

<b>INTERAGENCY AGREEMENT</b>		1. IAA NO. NRC-HQ-60-16-T-0011		PAGE 1		OF 3	
2. ORDER NO.		3. REQUISITION NO. RES-16-0446		4. SOLICITATION NO.			
5. EFFECTIVE DATE 08/09/2016		6. AWARD DATE 08/09/2016		7. PERIOD OF PERFORMANCE 08/15/2016 TO 09/30/2017			
8. SERVING AGENCY OAK RIDGE NATIONAL LAB ALC: DUNS: 012075755 +4: US DEPARTMENT OF ENERGY OAK RIDGE NATION LABORATORY SITE OFFICE BUILDING 4500N MS 6269 PO BOX 2008 OAK RIDGE TN 37831-6269 POC Deborah Garland, CO TELEPHONE NO. (865) 241-9566				9. DELIVER TO MOURAD AISSA US NUCLEAR REGULATORY COMMISSION MAIL STOP T10-A3 11555 ROCKVILLE PIKE ROCKVILLE MD 20852			
10. REQUESTING AGENCY ACQUISITION MANAGEMENT DIVISION ALC: 31000001 DUNS: 040535809 +4: US NUCLEAR REGULATORY COMMISSION ONE WHITE FLINT NORTH 11555 ROCKVILLE PIKE ROCKVILLE MD 20852-2738 POC Jeffrey R. Mitchell TELEPHONE NO. 301-415-5074				11. INVOICE OFFICE US NUCLEAR REGULATORY COMMISSION ONE WHITE FLINT NORTH 11555 ROCKVILLE PIKE MAILSTOP 03-E17A ROCKVILLE MD 20852-2738			
12. ISSUING OFFICE US NRC - HQ ACQUISITION MANAGEMENT DIVISION MAIL STOP TWEN-5E03 WASHINGTON DC 20555-0001				13. LEGISLATIVE AUTHORITY Energy Reorganization Act of 1974			
				14. PROJECT ID			
				15. PROJECT TITLE UNCERTAINTY ASSESSMENT OF NUCLEAR DATA AND CE MONT			
16. ACCOUNTING DATA 2016-X0200-FEEBASED-60-60D003-11-6-213-1045-253D							
17. ITEM NO.	18. SUPPLIER/SERVICES			19. QUANTITY	20. UNIT	21. UNIT PRICE	22. AMOUNT
	TASK ORDERING AGREEMENT: NRC-HQ-60-14-D-0005 TASK ORDER NUMBER: NRC-HQ-60-16-T-0011  The NRC and the DOE Lab (ORNL) hereby enter into this Agreement/Task Order, NRCHQ6014D0005 - NRCHQ6016T0011, for the project entitled, "Uncertainty Assessment of Nuclear Data and CE Monte Carlo"  The performance period for this agreement shall commence on August 15, 2016 and will expire on September 30, 2017. Continued ...						
23. PAYMENT PROVISIONS				24. TOTAL AMOUNT \$500,000.00			
25a. SIGNATURE OF GOVERNMENT REPRESENTATIVE (ISSUING)				25b. SIGNATURE OF GOVERNMENT REPRESENTATIVE (REQUESTING)			
25c. NAME AND TITLE Deborah L. Garland, Contracting Officer				25d. NAME AND TITLE JEFFREY R. MITCHELL			
25e. DATE 8/10/16				25f. DATE 8/9/2016			

SUNSI REVIEW COMPLETE

TEMPLATE - ADMIN

OCT - 6 2016

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IAANO NRC-HQ-60-16-T-0011		ORDER NO		PAGE 2	OF 3
	<p>NRC Contracting Officers Representative (COR): Mourad Aissa and Don Algama ORNL Project Manager: Stephen M. Bowman and William Matisiak.</p> <p>Consideration and Obligations: (a) Authorized Cost Ceiling \$500,000.00</p> <p>(b) The amount presently obligated with respect to this DOE Agreement is \$500,000.00. When and if the amount(s) paid and payable to the DOE Laboratory hereunder shall equal the obligated amount, the DOE Laboratory shall not be obligated to continue performance of the work unless and until the NRC Contracting Officer shall increase the amount obligated with respect to this DOE Agreement. Any work undertaken by the DOE Laboratory in excess of the obligated amount specified above is done so at the DOE Laboratory's sole risk.</p> <p>The following documents are hereby made part of this Agreement: Attachment No. 1: Statement of Work</p> <p>The issuance of this Task Order does not amend any terms or conditions of the subject Agreement. Master IAA: NRCHQ6014D0005</p>				
00001	<p>Authorized Cost Celng Total Obligated Amount\$500,000.00 Incrementally Funded Amount: \$500,000.00</p> <p>This agreement is entered into pursuant to the authority of the Energy Reorganization Act of 1974, as amended (42 U.S.C 5801 et seq.). This work will be performed in accordance with the NRC/DOE Memorandum of Understanding dated November 24, 1998. To the best of our knowledge, the work requested will not place the DOE and its contractor in direct competition with the domestic private sector.</p> <p>[ ] Fee Recoverable Work [ X ] Non-fee Recoverable Work</p> <p>Continued ...</p>				500,000.00

