

<b>AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT</b>				1. CONTRACT ID CODE		PAGE OF PAGES	
						1      6	
2. AMENDMENT/MODIFICATION NO.		3. EFFECTIVE DATE		4. REQUISITION/PURCHASE REQ. NO.		5. PROJECT NO. (If applicable)	
M0023		See Block 16C		ZEROREQ-RES-20-0100			
6. ISSUED BY		CODE		7. ADMINISTERED BY (If other than Item 6)		CODE	
US NRC - HQ		NRCHQ					
ACQUISITION MANAGEMENT DIVISION							
MAIL STOP TWFN-07B20M							
WASHINGTON DC 20555-0001							
8. NAME AND ADDRESS OF CONTRACTOR (No., street, county, State and ZIP Code)				(x)			
UNIVERSITY OF MICHIGAN				9A. AMENDMENT OF SOLICITATION NO.			
ATTN MR KULLIE KENNEDY							
503 THOMPSON ST				9B. DATED (SEE ITEM 11)			
ANN ARBOR MI 481091340							
				x			
				10A. MODIFICATION OF CONTRACT/ORDER NO.			
				NRC-HQ-60-15-C-0012			
				10B. DATED (SEE ITEM 13)			
				09/28/2015			
CODE 073133571		FACILITY CODE					
<b>11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS</b>							
<input type="checkbox"/> The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers <input type="checkbox"/> is extended. <input type="checkbox"/> is not extended. Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods: (a) By completing Items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or electronic communication which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by letter or electronic communication, provided each letter or electronic communication makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.							
12. ACCOUNTING AND APPROPRIATION DATA (If required)							
N/A							
<b>13. THIS ITEM ONLY APPLIES TO MODIFICATION OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.</b>							
CHECK ONE	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.						
	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation data, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).						
X	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF: FAR 52.243-2 CHANGES - COST-REIMBURSEMENT. (AUG 1987) - ALTERNATE V (APR 1984)						
	D. OTHER (Specify type of modification and authority)						
<b>E. IMPORTANT:</b> Contractor <input type="checkbox"/> is not <input checked="" type="checkbox"/> is required to sign this document and return <u>1</u> copies to the issuing office.							
14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)							
**SEE PAGE TWO (2) FOR DESCRIPTION OF MODIFICATION TO ADD TASK 11, THEREBY INCREASING THE CONTRACT CEILING, REVISING THE PRICE SCHEDULE, AND EXTENDING THE PERIOD OF PERFORMANCE OF THE CONTRACT.**							
Total Contract Ceiling Amount: \$1,899,836.00 (Changed) Total Contract Obligations Amount: \$1,575,161.97 (Unchanged) Period of Performance: 10/01/2015 to 03/31/2021							
Except as provided herein, all terms and conditions of the document referenced in Item 9 A or 10A, as heretofore changed, remains unchanged and in full force and effect.							
15A. NAME AND TITLE OF SIGNER (Type or print)				16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)			
				JENNIFER A. DUDEK			
15B. CONTRACTOR/OFFEROR		15C. DATE SIGNED		16B. UNITED STATES OF AMERICA		16C. DATE SIGNED	
				[REDACTED]		04/27/2020	
(Signature of person authorized to sign)				(Signature of Contracting Officer)			

The purpose of this contract modification is add Task 11 entitled, "Pin Power Reconstruction Method for PARCS Hexagonal Nodes in VVER Reactors," to the scope of work, thereby: 1) increasing the contract ceiling by \$138,000 from \$1,761,836.00 to \$1,899,836.00; 2) revising the PRICE SCHEDULE; 3) extending the period of performance by six months, from September 30, 2020 through March 31, 2021; and 4) revising Attachment A – PARCS SOW to add in Task 11. Accordingly, the contract is hereby modified as follows:

1. **Standard Form (SF) 26, Block 15G TOTAL AMOUNT OF CONTRACT**, is deleted in its entirety and replaced with the following:

"\$1,899,836.00"

2. Section **CONSIDERATION AND OBLIGATION - COST REIMBURSEMENT-NO FEE (AUG 2011) ALTERNATE I (AUG 2011)**, paragraph (a), is deleted in its entirety and replaced with the following:

"(a) The total estimated cost to the Government for full performance under this contract is \$1,899,836.00."

