

APR 15 2016

<b>INTERAGENCY AGREEMENT</b>		1. IAA NO. NRC-HQ-60-16-T-0004		PAGE 1 OF 3	
2. ORDER NO.		3. REQUESTION NO. RES-16-0131		4. SOLICITATION NO.	
5. EFFECTIVE DATE 03/24/2016		6. AWARD DATE 03/24/2016		7. PERIOD OF PERFORMANCE 03/24/2016 TO 02/28/2018 SFO CO acceptance	
8. SERVING AGENCY ALBUQUERQUESANDIA NATL LAB ALC: DUNS: 155505027 +4: DOENNSASFO CONTRACTING OFFICER PO BOX 5400 ALBUQUERQUE NM 87185-5400  POC: Dolores Lineback TELEPHONE NO. 505-845-6066 IAADMIN@SANDIA.GOV (505) 844-3811		9. DELIVER TO HOSSEIN ESMAILI US NUCLEAR REGULATORY COMMISSION MAIL STOP T10-B49 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 TWFN-5E03 WASHINGTON DC 20555-0001		13. LEGISLATIVE AUTHORITY Energy Reorganization Act of 1974			
		14. PROJECT ID			
		15. PROJECT TITLE MELCOR COMPUTER CODE DEVELOPMENT			
16. ACCOUNTING DATA 2016-X0200-FEEBASED-60-60D003-11-6-213-1045-253D					
17. ITEM NO.	18. SUPPLIES/SERVICES	19. QUANTITY	20. UNIT	21. UNIT PRICE	22. AMOUNT
	The NRC and the DOE Lab Sandia National Laboratories (SNL) hereby enter into this Task Order NRC-HQ-60-16-T-0004 under Agreement, NRC-HQ-60-13-D-0001 for the project entitled, "MELCOR COMPUTER CODE DEVELOPMENT"  The performance period for this agreement shall commence on March 24, 2016 and will expire on February 28, 2018. Sandia start date is date of SFO CO acceptance  Consideration and Obligations: (a) Authorized Cost Ceiling \$3,960,425.00. Continued ...			3Z (05499) 450140374 (7000100) SNL \$776,699.03 58 \$23,300.97 NRCHQ6016T0004  Rene Pacheco 2016.04.05 16:34:50 -06'00'	
23. PAYMENT PROVISIONS		24. TOTAL AMOUNT \$800,000.00			
25a. SIGNATURE OF GOVERNMENT REPRESENTATIVE (SERVICING)		25b. SIGNATURE OF GOVERNMENT REPRESENTATIVE (REQUESTING)			
26a. NAME AND TITLE Dave Ferguson NNSA Contracting Officer		26b. DATE 4/14/16		26c. DATE 3/10/2016	

SUNSI REVIEW COMPLETE

TEMPLATE - ADMIN

APR 29 2016

ADMIN

(b) The amount presently obligated with respect to this DOE Agreement is \$800,000.00. 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.

The following documents are hereby made part of this Agreement:

Attachment No. 1: Statement of Work

NRC CONTRACTING OFFICERS REPRESENTATIVE (COR):

Hossein Esmaili (Primary) and Don Algama (Alternate)

SNL PROJECT MANAGER: Randall Gauntt

Master IAA: NRCHQ6013D0001

00001

Authorized Cost Ceiling

Total Obligated Amount \$3,960,425.00

Incrementally Funded Amount: \$800,000.00

3,960,425.00

→ 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.

[ ] Fee Recoverable Work

[ X ] Non-fee Recoverable Work

ALC: 31000001

DUNS: 040535809

TAS: 31x0200.320

Notwithstanding the agreement effective dates and period of performance start dates stated  
Continued ...

IAANO NRC-HQ-60-16-T-0004	ORDER NO	PAGE 3	OF 3
<p>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.</p> <p>The total amount of award: \$3,960,425.00. The obligation for this award is shown in box 24.</p>			

## STATEMENT OF WORK

NRC Agreement Number  NRC-HQ-60-13-D-0001	NRC Agreement Modification Number	NRC Task Order Number (If Applicable)  NRC-HQ-60-16-T-0004	NRC Task Order Modification Number (If Applicable)
Project Title MELCOR Computer Code Development			
Job Code Number	B&R Number	DOE Laboratory Sandia National Laboratories	
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)		Inspection Report Number (If Fee Recoverable/Applicable)	
Technical Assignment Control Number (If Fee-Recoverable/Applicable)		Technical Assignment Control Number Description (If Fee-Recoverable/Applicable)	

### 1.0 BACKGROUND

#### Regulatory Context

MELCOR is used for targeted applications including: (1) Technical support for the Agency's full scope site Level 3 PRA by performing severe accident progression analysis for both the reactor and spent fuel pool, and thermal-hydraulic analysis for success criteria, (2) State-of-the-Art Reactor Consequence Analyses accident progression and source term analysis including uncertainty analysis, (3) analysis of new/advanced reactors and support reactor design certification including small modular reactors, and (4) analysis of the event at Fukushima, and to support the Japan Lessons Learned Directorate and Near Term Task Force (NTTF) recommendations to more effectively meet Agency's mission to protect the safety of the people.