Notwithstanding the agreement effective dates and period of performance start dates stated elsewhere in the agreement, the effective date of the agreement and start date of the period of performance are the last date of signature by the parties.

The total amount of award: \$500,000.00. The obligation for this award is shown in box 24.

## STATEMENT OF WORK

NRC Agreement Number  NRC-HQ-60-14-D-0005	NRC Agreement Modification Number	NRC Task Order Number (If Applicable)  NRC-HQ-60-16-T-0011	NRC Task Order Modification Number (If Applicable)
Project Title <b>Uncertainty Assessment of Nuclear Data and CE Monte Carlo</b>			
Job Code Number	B&R Number	DOE Laboratory  ORNL	
NRC Requisitioning Office  RES			
NRC Form 187, Contract Security and Classification Requirements <input type="checkbox"/> Applicable <input checked="" type="checkbox"/> Not Applicable		<input type="checkbox"/> Involves Proprietary Information <input type="checkbox"/> Involves Sensitive Unclassified	
<input checked="" type="checkbox"/> Non Fee-Recoverable		<input type="checkbox"/> Fee-Recoverable (If checked, complete all applicable sections below)	
Docket Number (If Fee-Recoverable/Applicable)  N/A		Inspection Report Number (If Fee Recoverable/Applicable)  N/A	
Technical Assignment Control Number (If Fee-Recoverable/Applicable)  N/A		Technical Assignment Control Number Description (If Fee-Recoverable/Applicable)  N/A	

### 1.0 BACKGROUND

#### Regulatory Context:

The Nuclear Regulatory Commission (NRC) relies on SCALE as a robust, state-of-the-art nuclear analysis computer code system that ensures independent review of licensee submittals and accurate investigations of reactor and fuel phenomena important to nuclear safety.

This code affects all licensing evaluations that are being performed at the NRC that relies on independent nuclear data libraries. This work will evaluate and enhance the current uncertainties associated with these libraries.

#### Technical Context:

CE Monte Carlo (MC) Depletion is the highest-fidelity solution available for reactor physics analysis. For new, applications lacking validation measurements as well as for non-Light Water Reactor (LWR) systems (e.g. sodium fast reactors and molten salt reactors), it has become the

preferred method as analysts are able to cope with the higher computational demand in exchange for more confidence in the results. However, although the bias due to the method itself can be driven to zero with more particles and smaller time steps, the *total* bias and uncertainty requires consideration of sources of uncertainty in nuclear data, manufacturing processes, and incomplete knowledge of the system. In addition, MC also has its own introduced biases/uncertainties, e.g. due to the finite number of particles or lack of source convergence. For these new systems, analyzed with CE MC Depletion, developing a complete uncertainty analysis methodology will be extremely important. Here "complete" means all relevant data have uncertainties, all input parameters may be assigned uncertainties, all uncertainties are propagated to burnup-dependent CE MC solutions, and the uncertainties in all reactor physics quantities may be directly analyzed. The natural platform for such uncertainty analysis is the Sampler module in SCALE.

## **2.0 OBJECTIVE**

The main objective of this Task Order Agreement is twofold: (1) Assessment and enhancement of nuclear data uncertainty, (2) Development of the data and capability necessary to provide a robust and complete uncertainty assessment of reactor physics quantities as calculated by continuous energy (CE) Monte Carlo Depletion methods.

## **3.0 SCOPE OF WORK**

The DOE Laboratory must provide all resources necessary to accomplish the tasks and deliverables described in this statement of work (SOW). Required expertise to perform the work is listed for each task in Section 4 of the SOW.

