AD

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

005391

OCT 23 2000

Purdue Research Foundation
ATTN: Edie Doland
1063 Hovde Hall, Purdue University
West Lafayette, IN 47907-1063

Dear Ms. Doland:

SUBJECT: TASK ORDER NO. 8 MODIFICATION NO. 6 ENTITLED "IMPROVEMENTS TO PARCS" UNDER CONTRACT NO. NRC-04-97-046

In accordance with Section G.4, Task Order Procedures, of the subject contract, this letter definitizes Task Order No. 8 Modification No. 6. This effort shall be performed in accordance with the enclosed Statement of Work.

The period of performance for Task Order No. 8 is changed to run June 1, 1998 through November 30, 2001. The total estimated cost for full performance of this task order is increased by $228,954 from $268,908 to $497,862. Funds obligated to this task order are hereby increased by $35,000 from $268,908 to $303,908. The Contractor shall not incur costs for this task order which exceed the cumulative obligated amount of $303,908.

Accounting data for Task Order No. 8 Modification No. 6 is as follows:

B&R No.: 16015110135
Job Code: W-6749
BOC Code: 252A
RES ID: RES-C01-304
Appropriation No.: 31X0200
Obligated Amount This Action: $35,000
FY 98 Obligations: $59,654
FY 99 Obligations: $ 89,497
FY 00 Obligations $ 119,757
FY 01 Obligations $ 35,000
Cumulative Obligations: $303,908

The following individuals are considered by the Government to be essential to the successful performance of the work hereunder:

Thomas Downar

The contractor agrees that such personnel shall not be removed from the effort under this task order without compliance with Contract Clause H.2-Key Personnel

The issuance of this task order does not amend any terms or conditions of the subject contract.

Your contacts during the course of this task order are:

Technical Matters: James Han, Project Officer
(301) 415-6023

Contractual Matters: Stephen Pool, Contract Specialist
(301) 415-8168

Please indicate your acceptance of this task order by having an official, authorized to bind your organization, execute three copies of this document in the space provided and return two copies to the Contract Specialist. You should retain the third copy for your records.

Sincerely,

Stephen M. Pool, Contracting Officer
Division of Contracts and Property Management

Enclosure:
As stated

ACCEPTED: TASK ORDER NO. 8 MOD 6

By Peter E. Dunn

NAME

NOV 1 2000

DATE

Peter E. Dunn
Assistant Vice President for Research

TITLE

Statement of Work for Modification (No. 6) to Task Order #8, "Improvements to PARCS," under Contract #NRC-04-97-046 and Job Code W6749, "Thermal-Hydraulic Research"

Background Information

Task Order #8 provides improvements to the PARCS kinetics code, which will eventually become part of the consolidated TRAC-M code. Two kinds of improvements are needed – code functional improvements and code method improvements. Code functional improvements are to ensure that PARCS provides 1-D and 3-D kinetics analysis capabilities for both PWR and BWR cores with minimal user input requirements. Code method improvements are to remove the limitations in the accuracy of the current two-group, analytic nodal methods so that PARCS will provide accurate neutronics solutions for all current and anticipated light water reactor core fuel loadings including the use of MOX fuel.

Additional Work Requirements (for performance period of 10/1/00 - 11/31/01)

Add the following new Tasks 10 through 17 to the SOW. New Tasks 10 through 14 are for code functional improvements, and new Tasks 15 through 17 are for code method improvements.

Task 10. PWR 3D Kinetics for OECD MSLB Exercise 3

The spatial kinetics portion of the OECD MSLB Benchmark problem (Exercise 2) was funded under Modification 3 of Task Order #8. The thermal-hydraulic system portion of the Benchmark (Exercise 1) was performed by LANL. The integration of the spatial kinetics and system TH models (Exercise 3) was begun during the first quarter of FY2000. But problems were encountered in the systems model and were partially resolved. Further work is needed in collaboration with D. Barber of ISL. A report will be provided in both text and electronic format.