#### Technical Context

NRC currently maintains the MELCOR computer code for both severe accident analysis and source term and the containment related design basis analysis. The MELCOR computer code

represents the current state of the art in severe accident analysis which has been developed through the NRC and international research performed since the accident at Three Mile Island in 1979. MELCOR is a fully integrated, engineering-level computer code and includes a broad spectrum of severe accident phenomena with capabilities to model core heatup and degradation, fission product release and transport within the primary system and containment, core relocation to the vessel lower head, and ex-vessel core concrete interaction.

The MELCOR code is composed of an executive driver and a number of major modules, or packages, that together model the major systems of a reactor plant and their generally coupled interactions. The various code packages have been written using a carefully designed modular structure with well-defined interfaces between them. This allows the exchange of complete and consistent information among them so that all phenomena are explicitly coupled at every step. The structure also facilitates maintenance and upgrading of the code. MELCOR modeling is general and flexible, making use of a "control volume" approach in describing the thermal-hydraulic response of the plant. No specific nodalization is provided, which allows a choice of the degree of detail appropriate to the task at hand. Reactor-specific geometry is imposed only in modeling the reactor core. The MELCOR code has been modernized (source code upgrade to Fortran95) to provide an efficient code structure for ease of maintenance, resulting in the release of MELCOR version 2.1. The new upgraded version of the code architecture supports advancements in computer hardware and software, and the code numerics improvements to carry out reasonable execution times.

MELCOR code development meets the following criteria:

- Prediction of phenomena is in qualitative agreement with current understanding of physics and uncertainties are in quantitative agreement with experiments.
- Focus is on mechanistic models where feasible with adequate flexibility for parametric models.
- Code is portable, robust, and relatively fast running, and the code maintenance follows established Software Quality Assurance (SQA) standards.
- Availability of detailed code documentation.

The NRC supports and hosts a number of meetings annually to exchange progress in severe accident research and to report MELCOR code development and assessment status which are listed below:

Cooperative Severe Accident Research Program (CSARP) Technical Meeting: An annual meeting in September hosted by NRC to provide a forum to exchange technical information on severe accident research and to gain insight into regulatory and safety issues. This meeting provides an overview of the research at various international organizations.

MELCOR Code Assessment Program (MCAP): This program focuses on the MELCOR code development and assessment and provides a forum for the presentation and discussion of the user experience. MCAP follows the CSARP meeting.

European MELCOR User Group (EMUG): This group was founded to facilitate collective discussion and exchange of experience between European MELCOR users and with the U.S.

NRC and Sandia National Laboratories and to support the training of new MELCOR users. The host organization is among the European MELCOR community and from a country which is a member of CSARP

Asian MELCOR User Group (AMUG): The focus of this group is similar to EMUG, but participation is restricted to Asian countries who are CSARP members.

## **2.0 OBJECTIVE**

The objectives of the work is to (1) insure that the analytical models in the code simulate the entire spectrum of severe accident phenomena as well as design basis accidents in adequate detail, (2) conduct an assessment of the code, particularly its predictive capability, modeling adequacy, run time efficiency, and machine portability, and (3) provide continuing maintenance and user support for the code.

## **3.0 SCOPE OF WORK**

The scope of work is mainly focused on the development, improvement, and assessment of the MELCOR computer code, and provide support for the code users. The main activities consists of (1) improving the existing models and implementing new models to better capture the outcome of severe accidents (especially following the Fukushima accident) based on shared knowledge and the research conducted with the international community, (2) code maintenance and debugging, and (3) providing code user support for domestic as well as international partners to fulfill NRC's obligations under international agreements. In addition, software quality assurance (SQA) should be an integral part of the development process to focus on reducing code error and improving documentation of all processes.

## **4.0 SPECIFIC TASKS**

Sandia National Laboratory (SNL) must perform the following tasks under the technical direction of the NRC Contracting Officer Representative (COR).