3. Section **PRICE SCHEDULE** is deleted in its entirety and replaced with the following:

ITEM NO.	DESCRIPTION OF SUPPLIES/SERVICES	ESTIMATED COST
00001	Support for the Purdue Advanced Reactor Core Simulator (PARCS) Code Suite	\$1,899,836.00
<b>Total Estimated Cost</b>		<b>\$1,899,836.00</b>

\*All travel must receive prior approval from the Contracting Officer's Representative (COR)

4. Section **NRCF030 PERIOD OF PERFORMANCE** is deleted in its entirety and replaced with the following:

"This contract shall commence on **October 1, 2015** and will expire on **March 31, 2021**.  
(End of Clause)"

5. **SECTION J – LIST OF DOCUMENTS, EXHIBITS, AND OTHER ATTACHMENTS, ATTACHMENT A – PARCS SOW**, is updated to add in Attachment 1 to this modification entitled, "Task 11 – Pin Power Reconstruction (PPR) Method for PARCS Hexagonal Nodes in VVER Reactors."

All other terms and conditions of the contract remain the same.

## **Additions to Section C.6 List of Services/Deliverables**

### **Task 11 – Pin Power Reconstruction (PPR) Method for PARCS Hexagonal Nodes in VVER Reactors**

The nodal methods used to perform the core solution do not directly provide the detailed fuel pin power information which can be important for the safety assessment of a core fuel loading. In most of the modern neutronics codes such as PARCS which employ advanced nodal methods, the pin power information is obtained through a pin power reconstruction or “dehomogenization” process. The terms reconstruction and dehomogenization arise from the fact that the neutron flux calculation performed in a nodal code is based on homogenized nodal cross sections so that the resulting intranodal flux distribution cannot reflect any local heterogeneity within an assembly. A reconstruction process is thus required to incorporate the actual heterogeneous structure of each assembly into the smoothly-varying intranodal flux distribution.

The pin power reconstruction process involves a fundamental assumption; that is, detailed pin-by-pin distributions within an assembly can be estimated by the product of a global intranodal distribution and a local heterogeneous form function. The form function accounts for assembly heterogeneities caused by water holes, burnable absorber pins, enrichment zonings, etc., and it is generated for each fuel assembly type by a lattice physics code at the same time when the homogenized nodal cross sections are generated.

A polynomial function expansion method for the hexagonal geometry will be developed that is consistent with the pin power reconstruction method currently used for the cartesian geometry in PARCS. Similar to the cartesian geometry, the axial variations of the flux are rather smooth for hexagonal assemblies, so it is assumed that the radial and axial dependences of the intranodal flux are separable and the pin power reconstruction method deals primarily with a 2D problem. The 2D intranodal flux distribution will be determined such that it is consistent with the neutron balance equation and it also satisfies the 2D neutron diffusion equation for the node. The pin power reconstruction capability will be developed and implemented for the current TPEN capability using full core, assembly centered geometry.

### **Summary of SubTasks and Deliverables**

**Subtask 11.1:** Derive and document the Hexagonal PPR equations that will be used for PARCS. The existing Hexagonal PPR method will be adapted to the existing TPEN nodal solver in the PARCS code system.

**Deliverable for Subtask 11.1:** Updated Draft Theory Manual – Chapter 7 of the Theory Manual will be updated with the adapted Hexagonal PPR method, specifically, the additional equation set to be solved.

The updated Theory Manual will be delivered to the COR **103 days** after task commencement.

**Subtask 11.2:** Implement the adapted Hexagonal PPR kernel into the PARCS code system.

The adapted Hexagonal PPR kernel will be implemented in the PARCS code system. The “Code system” will include the PARCS source code, and any associated updates to the

GenPMAXS source to support Hexagonal PPR to include user input flags and output edits. "Code system" will also include any new modules/source files, possible changes to the build system of both codes, and changes to the LaTeX documentation harness.

**Deliverable One for Subtask 11.2:** A draft **Software Design and Implementation Document (SDID)** which describes the implementation of the technical specifications and algorithms outlined in the SRS, i.e., how the software will be structured and designed will be developed which outlines how the Hexagonal PPR will be implemented into the PARCS code system. The SDID will outline any anticipated code changes and possible code restructuring.

The SDID will be delivered to the COR **152 days** after task commencement.