Estimated Level of Effort: 1 staff-month (for 10/1/00 - 11/30/00)
Estimated Completion Date: November 30, 2000

Task 11. BWR 3-D Kinetics for 3D MAPTAB

The automation of the MAPTAB generation for the BWR 3D kinetics is being completed and it will be tested using the Peach Bottom Turbine Trip Benchmark problem. Additional work is needed to modify the TDMR and the GI to accommodate the heat structure modification. Furthermore, the MAPTAB files for all the spatial kinetics test problems will be revised accordingly. An SQA document will be provided in both text and electronic format.

Estimated Level of Effort: 1 staff-month (for 10/1/00 - 11/30/00)
Estimated Completion Date: November 30, 2000

Task 12. PWR 3D Kinetics for Generalization of Cross Section Modeling

The overall cross section modeling in PARCS will be generalized to handle both polynomials and table look up formats. This will include the revision of the cross section input as described in subtask 1.17. An SQA document will be provided in both text and

electronic format.

Estimated Level of Effort: 1.5 staff-months
Estimated Completion Date: May 31, 2001

Task 13. PARCS Coding Improvements for Code Coupling Scheme

The TRAC-M thermal-hydraulics and the PARCS spatial kinetics calculation are currently explicitly coupled and advance at the same time step. A more advanced code coupling scheme needs to be developed in order to improve the code efficiency. This task involves the implementation of logic to activate the spatial kinetics calculation only when substantial variations in the core thermal-hydraulics conditions occur. The implementation will be tested with both the OECD MSLB and OECD Peach Bottom Turbine Trip benchmark problems. An SQA document will be provided in both text and electronic format.

Estimated Level of Effort: 1 staff-month
Estimated Completion Date: October 31, 2001

Task 14. QA and Testing for Test problem automation

Test problems will be consolidated for testing all the code functionality and will be executed using a script to automate the qualification of new code versions. The test problems will also demonstrate the code accuracy. The functionality described in Task 1.8 (Radial Discontinuity Factors) will also be included in one of the test problems as part of this task. An SQA document will be provided in both text and electronic format.

Estimated Level of Effort: 1.5 staff-months
Estimated Completion Date: November 30, 2001

Task 15. Multi-Group P1 Nonlinear Nodal Method

This task consists of five subtasks. Upon the completion of all subtasks, an SQA document will be provided in both text and electronic format.

Subtask 15.1 Multi-Group Nodal Diffusion Method

The transverse integrated Analytic Nodal Method (ANM) is the current industry standard for advanced nodal codes. ANM provides an accuracy which is required for LWR analysis, however this method is not easily adaptable to multiple energy groups and the work here will develop a pin by pin finite difference method that can be implemented within the framework of the nonlinear iteration technique. The method will be developed for both the steady state eigenvalue and for the transient fixed source problem.

Estimated Level of Effort: 1.5 staff-months (for 10/1/00 - 11/30/00)
2 staff-months (for 12/1/00 - 11/30/01)

Estimated Completion Date: February 15, 2001

Subtask 15.2 Implementation in the PARCS Code

The PARCS code is currently structured for two energy groups. The implementation of the

Multi-Group P1 method will require rewriting selected portions of the code and will require the development of some new subroutines.

Estimated Level of Effort: 2.5 staff-months
Estimated Completion Date: May 15, 2001

Subtask 15.3 Validation for a Steady-State Test Problem

The testing of the Multi-Group P1 method will first be performed for a steady-state (eigenvalue) test problem.

Estimated Level of Effort: 0.5 staff-month
Estimated Completion Date: May 31, 2001

Subtask 15.4 Validation for a Transient Test Problem

The testing of the Multi-Group P1 method will then be performed for a transient fixed source test problem.

Estimated Level of Effort: 1 staff-month
Estimated Completion Date: June 30, 2001

Subtask 15.5 Numerical Method

The computational burden in PARCS will increase with the multi-group, pin by pin method. The current preconditioned Krylov method in PARCS will provide a useful starting point for a more efficient numerical solution method. This subtask will be to develop and implement a numerical scheme that will provide reasonable execution times for practical transient problems.