### **Task 1 – Development/Improvement of MELCOR Code Models**

SNL shall develop new and/or improved models for the MELCOR code to support NRC research activities, integrate these new models into the MELCOR code, and perform appropriate testing. The priority of these models (or other items not listed) will be based on other NRC needs (e.g., design certification for new and advanced reactors) and the on-going Fukushima forensic evaluation. Candidate modeling improvements include (but not limited to):

- Enhancement to the lower head modeling including the effects of external cooling
- Enhancement to core/concrete interactions with an overlying pool and fission product release from ex-vessel core debris
- Modeling radionuclide decay chains
- Modeling parameters and heat and mass transfer correlations (especially for new reactor design such a modular reactors)
- Expanded radionuclide classes (based on new knowledge regarding fission product speciation gained from programs such as Phebus, VERCORs and VEGA)

- Fission product inventory Specification

SNL shall continue to assess the MELCOR predictions against experimental results to improve the MELCOR modeling capability. The experimental database includes various phases and phenomena associated with severe accidents and design-basis accidents, as well as International Standard Problems (ISP). The MELCOR assessment activities should be integrated into Volume 3 of the code manuals.

In addition, SNL shall submit a preliminary report on each model or code assessment to the NRC COR 1 month after model development or integral testing, followed by a final report 1 month after NRC review of the preliminary report.

Completion Date: 2/28/2018

## **Task 2 – Code Maintenance and Configuration**

MELCOR has a multi-level modular code architecture, which permits easy insertion of new modules describing new or modified phenomenological models; however, integration of new models requires proper communication between code modules. Therefore, code maintenance and configuration management is essential for successful application of the code.

These activities include software quality assurance (SQA) adopted from internationally recognized standards (e.g., ISO9001), code build testing and optimization, error correction and anomaly resolution using MELCOR on-line bug reporting capability, integration and validation of new models, and code numerics. Related activities include updating the code documentation based on implementation of new and improved models; improving input/output and graphics features; and releasing interim code versions when minor modifications are made under this task. In addition, SNAP is being used more frequently for input deck generation and animation of the results as well as a tool for converting input decks from older version of MELCOR to the most recent version 2.1. The SNAP plug-in module bugs and conversion issues need to be addressed and corrected.

SNL shall perform all of the above maintenance functions and other related functions not specifically called out above. Specific duties involving major improvements shall be coordinated in advance with the NRC COR, and approval shall be obtained prior to performing such activities.

“Configuration” is herein taken to mean configuring MELCOR (and related files) on all supported platforms. This includes necessary modifications to ensure compatibility with different operating systems, and documentation of instructions for installation of these systems. “Maintenance” is herein taken to mean maintaining MELCOR and the related documentation outside of all code modifications and enhancements; including processing of minor code bug issues; processing and tracking interim code versions; distributing the code, and maintaining all related documentation and code manuals.

Completion Date: 2/28/2018

### **Task 3 – Code Numerics Improvement**

MELCOR applications often require sensitivity analysis and uncertainty quantification, therefore, there is a need for a fast running, robust software. SNL shall improve the code numerics and physics that incorporate the appropriate length scales and time scales of various phenomena, and software that is easy to maintain. This task shall include code improvements to address known code numerical sensitivities to time step selection, flow path ordering and other small perturbations to code input in order to reduce where possible such sensitivities as previously reported to NRC. This process should be implemented in an evolutionary approach where certain MELCOR packages are modernized and then reconnected back to the legacy software so as not to have a negative impact on any of the current NRC work.

Completion Date: 2/28/2018

### **Task 4 – CSARP Support and MELCOR Users Group Meetings and Workshops**

As part of the NRC's obligation to CSARP members, SNL shall provide required support in organizing and conducting CSARP and MCAP technical review meetings. The NRC plans yearly MELCOR workshops prior to CSARP that may include a week-long basic workshop or a one day special topic workshop. In addition, annual workshops are planned under EMUG and AMUG that are typically held in a European or Asian country that is a member of CSARP. The focus of these workshops is on: (1) reviewing the organization and improvement of the code; (2) preparing input decks; (3) reviewing plant calculations and practical exercises; (4) reviewing the interpretation of MELCOR results; and (5) discussing MELCOR approximations and how to perform a sensitivity analysis for MELCOR.

SNL shall provide a draft of the MELCOR presentation material, consistent with any NRC comments and directions, to the NRC COR at least 1 month before the workshop or the meetings commence. SNL shall also provide all material used in the presentations, sample problems and their solutions, and other necessary and appropriate materials. Following the workshop, SNL shall provide one complete set of all materials provided to workshop attendees and a list of attendees.

Completion Date: 2/28/2018

### **Task 5 – Technical Support**

SNL shall provide technical support to NRC and code users as described in the following subtasks.

#### **Task 5.1 Project Support**

SNL shall provide limited technical support to the NRC on an as needed basis. This support shall include (1) attending meetings with domestic and international organizations discussing the unique capabilities of MELCOR and code to code comparison with other available severe accident codes (e.g., MAAP and ASTEC) (est. 1-2 per year), (2) develop presentations for



various meetings (e.g., CSARP and MELCOR Code Assessment Program (MCAP) meetings) (est. 3 per year), (3) reviewing documents on severe accident phenomenology and code specific analysis using MELCOR in support of regulatory decision-making (est. 3-5 per year, with an average of 40 hours of LOE per document), and (4) perform additional MELCOR specific analyses (est. 3-5 per year, with an average of 40 hours of LOE per analysis), as requested by the NRC COR.

