name: BNL Point of Contact Name: David Brown Point of Contact Phone: 631-344-2814	Reference: DP0902000 Date of Report: Jan. 24, 2020

BUDGET



1. **Carryover into FY 2020** = $0
2. **Approved FY 2020 Budget** = $75,000
3. **Actual spending for 1st Quarter FY 2020** = $10,000
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021 =** $

ACCOMPLISHMENTS

Sophia Hollick (a DOE SULI student collaborator, Fall 2019) completed development of new algorithm to estimate the mean resonance spacing D from resonance data.

Pedro Rodriguez (a DOE SULI student collaborator, Spring 2020) will extend this work to average widths.

We aim to submit this work for publication this FY.

NCSP Quarterly Progress Report (FY-2020 Q1)

BNL TS6 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone
			

QUARTER	MILESTONE	STATUS	ISSUES/PATH FORWARD
Q1	NONE		
Q2	NONE		
Q3	NONE		
Q4	Provide NCSP Manager annual report of succession planning efforts.		

NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**	**No**	
Q2	**N/A**	**No**	
Q3	**N/A**	**No**	
Q4	**N/A**	**No**	

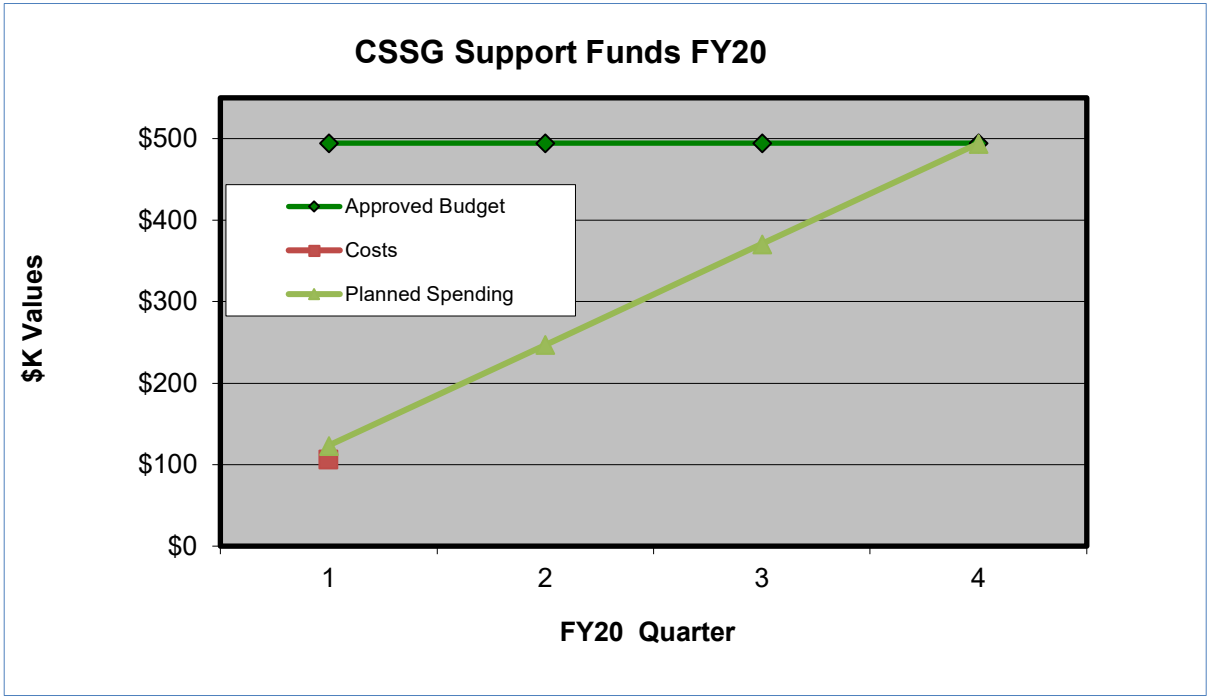
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**	No	
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: TS1
Task Title: CSSG Support
M&O Contractor Name(s): ANL, LANL, LLNL, ORNL, SRS
Point of Contact Name: David Hayes (CSSG Deputy Chair)
Point of Contact Phone: 505-667-4523

Reference: B&R DP 0909010
Date of Report: January 31, 2020

BUDGET



1. **Carryover into FY 2020** = $ 21,452
2. **Approved FY 2020 Budget** = $ 494,452
3. **Actual spending for 1st Quarter FY 2020** = $105,902
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021** = $

MAJOR ACCOMPLISHMENTS

- November CSSG Face to Face Meeting
- CSSG Telecons

NCSP Quarterly Progress Report (FY-2020 Q1)

CSSG TS Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	MILESTONE	STATUS	ISSUES/PATH FORWARD
Q1	Provide the NCSP manager with a summary of CSSG activities, meetings, and tasks. (TS1)		**No Issues**
Q2	Provide the NCSP manager with a summary of CSSG activities, meetings, and tasks. (TS1)		
Q3	Provide the NCSP manager with a summary of CSSG activities, meetings, and tasks. (TS1)		
Q4	Provide the NCSP manager with a summary of CSSG activities, meetings, and tasks. (TS1)		

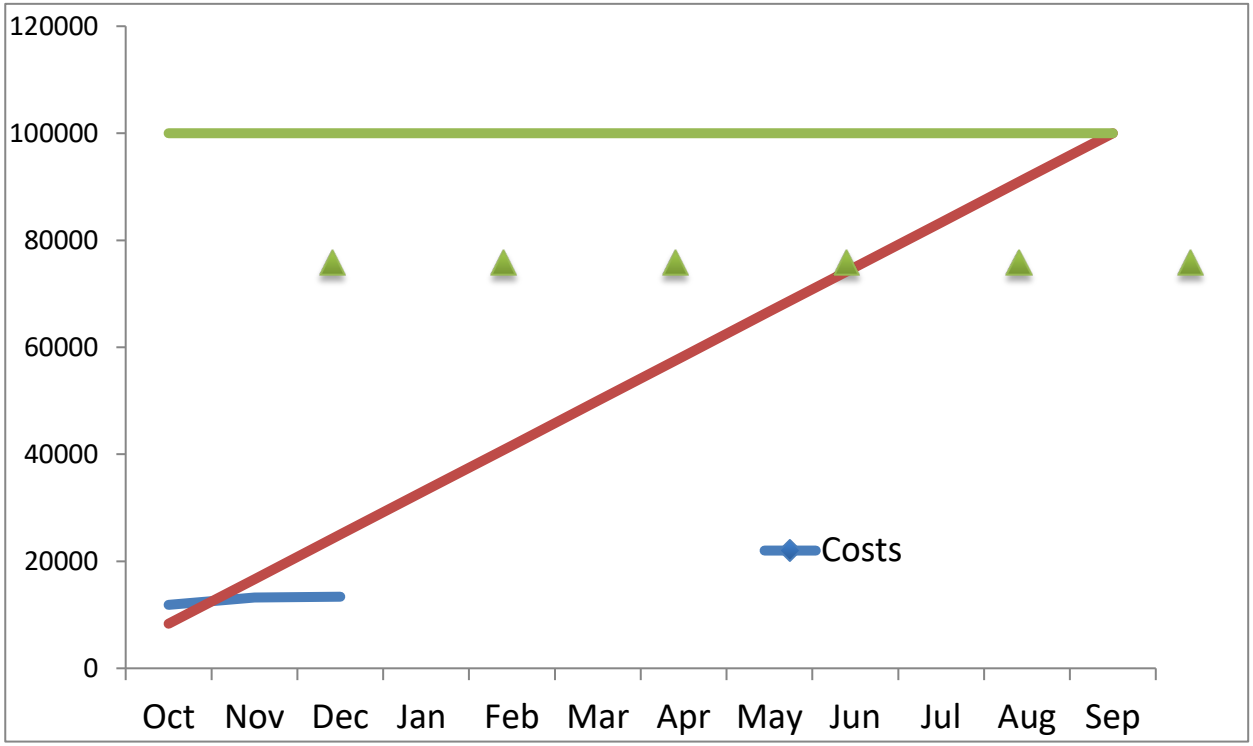
Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element: LANL TS4
Task Title: AM, IE, ND Succession Planning
M&O Contractor Name: Los Alamos National Laboratory (LANL)
Point of Contact Name: Brian K. Bluhm
Point of Contact Phone: (505) 667-2440