## **4.0 SPECIFIC TASKS**

The DOE Laboratory must perform the following tasks:

### ***Task 1: Nuclear Data Uncertainty Enhancement***

There has been recent work on nuclear data uncertainties. However, numerous data components have incomplete uncertainty data (e.g., correlations between fission product yields and branching ratios), or none at all (such as the JEFF activation library used by ORIGEN for depletion calculations). This task will perform a survey of the current status of the data, prioritize enhancements, determine appropriate sources for uncertainty data, and add/update the new uncertainty data in the SCALE data repository. In the case that a particular type of data currently has no uncertainty files (e.g. energy per fission), an appropriate file type will be developed and integrated into the SCALE data repository. The main goal for this task is to have uncertainty data formats and reasonable values defined for all data sources. Subsequent work in uncertainty quantification (UQ) will undoubtedly lead to refinements, but initial estimates (and relevant files) are necessary to provide a robust UQ assessment capability for new reactor and fuel designs.

Deliverable: NUREG/CR describing the complete assessment of the current nuclear data uncertainties and the associated prioritized enhancements

*Required Expertise:*

- 1) Coupled transport/depletion methodology and data resources required.
- 2) Specific SCALE Data resources used by SCALE/TRITON.
- 3) Depletion covariance data generation methodology including correlations between fission product yield and decay branch fraction data.
- 4) Sampler methodology to set up perturbed data resources.

**Task 2: CE Cross Section Perturbations from MG Perturbations**

SCALE has a comprehensive set of multigroup cross section uncertainty data, collected from a variety of sources, and available in various group structures. Although current R&D may allow for the complete Monte Carlo approach of generating perturbed CE data directly, the option to use the existing multigroup perturbations, and apply them to CE data in a reasonable way is a practical first step and will be implemented in this task.

Cross section uncertainties in SCALE are described by multigroup covariances that are applied to multigroup transport calculations. The standard deviations in the multigroup cross section effectively represent the average uncertainties in the energy-dependent data spanned by the group energy interval. In this work data perturbations sampled from the current multigroup covariance libraries will be projected onto the CE data, thus providing a perturbed library for CE KENO calculations. Several algorithms will be examined to convert perturbed MG to CE cross sections. For example the lowest order method is to perturb CE data at all energy points in a given MG energy interval by the corresponding MG perturbation factor.

Deliverable: Letter Report summarizing the generation of the perturbed CE Library from MG covariance libraries

*Required Expertise:*

- 1) Understanding of CE nuclear data.
- 2) Familiarity with SCALE CE data formats.

**Task 3: Sampler Enhancements to Support the Uncertainty Assessment**

Sampler will be updated as needed to support the complete uncertainty assessment with CE TRITON depletion calculations. This may include such tasks as

- 1) Modifications to the parallel implementation in Sampler to allow both Sampler and its child sequence (e.g. CE TRITON) to use MPI parallelism

2) Modifications to the random sampling to allow explicit specification of the random number seed for various quantities (e.g. random sampling variables, Monte Carlo seed, etc.)

3) Ability to provide a correlation matrix for input variables

4) Modifications to give estimates of major sensitivities from output correlation indices.

Enhancements will be prioritized to focus on those which best advance the overarching goal of providing a complete UQ analysis capability with CE MC depletion.

Deliverable: Letter Report documenting the Sampler modifications to support the uncertainty assessment results and the subsequent SCALE user's manual revisions

*Required Expertise:*

1) Understanding of sampling-based uncertainty quantification.

2) SCALE Sampler familiarity.

#### **Task 4: UAM Benchmark Support**

The goal of the OECD/NEA benchmark on Uncertainty Analysis in Modeling (UAM) of LWR core calculations is to support the quantification of reactor design margins. The benchmark has focused on Three Mile Island Unit core steady-state calculations. In the past, ORNL and the University of Michigan collaborated in this benchmark to propagate nuclear data uncertainties available in the SCALE package to PARCS. The uncertainty quantification was accomplished using the SCALE/Sampler module to generate perturbed nuclear data libraries for Polaris/GenPMAXS/PARCS/PATHS calculations.

The UAM benchmark activity has been expanded to include the sodium fast reactor SFR-UAM. Thus, UAM is now focused on both LWRs and advanced reactors. This task will support continued participation in UAM to apply and demonstrate the new SCALE UQ capabilities developed in this project for advanced reactor applications. ORNL will prepare and submit updated results for the OECD/NEA UAM Benchmark as well as attend the 2017 UAM-11 Benchmark workshop. This includes one foreign trip in FY 2017.