Completion Date: 2/28/2018

#### **Task 5.2 User Consultation and Support**

SNL shall provide on-call user support to NRC staff, designated NRC contractors, and CSARP partners to fulfill the NRC's obligation to CSARP members. This support shall include: (1) distributing the MELCOR code and associated documentation package to new users; (2) distributing subsequent periodic updates and documentation changes to all users; and (3) assisting with installation of the code and its updates, responding to user questions, and resolving difficulties.

Completion Date: 2/28/2018

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

<b>Task</b>	<b>Deliverable/Milestone Description</b>	<b>Date (or frequency)</b>
1	Draft report	One month after completion of code assessment or model development
	Final report	One month after NRC review of the draft report
2	Modification to the code and the manuals	As Needed As requested by COR (major improvements only, per the task description)
3	Letter reports and/or described in the MLSR	As requested by COR (Est. 1-2 reports per year)
4	Draft presentations and workshop exercises	One month before workshop for NRC review
	Final presentations and workshop exercises	One month after workshop

5	5.1: Letter reports or presentations, and/or described in the MLSR	As requested by COR
	5.2: Letter reports and/or described in the MLSR	As needed per the task description

## 6.0 TECHNICAL AND OTHER SPECIAL QUALIFICATIONS REQUIRED

This work requires an in-depth understanding of MELCOR and their utility codes as well as severe accident phenomenology. Expertise is required in all aspects of severe accidents including in-vessel and ex-vessel accident progression, containment thermal-hydraulics and fission product release and transport. Experience developing, maintaining, and performing SQA on MELCOR for the NRC is needed. Expertise in uncertainty analysis is also required as is access to high performance computer clusters for running computationally intensive calculations.

KEY PERSONNEL	
1	Larry L. Humphries
2	Rodney C. Schmidt
3	K. Noel Belcourt
4	David L.Y. Louie
5	Chun Fu
6	Jesse Phillips
7	Vincent A. Mousseau
8	John Reynolds (Subcontractor)

## 7.0 ESTIMATED LABOR CATEGORIES AND LEVELS OF EFFORT (OPTIONAL SECTION)

Intentionally left blank.

## 8.0 MEETINGS AND TRAVEL

Up to six SNL representatives shall attend the annual week-long CSARP and MCAP meetings, as well as the MELCOR workshops. Presentation materials shall be provided no later than 30 days prior to each meeting. In addition, the NRC anticipates that two SNL representatives will travel to Europe or Asia each year to participate in various international meetings (e.g., European and Asian MELCOR User Group meetings).

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 11 Professional. Deliverables must be submitted free of spelling and grammatical errors and conform to requirements stated in this section.

### ***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.

Additional copies of MLSRs will be sent electronically to the following list with copies to the Division of Contracts as follows:

NRC COR	<a href="mailto:Hosseini.Esmaili@nrc.gov">Hosseini.Esmaili@nrc.gov</a>
RES/DSA/FSCB Branch Chief	<a href="mailto:Richard.Lee@nrc.gov">Richard.Lee@nrc.gov</a>
RES/DSA Division Director	<a href="mailto:Michael.Case@nrc.gov">Michael.Case@nrc.gov</a>
RES/DSA Deputy Division Director	<a href="mailto:Stephanie.Coffin@nrc.gov">Stephanie.Coffin@nrc.gov</a>

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 a narrative of the month's activities detailing, by position, the tasks or activities performed listing of the documents reviewed, letters drafted, databases examined, etc. by that position. Broad statements on the intent of the research, are to be avoided. Merely repeating the previous month's report is unacceptable. The preferred format for a MLSR can be found in Attachment 1.

## **10.0 PERIOD OF PERFORMANCE**

Refer to Block 7 of 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: Hossein Esmaili  
Agency: U.S. Nuclear Regulatory Commission  
Office: Office of Nuclear Regulatory Research  
Mail Stop: TWFN 10-B58  
Washington, DC 20555-0001  
E-Mail: Hossein.Esmaili@nrc.gov  
Phone: 301-415-2155

##### Alternate Contracting Officer's Representative

Name: Don Algama  
Agency: U.S. Nuclear Regulatory Commission  
Office: Office of Nuclear Regulatory Research  
Mail Stop: TWFN 10-B58  
Washington, DC 20555-0001  
E-Mail: Don.Algama@nrc.gov  
Phone: 301-415-1940

#### **12.0 MATERIALS REQUIRED**

N/A

#### **13.0 NRC-FURNISHED PROPERTY/MATERIALS**

N/A

#### **14.0 RESEARCH QUALITY**

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**

N/A

#### **16.0 OTHER CONSIDERATIONS**

N/A

##### 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