Reference: B&R DP0909010
Date of Report: February 7, 2020

BUDGET



1. **Carryover into FY 2020** = $0K
2. **Approved FY 2020 Budget** = $100K (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $13K
4. **Actual spending for 2nd Quarter FY 2020** = $0K
5. **Actual spending for 3rd Quarter FY 2020** = $0K
6. **Actual spending for 4rd Quarter FY 2020** = $0K
7. **Projected carryover into FY 2021** = $0K

MAJOR ACCOMPLISHMENTS

•

NCSP Quarterly Progress Report (FY-2020 Q1)

LANL TS4 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone
			

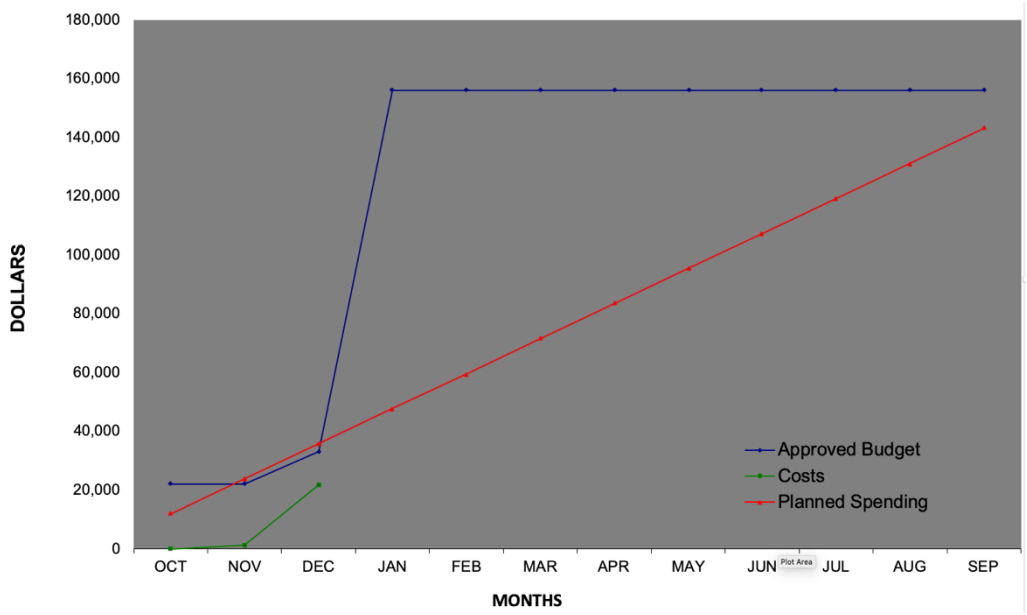
QUARTER	MILESTONE	STATUS	ISSUES/PATH FORWARD
Q1	NONE		
Q2	NONE		
Q3	NONE		
Q4	Provide NCSP Manager annual report of succession planning efforts.		

NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtasks: TS5 **Task Title:** LLNL Succession Planning **M&O Contractor Name:** Lawrence Livermore National Laboratory **Point of Contact Name:** David Heinrichs **Point of Contact Phone:** (925) 424-5679	**Reference: B&R DP0909010** **Date of Report: January 31, 2020**
BUDGET	**MAJOR ACCOMPLISHMENTS**



1. **Carryover into FY 2020** = $0
2. **Approved FY 2020 Budget** = $156,000 (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $21,715
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021 =** $0 (0%)

1. Jesse Norris attended Nuclear Data Week on November 4-8, 2019 at Brookhaven National Laboratory. (ND)
2. Liz Heckmaier attended the American Nuclear Society Winter Meeting on November 17-21, 2019, in Washington, DC. (IE)
3. Arnika Chidambaram transferred from the LLNL Safety Basis Division to the Nuclear Criticality Safety Division. (ND, IE)

NCSP Quarterly Progress Report (FY-2020 Q1)

LLNL TS5 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

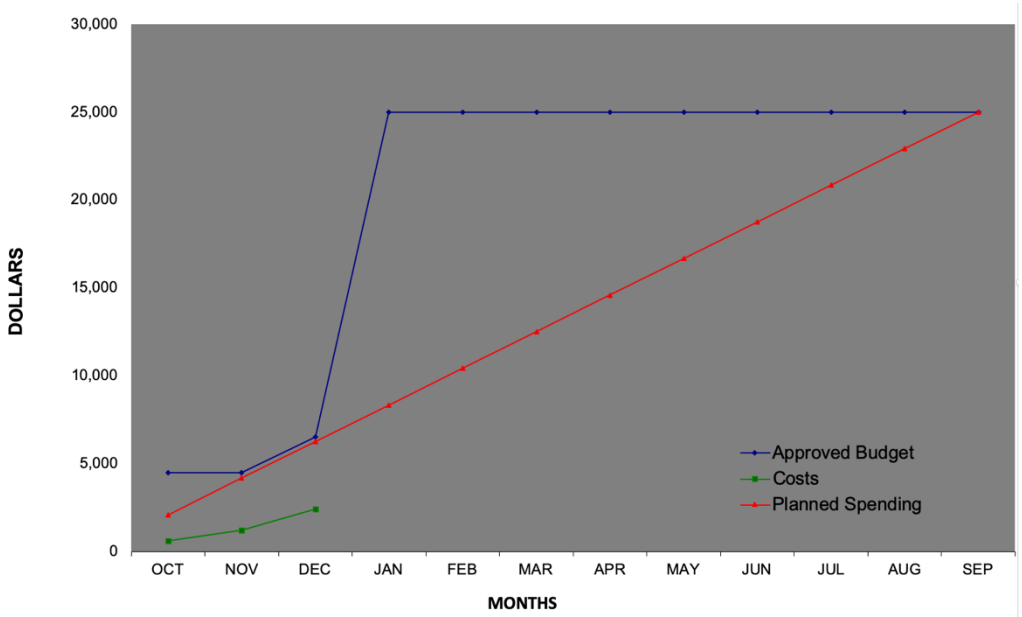
Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	MILESTONE	STATUS	ISSUES/PATH FORWARD
Q1	NONE		
Q2	NONE		
Q3	NONE		
Q4	Provide NCSP Manager annual report of succession planning efforts.		