Estimated Level of Effort: 1.5 staff-months
Estimated Completion Date: August 15, 2001

Task 16. Multi-Group P3 Nonlinear Nodal Method

This task consists of five subtasks. Upon the completion of all subtasks, an SQA document will be provided in both text and electronic format.

Subtask 16.1 Method Development

The P1 nonlinear nodal method to be developed under Task 15 will be extended to handle higher order transport by the development of a P3 transport kernel. The P3 kernel will be implemented within the framework of the pin by pin "one node" nonlinear nodal method. The method will be developed for both the steady state eigenvalue problem and for the transient fixed source problem. An adaptive algorithm will be developed in which the P3 kernel is only invoked when significant transport effects are present.

Estimated Level of Effort: 2.7 staff-months
Estimated Completion Date: February 28, 2001

Subtask 16.2 Implementation in PARCS

This subtask involves the implementation of the Multi-Group SP3 method in PARCS, and it will require additional routines and variables.

Estimated Level of Effort: 1.5 staff-months
Estimated Completion Date: April 15, 2001

Subtask 16.3 Validation for a Steady-State Test Problem

The testing of the multigroup P3 method will first be performed for a steady-state (eigenvalue) test problem.

Estimated Level of Effort: 1 staff-month
Estimated Completion Date: May 31, 2001

Subtask 16.4 Validation for a Transient Test Problem

The testing of the multigroup P1 method will then be performed for a transient fixed source test problem.

Estimated Level of Effort: 1 staff-month
Estimated Completion Date: June 30, 2001

Subtask 16.5 Numerical Methods

Since an additional equation is being solved with the P3 equations, it is anticipated that the computational burden in PARCS will significantly increase. The preconditioned Krylov method will provide be extended to develop the most efficient numerical solution schemes.

Estimated Level of Efforts: 1 staff-month
Estimated Completion Date: July 31, 2001

Task 17. Homogenization / Dehomogenization Methods

This task consists of four subtasks. Upon the completion of all subtasks, an SQA document will be provided in both text and electronic format.

Subtask 17.1 Steady State Homogenization

The single most important approximation in nodal methods for MOX fuel analysis is fuel assembly homogenization. By using explicit pin representation and multiple energy groups, the homogenization error should be significantly reduced for mixed MOX / UO2 core problems. This task will investigate in detail the number of energy groups and individual pin wise cross sections that must be used to provide the accuracy required.

Estimated Level of Effort: 2 staff-months
Estimated Completion Date: September 30, 2001

Subtask 17.2 Steady State Dehomogenization

One of the advantages of the one-node method is that the pin-wise fluxes and powers are

a natural part of the solution process and the traditional pin power reconstruction methods are not required. This subtask will verify the accuracy of the pin-wise powers for the steady-state solution.

Estimated Level of Effort: 1 staff-month
Estimated Completion Date: October 31, 2001

Subtask 17.3 Transient Homogenization

During a reactor transient, the core will undergo large variations in the flux/power shape and an additional level of complexity is introduced in cross section homogenization. This subtask will continue the work of a(1) above and specifically address homgenization methods that are appropriate for transient core conditions.

Estimated Level of Effort: 1 staff-month
Estimated Completion Date: September 30, 2001

Subtask 17.4 Transient Dehomogenization

The prediction of the pin-wise powers during a transient is one of the single most important results of a spatial kinetics calculation since it provides a direct input to the determination of core TH limits (e.g. DNBR, etc.). This subtask will continue the steady-state work of task with specific application to core transient analysis.

Estimated Level of Effort: 2 staff-months
Estimated Completion Date: November 30, 2001

Meetings and Travel:

The contractor will attend two meetings at the NRC office in Rockville, Maryland. For planning purpose, each meeting will involve two people and last for two days. The contractor will be also allowed to attend a domestic technical meeting sponsored by ANS, ASME, or other national organizations. However, any travel must be approved in advance by the NRC Technical Monitor.