Deliverable: Technical Report summarizing the ORNL activities in support of the OECD/NEA UAM Benchmark and the benchmark results

#### **5.0 DELIVERABLES AND/OR MILESTONES SCHEDULE**

Please note that with all deliverables, a three (3) week NRC review time is to be incorporated into the road map. Any input decks developed, or used for, in this project should be provided with the draft and the final deliverables clearly annotated, where appropriate.

<b>Task Number</b>	<b>Deliverable/Milestone Description</b>	<b>Due Date</b>
1	NUREG/CR describing the complete assessment of the current nuclear data uncertainties and the associated prioritized enhancements	9/15/2017
2	Letter Report summarizing the generation of the perturbed CE Library from MG covariance libraries	5/31/2017
3	Letter Report documenting the Sampler modifications to support the uncertainty assessment results and the subsequent SCALE user's manual revisions	8/15/2017
4	Technical Report summarizing the ORNL activities in support of the OECD/NEA UAM Benchmark and the benchmark results	6/30/2017

## **6.0 TECHNICAL AND OTHER SPECIAL QUALIFICATIONS REQUIRED**

ORNL shall commit the appropriate number of qualified staff to the project. NRC reserves the right to approve the Project Manager and the individual personnel assigned to this task. The project manager and assigned staff shall be experienced with SCALE and in particular, code development with regard to cross section generation, and the peculiarities that are inherent with the code system

## **7.0 ESTIMATED LABOR CATEGORIES AND LEVELS OF EFFORT**

Intentionally left blank.

## **8.0 MEETINGS AND TRAVEL**

One foreign trip (One traveler for 6 days) is currently planned. All travel requires written Government approval from the CO, unless otherwise delegated to the COR.

Foreign travel for the DOE laboratory personnel requires a 60-day lead time for NRC approval. For prior approval of foreign travel, the DOE laboratory shall submit an NRC Form 445, "Request for Approval of Official Foreign Travel." NRC Form 445 is available in the MD 11.7 Documents library and on the NRC Web site at:

<http://www.nrc.gov/reading-rm/doc-collections/forms/>. Foreign travel is approved by the NRC Executive Director for Operations (EDO).

## **9.0 REPORTING REQUIREMENTS**



The DOE Laboratory is responsible for structuring the deliverable to follow agency standards. The current agency standard is Microsoft Office Suite 2010. The current agency Portable Document Format (PDF) standard is Adobe Acrobat 9 Professional. Deliverables must be submitted free of spelling and grammatical errors and conform to requirements stated in this section.

Please note that all deliverables are to provide for a 3 week NRC review period and include all input decks generated or used to complete the task, and where possible to be appropriately annotated for legibility. All submissions are to be provided in WORD and PDF format

### ***Monthly Letter Status Reports***

In accordance with Management Directive 11.7, NRC Procedures for Placement and Monitoring of Work with the U.S. Department of Energy, the DOE Laboratory must electronically submit a Monthly Letter Status Report (MLSR) by the 20<sup>th</sup> day of each month to the Contracting Officer Representative (COR) with copies to the Contracting Officer (CO) and the Office Administration/Division of Contracts to [ContractsPOT.Resource@nrc.gov](mailto:ContractsPOT.Resource@nrc.gov). If a project is a task ordering agreement, a separate MLSR must be submitted for each task order with a summary project MLSR, even if no work has been performed during a reporting period. Once NRC has determined that all work on a task order is completed and that final costs are acceptable, a task order may be omitted from the MLSR.

The MLSR must include the following: agreement number; task order number, if applicable; job code number; title of the project; project period of performance; task order period of performance, if applicable; COR's name, telephone number, and e-mail address; full name and address of the performing organization; principal investigator's name, telephone number, and e-mail address; and reporting period. At a minimum, the MLSR must include the information discussed in Attachment 1. The preferred format for a MLSR can also be found in Attachment 1.

## **10.0 PERIOD OF PERFORMANCE**

Refer to block 7 on the IAA award form.

## **11.0 CONTRACTING OFFICER'S REPRESENTATIVE**

The COR monitors all technical aspects of the agreement/task order and assists in its administration. The COR is authorized to perform the following functions: assure that the DOE Laboratory performs the technical requirements of the agreement/task order; perform inspections necessary in connection with agreement/task order performance; maintain written and oral communications with the DOE Laboratory concerning technical aspects of the agreement/task order; issue written interpretations of technical requirements, including Government drawings, designs, specifications; monitor the DOE Laboratory's performance and notify the DOE Laboratory of any deficiencies; coordinate availability of NRC-furnished material and/or GFP; and provide site entry of DOE Laboratory personnel.