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtasks: TS16 **Task Title:** LLNL - NDA Website Support **M&O Contractor Name:** Lawrence Livermore National Laboratory **Point of Contact Name:** David Heinrichs **Point of Contact Phone:** (925) 424-5679	**Reference: B&R DP0909010** **Date of Report: January 31, 2020**
BUDGET	**MAJOR ACCOMPLISHMENTS**



1. **Carryover into FY 2020** = $0
2. **Approved FY 2020 Budget** = $25,000 (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $2,400
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4th Quarter FY 2020** = $
7. **Projected carryover into FY 2021 =** $0 (0%)

1. Finalized and deployed https://nda.llnl.gov to the public and added it as a focus area on https://ncsp.llnl.gov.

NCSP Quarterly Progress Report (FY-2020 Q1)

LLNL TS5 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	MILESTONE	STATUS	ISSUES/PATH FORWARD
Q1	Provide the NCSP manager with a summary of NDA Website support		
Q2	Provide the NCSP manager with a summary of NDA Website support		
Q3	Provide the NCSP manager with a summary of NDA Website support		
Q4	Provide the NCSP manager with a summary of NDA Website support		

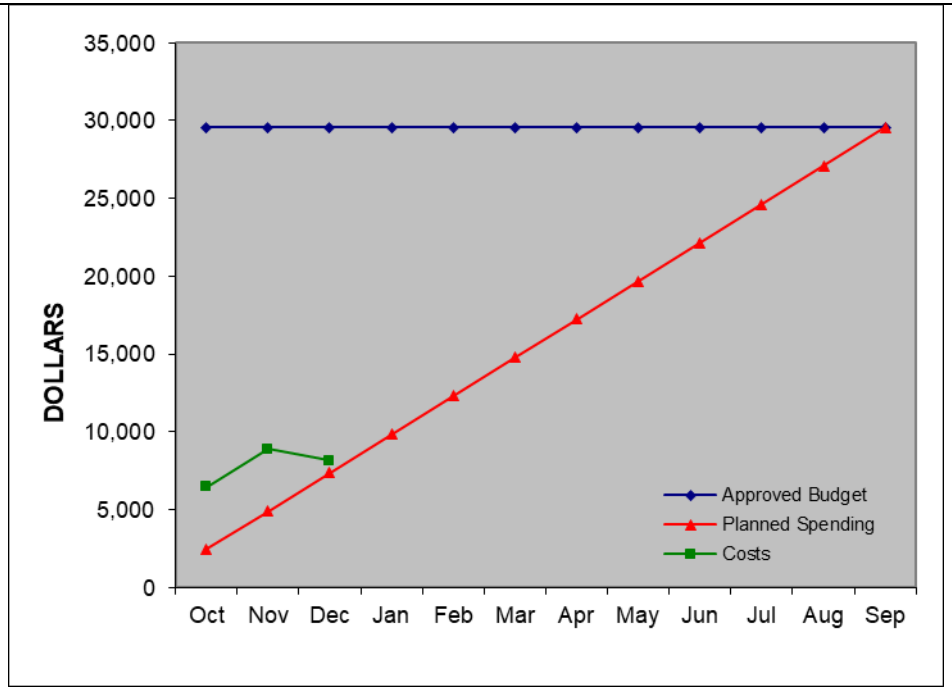
Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	"DOE NNSA Nondestructive Assay Program," LLNL-WEB-765077, Approved: January 3, 2019.	**Yes**	
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtasks: NNL TS9
Task Title: NNL – Support for NDAG Chair activities
M&O Contractor Name: NNL
Point of Contact Name: Mike Zerkle
Point of Contact Phone: (412) 476-6188

Reference: B&R DP0909010
Date of Report: January 31, 2020

BUDGET



1. **Carryover into FY 2020** = $0.5k
2. **Approved FY 2020 Budget** = $29.5k (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $8k
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2020 =** $ (0%)

MAJOR ACCOMPLISHMENTS

1. Participated in NR/NCSP RPI LINAC Program Review
2. Participated in 2019 ICSBEP, IRPhEP, and SINBAD Technical Program Review meetings at OECD/NEA
3. Participated in Oct 2019 IE Face-to-Face Meeting as NDAG Chair
4. Participated in 2019 CSEWG Meeting
    a. Gave presentation entitled "Validation of H-H2O at Elevated Temperatures using Diffusion Experiments"
    b. Collaborated with LLNL on "beta-eff Benchmarks" presentation.
    c. Appoint CSEWG Validation Chair
5. Chaired Nov 2019 NDAG Meeting
6. Participated in Nov 2019 CSSG Meeting in ex-officio capacity as NDAG Chair.
7. Participated in WANDA-2020 organization meetings
8. CEdT process support as NDAG Chair and CEdT Team Member for several IERs

NCSP Quarterly Progress Report (FY-2020 Q1)

NNL TS9 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	MILESTONE	STATUS	ISSUES/PATH FORWARD
Q1	Provide the NCSP manager with a summary of NDAG chair activities, meetings, and tasks. (TS9)		
Q2	Provide the NCSP manager with a summary of NDAG chair activities, meetings, and tasks. (TS9)		
Q3	Provide the NCSP manager with a summary of NDAG chair activities, meetings, and tasks. (TS9)		
Q4	Provide the NCSP manager with a summary of NDAG chair activities, meetings, and tasks. (TS9)		

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	OECD/NEA Paris, France Oct-19 TS9 ICSBEP and IRPhE Technical Review Meetings (Zerkle) Provide oversight of NCSP IE tasks as ICSBEP tasks are the end product of the NCSP IE process.		
Q3	Cambridge, England Apr-20 TS9 Attend PHYSOR 2020 meeting of the ANS. NCSP task that travel. (Zerke) Present paper on thermal neutron scattering.		
	OECD/NEA Paris, France May-20 TS9 Participate in WPEC annual meeting (Zerkle) As NDAG Chair, participate in WPEC.		
Q4	**N/A**		

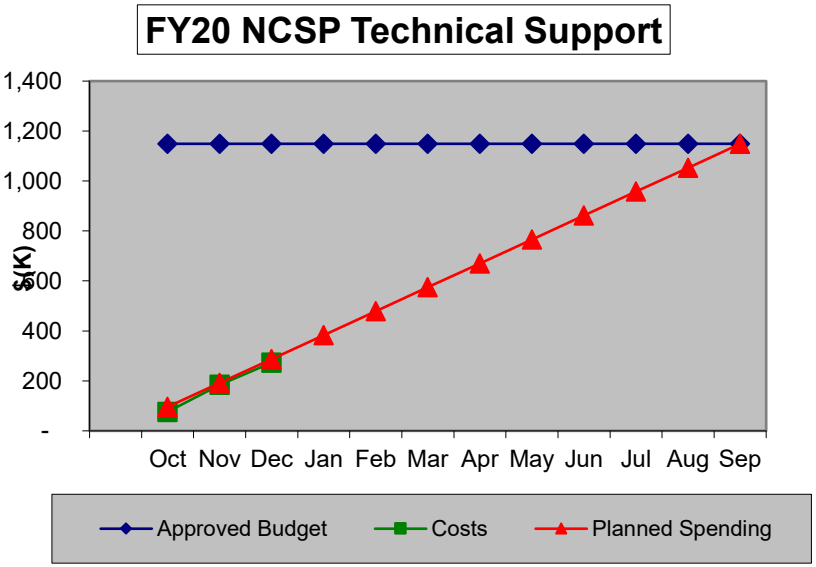
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	M. L. Zerkle, J. C. Holmes, and J. L. Wormald, "Re-evaluation of the TSL for Yttrium Hydride," *PHYSOR-2020*, Cambridge, UK, March 29-April 2, 2020 (accepted).	No	Will be submitted in Q2
	J. L. Wormald, M. L. Zerkle, and J. C. Holmes, "Generation of the TSL for Zirconium Hydrides from Ab Initio Methods," *PHYSOR-2020*, Cambridge, UK, March 29-April 2, 2020 (accepted)	No	Will be submitted in Q2
	J. C. Holmes, M. L. Zerkle, and A. I. Hawari, "Validation of Thermal Scattering Laws for Light Water at Elevated Temperatures with Diffusion Experiments," PHYSOR-2020, Cambridge, UK, March 29-April 2, 2020 (accepted)	No	Will be submitted in Q2
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: TS2 (Support for Lead Lab to Execute the NCSP**), TS7** (AM/ND Succession Planning), **TS8** (NCSP MGT Tool Development), **TS11** (CEdT Manager Support), **TS13** (NDA Technical Support Group and NDA Technical Infrastructure Project)
M&O Contractor Name: ORNL
Point of Contact Name: Doug Bowen
Point of Contact Phone: (865) 576-0315