**Deliverable Two for Subtask 11.2:** Proposed verification tests will be included in a **draft Qualification Test Plan (QTP)**, to include model inputs outlining the numerical verification tests that will be used to demonstrate the proper implementation of the Hexagonal PPR method. Higher fidelity models will be used for numerical verification (i.e., any lattice transport code, fine mesh finite difference diffusion code, or Monte Carlo code).

The Qualification Test Plan (QTP) also referred to as the "test plan" in NUREG-1737.

The QTP will be developed consistent with NUREG-1737 which provides for a document describing how the implemented capability will be tested, i.e. the test problems which will be used to demonstrate the new capability.

The contractor shall deliver the draft QTP with the verification test models to the COR **201 days** after task commencement.

**Deliverable Three for Subtask 11.2:** A **Beta Version of the PARCS/GenPMAXS Code Distribution(s)** will be delivered to include the updated PARCS and GenPMAXS source codes (source distribution) which include the adapted PPR method.

The Beta PARCS/GenPMAXS build will be delivered to the COR **300 days** after task commencement. The distribution will include updates to the test suite from Deliverable Two.

**Deliverable Four for Subtask 11.2:** An **Updated Draft User Manual** with additional flags that are needed to activate the Hexagonal PPR calculation will be delivered. The manual will also demonstrate how to view the additional edits from the method through existing or new PARCS output files.

The updated Draft User Manual will be delivered to the COR **321 days** after task commencement.

**Subtask 11.3: Finalization of Subtasks 11.1 and 11.2 Work Products**

The work products that have been cumulatively delivered with Subtasks 11.1 through 11.2 will be finalized and delivered for subtask 11.3.

**Deliverable for Subtask 11.3:** The **Finalized Deliverables** will include the final revisions incorporating COR feedback on all documents and code deliverables associated with Subtasks 11.1 through 11.2.

The updated PARCS/GenPMAXS source distribution, test problems, theory/user manuals, the verification test problems, and SDID will be delivered to the COR **349 days** after task commencement.

**Additions to Section C.6.2 Table of Deliverables**

<b>Task #</b>	<b>Deliverable #</b>	<b>Deliverable</b>	<b>Deliverable Due Date</b>	<b>Acceptance Criteria</b>	<b>Deliverable Format</b>
11.1		Derivation and Documentation of Hexagonal PPR Equations within TPEN	Within 103 days of task commencement	Draft Theory Manual updated with needed equations, to the level of detail already present within the manual.  COR shall be able to brief NRC staff on basis of Hexagonal PPR from the Theory Manual	Transmitted via mechanism specified by COR
11.2	One	Draft SDID	Within 152 days of task commencement	The document outlines the anticipated code changes for Hexagonal PPR	Transmitted via mechanism specified by COR
11.2	Two	Draft QTP -- Proposed verification tests	Within 201 days of task commencement	Document should describe the higher fidelity benchmark models that serve to validate the implementation of the Hexagonal PPR algorithm	Transmitted via mechanism specified by COR
11.2	Three	Beta PARCS/GenPM	Within 300 days of task commencement	Distribution contains required content	Transmitted via mechanism

<b>Task #</b>	<b>Deliverable #</b>	<b>Deliverable</b>	<b>Deliverable Due Date</b>	<b>Acceptance Criteria</b>	<b>Deliverable Format</b>
		AXS Code Distribution(s)			specified by COR
11.2	Four	Updated Draft User Manual	Within 321 days of task commencement	Updated User Manual should have required changes needed to activate the calculation and viewing of Hexagonal PPR	Transmitted via mechanism specified by COR
11.3		Updated Cumulative Package (Revised Deliverables from Tasks 11.1 through 11.2)	Within 349 days of task commencement	All deliverables should be updated after COR feedback	Transmitted via mechanism specified by COR

### **Additions to Section C.7 Estimated Level-of-Effort (LOE)**

The effort level and staffing for the proposed work over a continuous 1-year effort is 1,136 staff hours. The estimated distribution of the effort for this task is broken down in the following table. The submitted budget provides a cost estimate consistent with this level of effort.

<b>LABOR CATEGORY</b>	<b>ESTIMATED LEVEL OF EFFORT</b>
Project Manager ( [REDACTED] )	[REDACTED]
Senior Engineer ( [REDACTED] )	[REDACTED]
Research Associate PARCS/GenPMAXS ( [REDACTED] )	[REDACTED]
Research Associate PARCS/GenPMAXS ( [REDACTED] )	[REDACTED]
<b>Total Level of Effort</b>	<b>1,136</b>