### **Contracting Officer's Representative**

Name: Mourad Aissa  
Agency: U.S. Nuclear Regulatory Commission  
Office: RES

Mail Stop: T10 B58  
Washington, DC 20555-0001  
E-Mail: Mourad.Aissa@nrc.gov  
Phone: 301.415.0380

Alternate Contracting Officer's Representative

Name: Don R. Algama  
Agency: U.S. Nuclear Regulatory Commission  
Office: RES  
Mail Stop: T10 B58  
Washington, DC 20555-0001  
E-Mail: [don.algama@nrc.gov](mailto:don.algama@nrc.gov)  
Phone: 301.451.1940

**12.0 MATERIALS REQUIRED (TYPE N/A IF NOT APPLICABLE)**

N/A

**13.0 NRC-FURNISHED PROPERTY/MATERIALS**

N/A

**14.0 RESEARCH QUALITY (TYPE N/A IF NOT APPLICABLE)**

The quality of NRC research programs are assessed each year by the Advisory Committee on Reactor Safeguards. Within the context of their reviews of RES programs, the definition of quality research is based upon several major characteristics:

Results meet the objectives (75% of overall score)

Justification of major assumptions (12%)

Soundness of technical approach and results (52%)

Uncertainties and sensitivities addressed (11%)

Documentation of research results and methods is adequate (25% of overall score)

Clarity of presentation (16%)

Identification of major assumptions (9%)

It is the responsibility of the DOE Laboratory to ensure that these quality criteria are adequately addressed throughout the course of the research that is performed. The NRC COR will review all research products with these criteria in mind.

**15.0 STANDARDS FOR CONTRACTORS WHO PREPARE NUREG-SERIES  
MANUSCRIPTS**

The U.S. Nuclear Regulatory Commission (NRC) began to capture most of its official records electronically on January 1, 2000. The NRC will capture each final NUREG-series publication in its native application. Therefore, please submit your final manuscript that has been approved by your NRC Project Manager in both electronic and camera-ready copy.

The final manuscript shall be of archival quality and comply with the requirements of NRC Management Directive 3.7 "NUREG-Series Publications." The document shall be technically edited consistent with NUREG-1379, Rev. 2 (May 2009) "NRC Editorial Style Guide." The goals of the "NRC Editorial Style Guide" are readability and consistency for all agency documents.

All format guidance, as specified in NUREG-0650, "Preparing NUREG-Series Publications," Rev. 2 (January 1999), will remain the same with one exception. You will no longer be required to include the NUREG-series designator on the bottom of each page of the manuscript. The NRC will assign this designator when we send the camera-ready copy to the printer and will place the designator on the cover, title page, and spine. The designator for each report will no longer be assigned when the decision to prepare a publication is made. The NRC's Publishing Services Branch will inform the NRC Project Manager for the publication of the assigned designator when the final manuscript is sent to the printer.

For the electronic manuscript, the Contractor shall prepare the text in Microsoft Word, and use any of the following file types for charts, spreadsheets, and the like.

File Types to be Used for NUREG-Series Publications	
File Type	File Extension
Microsoft® Word®	.doc
Microsoft® PowerPoint®	.ppt
Microsoft® Excel	.xls
Microsoft® Access	.mdb
Portable Document Format	.pdf

This list is subject to change if new software packages come into common use at NRC or by our licensees or other stakeholders that participate in the electronic submission process. If a portion of your manuscript is from another source and you cannot obtain an acceptable electronic file type for this portion (e.g., an appendix from an old publication), the NRC can, if necessary, create a tagged image file format (file extension.tif) for that portion of your report. Note that you should continue to submit original photographs, which will be scanned, since digitized photographs do not print well.

If you choose to publish a compact disk (CD) of your publication, place on the CD copies of the manuscript in both (1) a portable document format (PDF); (2) a Microsoft Word file format, and

(3) an Adobe Acrobat Reader, or, alternatively, print instructions for obtaining a free copy of Adobe Acrobat Reader on the back cover insert of the jewel box.

## **16.0 OTHER CONSIDERATIONS**

### References

N/A

### Access to Non-NRC Facilities/Equipment

N/A

### Applicable Publications

N/A

### Controls over document handling and non-disclosure of materials

N/A