Reference: DP0909010/ORNL
Date of Report: January, 2020

BUDGET



1. **Carryover into FY 2020** = $183K
2. **Approved FY 2020 Budget** = $ (includes carryover) $1149K
3. **Actual spending for 1st Quarter FY 2020** = $273K
4. **Actual spending for 2nd Quarter FY 2020** = $ –
5. **Actual spending for 3rd Quarter FY 2020** = $ –
6. **Actual spending for 4rd Quarter FY 2020** = $ –
7. **Projected carryover into FY 2021 = $ –**

MAJOR ACCOMPLISHMENTS

TS2

- Prepare and maintain elements of NCSP Plan and associated activities:
  - Monitor Five-Year Plan progress,
  - Review/revise task list, and
  - Schedule/participate in meetings and teleconferences.
  - Manage and provide oversight/coordinate efforts for the NCSP Information, Preservation, and Dissemination task element.
  - Manage and provide oversight/coordinate efforts for the NCSP Training and Education Program task element.
- Participated in NCSP management team and other NCSP-related meetings, as required by the NCSP Manager.
- Prepared Q4 QPRs into a single bookmarked PDF file for use in QPR. Conducted Q4 telecon. Started to compile Q1 FY2020 QPRs.
- Prepared final drafts of an NCSP newsletter
- Participated in CSSG telecons and assisted with CSSG tasks as necessary. Bowen supported CSSG tasking 2018-01 CSO course baseline and developed and completed the CSO course development plan. Course materials are ready for review.
- Completed efforts to improve documentation of NCSP accomplishments to ensure NCSP work is linked to final 5YP milestones. Lori Scott has distributed new quarterly reporting templates for distribution to the site task managers.
- Led and participated telecons and WebEx meetings as necessary to track NCSP MGT team actions and deliverables.
- Started the process to populate the NDA website (http://nda.llnl.gov) with materials to support the NDA Technical Infrastructure Project.
- IE 5-year plan was completed in Nov. 2019 after the FY19Q4 call. Rev. 2 of the Main 5-year plan was drafted.
- Trained Marsha Henley in NCSP MGT team work.

TS7

- Chris Chapman continued to work on nuclear data evaluations with Vlad Sobes and Marco Pigni on Ce and V nuclear data evaluations. Chris is also working on thermal neutron scattering measurements at the ORNL SNS. Jesse Brown has been utilizing these funds to train on GELINA and RPI nuclear data measurements alongside Klaus Guber.

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element and Subtask: TS2 (Support for Lead Lab to Execute the NCSP**), TS7** (AM/ND Succession Planning), **TS8** (NCSP MGT Tool Development), **TS11** (CEdT Manager Support), **TS13** (NDA Technical Support Group and NDA Technical Infrastructure Project) **M&O Contractor Name:** ORNL **Point of Contact Name:** Doug Bowen **Point of Contact Phone:** (865) 576-0315	**Reference:** DP0909010/ORNL **Date of Report:** January, 2020

	TS8
	• ORNL continued work on an initial prototype of a new NCSP Program Management Tool that should have been completed in FY20 Q1. There were some issues getting the new IER system implemented in the G2 system and NNSA/programmers made some fundamental mistakes with coding due to reorganization and staffing issues. Bowen supported multiple meetings in person and via WebEx with G2 programmers to discuss desired IER database features This has been an extensive effort. IER database is due to be implemented in Q2 or Q3 of FY2020.
	
	TS11
	• ORNL lead a face-to-face IE meeting at LANL in FY20 Q1. An IE telecon was conducted in December to status IERs before the holidays..
	• The C_EDT manager tracked IER products and Baseline Change Reviews and worked with the NCSP manager to approve tasks, as required.
	• Bowen worked with Miller (Sandia) in Q1 to continue transition efforts, although Doug still needed to lead CEDT efforts. and interacting with the task managers. John Miller is coming along well at this point and Bowen will be a backup.]
	TS13
	• Efforts continue on the TSG efforts to generate the new ANSI/ANS-8.28 standard for NDA administrative requirements in NCS programs. The first ANS-8 ballot was completed. Comments are being resolved.
	• Worked with Cecil Parks on a DOE-wide NDA program with the this task being part of that effort. Plans to visit the NA-50 administrator is in progress.
	• Dave Dolin, NDA technical support group chair, report to Angela Chambers, 12-27-2019:
	  • To my knowledge, Commitments 5.5.3 and 5.5.4 referenced from the Recommendation 2007-1 implementation plan and listed in the Recommendation closure letter of October 22, 2012 have never been performed as "triennial reviews of the need for new NDA holdup technology and the status of ongoing NDA-related research and development programs" or as "periodic reviews NDA holdup measurement programs to ensure technology is adequate for their intended purpose." The TSG charter identifies these items as functions of the TSG, but I'm not aware of reviews beyond the site visits conducted by the TSG initially as part of the Implementation Plan, even though the charter lists a target date of May 2015 for the first of the triennial reviews. Also, I do not recall discussions with the former TSG Chair, Frank Lamb, about receiving requests or planning for these follow-on reviews.
	  • Regarding other functions identified under the Mission of the TSG:
	  · The TSG has been integral in the development of consensus/DOE standards.

NCSP Element and Subtask: TS2 (Support for Lead Lab to Execute the NCSP**), TS7** (AM/ND Succession Planning), **TS8** (NCSP MGT Tool Development), **TS11** (CEdT Manager Support), **TS13** (NDA Technical Support Group and NDA Technical Infrastructure Project) **M&O Contractor Name:** ORNL **Point of Contact Name:** Doug Bowen **Point of Contact Phone:** (865) 576-0315	**Reference:** DP0909010/ORNL **Date of Report:** January, 2020
	· ANSI N15.56-2014, American National Standard for Methods of Nuclear Material Control – Nondestructive Assay Program – Nondestructive Assay Measurements of Nuclear Material Holdup: General Provisions, and · ANSI ANS-8.28, Draft, Administrative Practices for the Use of Nondestructive Assay Measurements for Nuclear Criticality Safety · DOE Technical Standard for Guidelines for Effective In-Situ Non-Destructive Assay Holdup Measurements in Support of Nuclear Criticality Safety (on-going effort) · Recently, the TSG has provided programmatic input regarding the development and implementation of a NDA holdup measurement program through the two NDA technical workshops conducted at ORNL in 2018 and 2019. As available, TSG representatives attend the bi-annual ANS Meetings and the recent INMM Meeting (Tom Sampson) to provide NDA input, often focusing as appropriate on criticality safety aspects of NDA capabilities. · The TSG provided SME review of recent evaluation report for Review of the NDA Systems and Total Measurement Uncertainty Determination for Transuranic Waste Characterization at INL · The TSG is available upon request to assess as SMEs, similar to the recent visit to INL by Bob Wilson and Bob McElroy to assist in a follow-on review of the INL program. • Most recent discussions regarding the mission of the TSG has involved the need to help develop a mission and vision document with eventual 5-year plan for a departmental NDA program. • Also, the TSG charter and membership list is out of date. I suspect the efforts to make any revision to the charter and recruitment of new members will depend on the organization, commitments and funding of a NDA Program. I understand that most recently Cecil Parks has been working to champion this effort with DOE.

NCSP Quarterly Progress Report (FY-2020 Q1)

ORNL TS Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	TASK	STATUS	ISSUES/PATH FORWARD
Q1	Manage CEdT 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)		Implementation of IER system is due in Q2 or Q3 of FY2020. Reorg efforts with the G2 system programmers has led to some delays and mistakes.
	Provide the NCSP manager with a summary of NCSP CEdT support. (TS11)		
	Provide the NCSP manager an update of NDA Technical Support Group and NDA Technical Infrastructure Project activities. (TS13)		
Q2	Manage CEdT 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 NCSP CEdT support. (TS11)		
	Provide the NCSP manager an update of NDA Technical Support Group and NDA Technical Infrastructure Project activities. (TS13)		
Q3	Manage CEdT 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 NCSP CEdT support. (TS11)		
	Provide the NCSP manager an update of NDA Technical Support Group and NDA Technical Infrastructure Project activities. (TS13)		
Q4	Manage CEdT 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 NCSP CEdT support. (TS11)		
	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. (TS7)		
	Provide the NCSP manager an update of NDA Technical Support Group and NDA Technical Infrastructure Project activities. (TS13)		

NCSP Quarterly Progress Report (FY-2020 Q1)

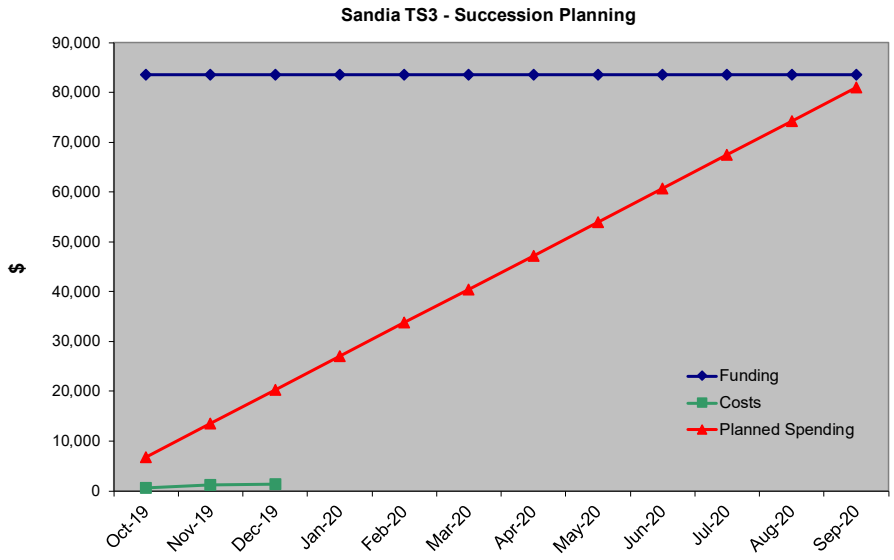
Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	London, UK Jun-20 NCSP-TS2 ISO TC85/SC5 Plenary and WG8 Nuclear Criticality Safety Meetings (Bowen) Continue to provide US leadership with ISO Nuclear Criticality		
Q4	Aldermaston, United Kingdom Mar 20 NCSP-TS2 Coordinate NCSP work as described in Appendix F of the Five Year Execution Plan. Bowen invited to participate.		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**(example)** J.L. Alwin, F.B. Brown, M.E. Rising, "Excluding Benchmark Statistical Outliers in Nuclear Criticality Safety Validation: A Comparison Study of Upper Subcritical Limits for Plutonium Systems using Whisper-1.1", LA-UR-18-27731, October 1, 2019	No	Publications will be submitted in Quarter 2
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element: SNL TS3
Task Title: Support for Experimentalist Succession Planning
M&O Contractor Name: Sandia National Laboratories (SNL)
Point of Contact Name: Gary A. Harms
Point of Contact Phone: (505)845-3244

Reference: B&R DP 0909010
Date of Report: December 31, 2019

BUDGET



1. **Carryover into FY 2019** = $2,593
2. **Approved FY 2020 Budget** = $83,593 (includes carryover)
3. **Actual spending for 1st Quarter FY 2020** = $1,400
4. **Actual spending for 2nd Quarter FY 2020** = $
5. **Actual spending for 3rd Quarter FY 2020** = $
6. **Actual spending for 4rd Quarter FY 2020** = $
7. **Projected carryover into FY 2021** = $

MAJOR ACCOMPLISHMENTS

- We have a matrixed employee who is being trained as an experimenter.
- The new experimenter has completed and published the evaluation of the IER-451 experiments.
- The new experimenter is now working on the IER-230 experiments.
- The new experimenter has been actively participating in the NCS community by attending conferences and publishing papers.
- Our year-round graduate student intern is working on documenting some critical experiments done at Sandia in the late ‘80s and early ‘90s.

NCSP Quarterly Progress Report (FY-2020 Q1)

SNL TS3 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

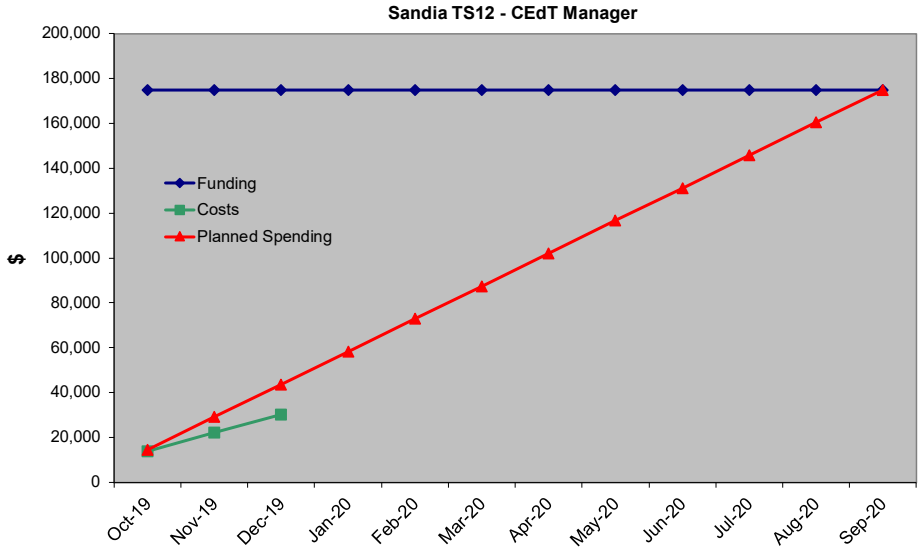
Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	MILESTONE	STATUS	ISSUES/PATH FORWARD
Q1	NONE		
Q2	NONE		
Q3	NONE		
Q4	Provide NCSP Manager annual report of succession planning efforts.		

NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	D. E. Ames, TITANIUM AND ALUMINUM SLEEVE EXPERIMENTS IN FULLY-REFLECTED WATER-MODERATED U(4.31)O2 FUEL ROD LATTICES WITH 2.8 CM PITCH, LEU-COMP-THERM-099, International Handbook of Evaluated Criticality Safety Benchmark Experiments, NEA/NSC/DOC(95)3, September, 2019.	Yes	
	D. E. Ames, "Sandia BUCCX Titanium and Aluminum Sleeve Experiments," ANS Winter Meeting and Expo, Washington DC, Nov. 2019.	Yes	
Q2			
Q3			
Q4			

NCSP Quarterly Progress Report (FY-2020 Q1)

NCSP Element: SNL TS12 **Task Title:** Sandia – NCSP C_EdT Manager Support **M&O Contractor Name:** Sandia National Laboratories (SNL) **Point of Contact Name:** Gary A. Harms **Point of Contact Phone:** (505)845-3244	**Reference: B&R DP 0909010** **Date of Report: December 31, 2019**
BUDGET	**MAJOR ACCOMPLISHMENTS**
 1. **Carryover into FY 2019** = $0 2. **Approved FY 2020 Budget** = $175,000 (includes carryover) 3. **Actual spending for 1st Quarter FY 2020** = $30,102 4. **Actual spending for 2nd Quarter FY 2020** = $ 5. **Actual spending for 3rd Quarter FY 2020** = $ 6. **Actual spending for 4rd Quarter FY 2020** = $ 7. **Projected carryover into FY 2021 =** $	Performed duties as the C_EdT Manager in support of the IE program element. Interacted directly with the various C_EdT Leads and other members, tracked progress on IER action items and 2020 milestones including WFO IER action items. Facilitated an IE meeting and issued meeting agenda and minutes. Worked in the IER database and maintained awareness of the transition to the new database. Assisted the DOE NCS Program Management Team on a broad scope of items.

NCSP Quarterly Progress Report (FY-2020 Q1)

SNL TS3 Milestones:

STATUS (copy color code and paste below in 'STATUS' field)

Complete	On Schedule	Behind Schedule	Missed Milestone

QUARTER	MILESTONE	STATUS	ISSUES/PATH FORWARD
Q1	Provide the NCSP manager with a summary of NCSP CEdT support. (TS12)		
Q2	Provide the NCSP manager with a summary of NCSP CEdT support. (TS12)		
Q3	Provide the NCSP manager with a summary of NCSP CEdT support. (TS12)		
Q4	Provide the NCSP manager with a summary of NCSP CEdT support. (TS12)		

NCSP Quarterly Progress Report (FY-2020 Q1)

Foreign Trip Reports (from Appendix C – 5YP)			
Quarter	**Foreign Trip Report** (please provide details for reports not listed below)	**Submitted yes/no**	**If no, state status of submittal**
Q1	**N/A**		
Q2	**N/A**		
Q3	**N/A**		
Q4	**N/A**		
Publications (add each publication on an individual line)			
Quarter	**Publication Reference**	**Submitted yes/no**	**If no, state status of submittal**
Q1	**(example)** J.L. Alwin, F.B. Brown, M.E. Rising, "Excluding Benchmark Statistical Outliers in Nuclear Criticality Safety Validation: A Comparison Study of Upper Subcritical Limits for Plutonium Systems using Whisper-1.1", LA-UR-18-27731, October 1, 2019	No	Publications will be submitted in Quarter 2
Q2			
Q3			
Q4			

Summary of MCNP Criticality Classes in FY 2020

F.B. Brown, M.E. Rising, J.L. Alwin
Monte Carlo Methods, Codes, & Applications Group (XCP-3), LANL

FY2020 – Q1 classes are highlighted in red.

Total Students

- FY2020 – Q1: 100 students (Criticality, UNM, Intro, Intermediate, VR, UM, NJOY classes)

Classes sponsored by DOE-NNSA-NCSP

- **Criticality Calculations with MCNP6 (LANL-AM1)**
  - **Oct 21-24, 2019, Y-12 22 students**
  - **March 9-13, 2020 LANL scheduled**
  - **August 3-7, 2020 LANL scheduled**

  MCNP criticality class for NCS & reactor physics practitioners, with focus on best practices. Includes 1 day on NCS validation using MCNP6-Whisper. For classes at LANL, NCSP-sponsored students do not pay registration fees. For classes at other DOE sites, there are no registration fees.

- **Monte Carlo Techniques for Nuclear Systems (LANL-AM1)**
  - **Aug 24 – Dec 6, 2019, UNM 18 students**

  This is a 1-semester class for senior undergrads & graduate students at the University of New Mexico. Required for UNM graduation in Nuclear Engineering. Includes Monte Carlo theory & practical use of MCNP6. Several of the students are part of the LANL NCS intern program. (This teaching is partially supported by NCSP, ASC, and other programs.)

Other Classes

- **Introduction to MCNP6**
  - **Oct 21-25, 2019, LANL 14 students**
  - **March 2-6, 2020 LANL scheduled**
  - **June 1-5, 2020 LANL scheduled**
  - **June 15-19, 2020 OECD-NEA scheduled**
  - **July 6-10, 2020 LANL scheduled**

  Standard introductory class, includes 1/2 day on criticality calculations (without coverage of NCS validation using mcnp6-whisper). Classes are supported by student registration fees.

- **Intermediate MCNP6**
  - **Oct 7-11, 2019, OECD-NEA, Paris 13 students**
  - **Oct 28 – Nov 1, 2019 LANL 13 students**
  - **June 22-26, 2020 OECD-NEA scheduled**
  - **July 20-24, 2020 LANL scheduled**
  - **Sept 28- Oct 2, 2020 LANL scheduled**
- **Unstructured Mesh with Attila4MC**
  - **Nov 5-9, 2019 LANL 9 students**
  - **July 13-17, 2020 LANL scheduled**
- **Variance Reduction**
  - **Oct 14-18, 2019 OECD-NEA, Paris 11 students**
  - **July 27-31, 2020 LANL scheduled**
  - **Sept 28- Oct 2, 2020 LANL scheduled**
- **Using NJOY to Create MCNP ACE Files & Visualize Nuclear Data**
  - **June 16-18, 2020 LANL scheduled**

Classes are supported by student registration fees.

2020 Q1 – SCALE Training Courses Report for the Nuclear Criticality Safety Program

Class Name	SCALE/TRITON Lattice Physics and Depletion
Class Dates	Oct 21– 25, 2019
Location	Oak Ridge National Lab, Oak Ridge, TN
Number of Attendees	12
Short Description	SCALE supports a wide range of reactor physics analysis capabilities. TRITON is SCALE's modular reactor physics sequence for a wide variety of system types. Attendees of this course will learn how to use TRITON for depletion analysis. The TRITON training material is centered around using the NEWT 2-D transport module for 2-D depletion analysis and briefly touches on 3-D depletion analysis. The course will instruct users on the use of KENO in place of NEWT for 3-D Monte Carlo-based depletion. Additional applications of TRITON are incorporated into the training, including the creation of ORIGEN libraries for rapid spent fuel characterization calculations, defining appropriate unit cell calculations of various reactor types for cross section processing, performing restart calculations, and performing uncertainty analysis of reactor physics calculations using Sampler.

Class Name	SCALE/ORIGEN Standalone Fuel Depletion, Activation, and Source Term Analysis Course
Class Dates	Oct 28 – Nov 1, 2018
Location	Oak Ridge National Lab, Oak Ridge, TN
Number of Attendees	19
Short Description	This is a hands-on class that covers the use of ORIGEN for isotopic depletion, decay, decay heat, and radiation source-terms calculations. The course features the use of the Fulcrum consolidated SCALE graphical interface and Fulcrum plotting capabilities for displaying nuclear data and results. The class includes solving activation, spent fuel, and nuclear safeguards and security analyses. This class provides an introduction to the ORIGAMI tool for convenient characterization of spent nuclear fuel with radially and axially varying burnup. Advanced applications including simulation of chemical processing, continuous feed and removal are also covered.

Class Name	NRC SCALE Shift Training
Class Dates	Nov 4 – 8, 2019
Location	Nuclear Regulatory Commission, Rockville, Maryland
Number of Attendees	17
Short Description	This was a specially prepared course to demonstrate the new integrations of the Monte Carlo code Shift (TRITON-Shift, MAVRIC-Shift, and CSAS-Shift), now in available is the beta version of SCALE 6.3. The course included discussion on modernization gains with Shift, Monte Carlo fundamentals, radiation shielding demos with parallel MAVRIC-Shift, criticality demos with CSAS-Shift, sodium fast Reactor (SFR) reactivity analysis, PWR/BWR nodal data generation comparing 2D lattice vs 3D assembly approach, and HTGR pebble depletion analysis. Additionally a new workflow was demonstrated using the NEAMS Workbench (a successor to SCALE/Fulcrum) where NRC could submit Shift jobs directly to ORNL high-performance computers through the GUI.

STATUS REPORT
on the
International Collaboration with the Atomic Weapons Establishment (AWE)

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
AWE effort currently on hold due to lack of resource.						
INTEGRAL EXPERIMENTS						
AWE-IE1	Inaugural international inter-comparison of nuclear accident dosimetry using Flattop	LLNL-IE1 IRSN-IE15	Co-author final report (CED-4b)	P. ANGUS	D. STONE	LLNL
Report completed and issued by C. Wilson before his departure in 2019. Next inter-comparison exercise anticipated to be 2021.						
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	P. ANGUS	D. STONE	LLNL
3x PNS developed and built. Irradiations at NPL planned for March 2020, with potential involvement from US community.						
AWE-IE3 **IER 406**	Cf-252 CAAS benchmark	LLNL-IE1 IRSN-IE28	Perform/support PNS(TLD) measurements with a shadow cone	P. ANGUS	D. HEINRICHS	LLNL
Dependent on completion of IE2.						
AWE-IE4 **IER 175**	Godiva-IV CAAS benchmark	ORNL-IE4 IRSN-IE27	Review of experiment design. Provide measurement capability as required	T. BIRKETT	J. SCORBY	ORNL
AWE involvement complete. Any further work dependent on future ORNL programme.						
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)	P. ANGUS	D. HEINRICHS	LLNL
Dependent on completion of IE2 (unfolding tools for directionality). Linked with IE11 (2021 International inter-comparison)						
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	P. ANGUS	S. KIM	LLNL

Reference			AWE Contributions and POCs			
AWE Reference	**Task Description**	**NCSP Reference**	**FY2018 AWE Contribution**	**AWE Technical POC**	**Collaborator POC**	**DOE Lab**
Not started due to long lead time (2023) and dependence on PNS availability (see IE2). Scope definition required.						
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 AWE to provide foil suggestions per MYERS	P. ANGUS	T. CUTLER B. MYERS	LANL
Awaiting LANL to advise on the extent of AWE involvement.						
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
Liquid scintillation system deployed to DAF in Q3. Measurement data acquired from bulk material assemblies. System and data returned to AWE and data analysis is underway. Summary report due to be produced by April 2020, with future measurements dependent on outcome.						
AWE-IE9	(Neutron multiplicity experiments) AWE/LLNL NCT 5 year measurement campaign	LLNL-PROPOSAL 18	Participate in experiment design, measurements and reporting	N. KELSALL	D. HEINRICHS	LLNL
AWE is continuing to prepare a report summarising the results from analysis of bulk material measurements. Lower mass assemblies give promising results, higher mass assemblies give high count rates requiring dead time correction that is still to be devised and incorporated.						
AWE-IE10	Enhanced methods of criticality accident dosimetry.	LLNL-IE1 IRSN-30 IRSN-33 Naval Dosimetry Center	Develop prototypes, participate in design, execution and reporting of dosimetry experiments	P. ANGUS	F. TROMPIER	LLNL
No progress to date. Potentially use IE11 as an opportunity to compare & test any new instrumentation.						
AWE-IE11	International inter-comparison of nuclear accident dosimetry AWE to assist in preliminary design FY19 and FY20	LLNL-IE18 SNL-IE4	Produce experiment design; participate in exercise; produce final report. Repeat 2 - 3 years	P. ANGUS	D. STONE	LLNL
Next international inter-comparison is scheduled for 2021.						
AWE-IE12	CIDAAS testing	Proposal 20	Deploy AWE CIDAAS for test irradiation. Repeat 2 - 3 years	T. BIRKETT	J. SCORBY	LLNL
AWE successfully tested CIDAAS in May 2018 and provided support to CED-4. Technical report detailing the results has been issued.						
AWE-IE13	Characterization of AFRRI TRIGA reactor radiation field	LLNL-IE18 SNL-IE4	Provide support to experiment design	P. ANGUS	A. ROMANYUKHA	LLNL

Reference			AWE Contributions and POCs			
AWE Reference	**Task Description**	**NCSP Reference**	**FY2018 AWE Contribution**	**AWE Technical POC**	**Collaborator POC**	**DOE Lab**
	AWE will provide onsite measurement					
AWE was fully prepared for July 2019 trial, prior to the regulatory shut-down of TRIGA. If trial is re-scheduled for 2020 AWE will be able to support it, provided sufficient notice is given.						
INFORMATION PRESERVATION AND DISSEMINATION						
AWE-IPD1	Conduct benchmark evaluations of legacy IEU integral experiments Requires no NCSP funding	LLNL-IPD1	Assess feasibility of sponsoring PhD; determine availability of data	R. JONES	D. HEINRICHS	LLNL
Considered unlikely to make any material progress.						
TRAINING AND EDUCATION						
AWE-TE1	Hands-on criticality safety training	ORNL-TE1 LANL-TE1 LLNL-TE1 LLNL-TE3 SNL-TE1 IRSN-TE1	AWE personnel to attend training course	R. JONES	D. BOWEN B. MYERS D. HEINRICHS G. HARMS S. EVO (IRSN)	ORNL
No AWE personnel attended courses during the reporting period. Currently no AWE personnel are expected to attend courses in the next quarter.						

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

	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
This task was initiated in the frame of the OECD/NEA UACSA expert group. Experimental correlations were established for LCT007 and LCT039 – need to contact Brad Rearden to discuss about the experiments of interest for the FY2019. 2019-Q4: IRSN proposal to work on experimental correlations of MIRTE 1 experiments but a lot of discussions about the calculations of experimental correlations on the SG1 subgroup of the OCDE/AEN/WPNCS Will also be discussed at the ICSBEP meeting in October 2019 FY20-Q1: No progress						
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
The next step will be in particular the number of fissions estimate (meeting about this subject during the TPR meeting, Amarillo). IRSN has to propose a new technical POC following the change of position of M. Duluc.						
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
Report provided by LANL to IRSN by Wim Haeck with detailed descriptions.						
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 participation to TPR in February 2020 and presentation at AMWG meeting						
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
Tool for generating AMPX multigroup cross section library with DRAGON. Task needs completion. Possibility of an AMPX training course in May 2020?						
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
FY20-Q1: MCNP feedback on identified errors were received and integrated by IRSN – Analysis of LEU and IEU results is in progress – Discussions are planned during the AM meeting in						

REFERENCE			IRSN Contribution / POC			
IRSN Reference	**Task Title**	**DOE Reference**	**FY 2020 IRSN Contribution**	**IRSN Technical POC**	**DOE Technical POC**	**DOE LAB**
February in Santa Fe and a brief synthesis will be presented during the TPR meeting						
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
In progress – LANL and ORNL results are available FY20-Q1: ORNL/LANL/IRSN meeting during the 2019 ANS winter meeting in November–Discussions are planned during the AM meeting in February in Santa Fe						
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
FY20-Q1: Iteration over the finalization of the EGAMCT report (issues with D. Mennerdhal's comments).						
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
Plutonium sulfate densities should be retrieved from US laboratories and a comparison could be done with plutonium nitrate densities. It is also planned to make density vs temperature measurements. Action to be revived when measurements planned.						
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 is involved in TEX program since the beginning in 2011 and participated in the kick-off meeting. IRSN is part of the CED team and review the CED reports. In addition, in 2014 and 2015, IRSN performed sensitivities calculations on the designed configurations for TEX-Ta experiments. Regular VTC were organized to discuss the status of experiments. IRSN participated at the 2 last experiments in NNSS and will be involved in the ICSBEP evaluation in 2019 as independent reviewer. 2019-Q4: IRSN contributed to the ICSBEP evaluation as the independent reviewer						
IRSN-IE3 **IER 209**	New 7uPCX experiment	SNL-IE1	Contribution to ICSBEP reevaluation.	N. LECLAIRE	G. HARMS	SNL
2019 –Q4: These experiments were presented at the ICSBEP 2019 meeting. IRSN was the independent reviewer.						
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
CED 1 report has been sent to the NCSP team review and has been validated by IRSN. It will be issued in January 2020. Preliminary effects on keff of experimental uncertainties have been calculated and will be added in the CED-2 report in 2020. (supported by a sub-contract) Some comments from Gary Harms, David Ames, Mike Zerkle, Dave Heinrichs (NCSP team) have been received and have been already taken into account (zoom on figures, editorial, new configurations) in the CED-1 report. Technical issues with respect to the use of Al-clad rods in nitrate solutions and with the diameter of Rh sleeves were raised. Zircaloy sleeves or recladding of 7uPCX rods should be planned. Investigation of a rhodium resin block should also be envisioned for the CED-2 report. Additional configurations are therefore planned and will be added in the CED-2 report.						
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

	REFERENCE		IRSN Contribution / POC			
IRSN Reference	**Task Title**	**DOE Reference**	**FY 2020 IRSN Contribution**	**IRSN Technical POC**	**DOE Technical POC**	**DOE LAB**
The CED-2 report has been postponed to mid 2020. As a consequence, this task should be finished in 2020. We looked at potential suppliers for the Mo sleeves and estimated the costs. However, we waited for the CED-2 report to be finished before proceeding to the supplying of sleeves.						
IRSN-IE8 **IER 451**	Ti experiment	SNL-IE1	Analysis of the experiments Comparison with MIRTE program	N. LECLAIRE	G. HARMS	SNL
The independent review of experiments was done for the ICSBEP October 2018 meeting. The experiments were calculated with MORET 5. Some comparisons of sensitivity profiles were expected with the sensitivity obtained with TSUNAMI. In addition, we also planned to compare them with the sensitivities obtained for the MIRTE experiments. A feedback on titanium cross sections was also provided (prior and posterior uncertainty analysis using GLLSM). These tasks were subject to a subcontract beginning in May 2019, which is now finished. A report from the subcontractor was issued. IRSN plans to deliver its own report in 2020.						
IRSN-IE11 **IER 297**	TEX - Hf experiment	LLNL-IE4	Contribution to Jemima plates characterization. Contribution to CED report.	M. BROVCHENKO	C. PERCHER	LLNL
IRSN was involved in the review of the CED2 report and provide some sensitivity calculations to LLNL. The status of the program has been discussed regularly during VTC until 2017 with LLNL. On stand-by?						
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
Task started in 2019. A first contact with Peter Angelo. Reports about the CRAC and SILENE review sent to NCSP.						
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
Design optimization for TEX-MOX ongoing. (Supported by sub-contracts in 2018 and 2019) CED1 report is on-going and has been sent to Catherine Percher for distribution to CED-team.						
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
Not funded in FY2020.						
IRSN-IE27 **IER 175**	GODIVA CAAS benchmark	ORNL-IE4	Participation in the design. Provide IRSN materials for irradiation, analysis of results.	M. DULUC	D. BOWEN	ORNL
Some contacts with Doug BOWEN and Riley CUMBERLAND. Discussions on detectors.						
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
Discussion in progress to perform additional measurements.						
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 C. WILSON	LLNL AWE
Task not started						
IRSN-IE30	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
Task not started						

	REFERENCE		IRSN Contribution / POC			
IRSN Reference	**Task Title**	**DOE Reference**	**FY 2020 IRSN Contribution**	**IRSN Technical POC**	**DOE Technical POC**	**DOE LAB**
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
Task not started						
IRSN-IE34	HEU critical and Subcritical measurements	LANL-IE23	Participation in the definition and the design of the experiment	W. MONANGE	J. HUTCHINSON	LANL
Task in progress. IRSN's simulations in progress.						
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
Task not started						
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
Task not started						
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
Delay (problems with HPC at IRSN still make it difficult to finish the simulation program) => end of analysis foreseen by the end of Q2						
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
Task not started						
IRSN-IE41	Thermal/Epithermal Experiments (TEX) with Chlorine and Lithium	LLNL-IE23	Participation in experiments design and CED reports. To be discussed with LLNL.	M. BROVCHENKO	D. HEINRICHS	LLNL
Task not started.						
IRSN-IE42	Neptunium Subcritical Observations (NeSO) experiment	LANL-IE3	Independent review of the ICSBEP evaluation.	W. MONANGE	J. HUTCHINSON	LANL
Participation to the experiments in 2019. Independent review of the ICSBEP evaluation.						
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**
Not funded in FY2020. To be proposed for FY2021.						
IRSN-IE44 **IER 516**	ZTA (Zirconium Test Assembly)	LANL-IE3	Participation in experiments design and CED reports.	N. LECLAIRE	T. CUTLER	LANL
Not funded in FY2020. To be proposed for FY2021.						
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
Not funded in FY2020. To be proposed for FY2021.						
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
Not funded in FY2020. To be proposed for FY2021.						
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
Review of LCT101 (SNL) and TEX-Ta (LLNL) done for October ICSBEP 2019 meeting						
IRSN-IPD3	ICSBEP benchmark reviewing	LLNL-IPD1	IRSN ICSBEP reviewing tasks	I. DUHAMEL	J. FAVORITE	LANL
Not started – waiting for FLATTOP re-evaluation						
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
2019: ^{103}Rh resolved evaluation completed. Progress on the ^{54}Fe and ^{56}Fe and preliminary resonance evaluation generated. IRSN benchmark assembled for testing the ^{55}Mn evaluation. New capture data from NTOF included in the Gd-155 and Gd-157 evaluation. Improved Gd resonance parameters available. Paper on Gd for ND2019 conference. Generation of covariance data for ^{155,157}Gd. Testing of the Gd evaluation has started. FY20-Q1: The Fe resonance evaluation continues						
IRSN-ND2	Nuclear data processing	LANL-ND1	Benchmark testing of ^{235}U and ^{239}Pu cross section library	L. LEAL	J. CONLIN	LANL
Test performed and new ^{235}U and ^{239}Pu resonance parameters generated. Benchmark testing on the ^{235}U and ^{239}Pu underway. Sensitivity analysis of the benchmark results will be done New Pu239 capture data measured at LANL by Shea Mosby included in the evaluation; Testing of the evaluation on the TEX experiments are under way						

	REFERENCE		IRSN Contribution / POC			
IRSN Reference	**Task Title**	**DOE Reference**	**FY 2020 IRSN Contribution**	**IRSN Technical POC**	**DOE Technical POC**	**DOE LAB**
FY20-Q1: Full paper submitted to Physor 2020						
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
Existing resonance evaluation extended to 2 keV. New resonance parameters derived. New ^{233}U fission and capture cross section data from n_TOF may become available shortly. The data will be incorporated in the evaluation and benchmark testing will be performed.						
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
2 IRSN staff authorized to attend the hands-on training in 2020.						