ORDER FOR SUPPLIES OR SERVICES

IMPORTANT: Mark all packages and papers with contract and/or order numbers. BPA NO.

1. DATE OF ORDER: 09-16-2009
2. CONTRACT NO. (If any): NRC-04-07-094
3. ORDER NO.: **NRC TASK ORDER 007** MODIFICATION NO.
4. REQUISITION/REFERENCE NO.: 04-07-094T007 RES-C09-739 (FFS #)
5. ISSUING OFFICE (Address correspondence to)
U.S. Nuclear Regulatory Commission
Div. of Contracts
Attn: H. (Eddie) Colón, Jr.
Mail Stop TWB-01-010M
Washington, DC 20555

6. SHIP TO:
a. NAME OF CONSIGNEE: U.S. Nuclear Regulatory Commission
b. STREET ADDRESS: Office of Nuclear Regulatory Research
Attn: Andrew Ireland, MS: CSB-3A07M
c. CITY: Washington d. STATE: DC e. ZIP CODE: 20555
f. SHIP VIA

7. TO:
a. NAME OF CONTRACTOR: PURDUE UNIVERSITY
b. COMPANY NAME: ATTN: KENNETH W. SUTER
YOUNG HALL
c. STREET ADDRESS: 302 WOOD STREET
d. CITY: WEST LAFAYETTE e. STATE: IN f. ZIP CODE: 479072108

8. TYPE OF ORDER
[ ] a. PURCHASE
REFERENCE YOUR ____
Please furnish the following on the terms and conditions specified on both sides of this order and on the attached sheet, if any, including delivery as indicated.
[X] b. DELIVERY
Except for billing instructions on the reverse, this delivery order is subject to instructions contained on this side only of this form and is issued subject to the terms and conditions of the above-numbered contract.

9. ACCOUNTING AND APPROPRIATION DATA
96015111205 N6911 252A 31X0200.960
OBLIGATE: $20,000.00 (FFS Commitment #: RES-C09-739)
DUNS #: 072051394

10. REQUISITIONING OFFICE: RES
RES/DRASP/NRCA

11. BUSINESS CLASSIFICATION (Check appropriate box(es))
[ ] a. SMALL [X] b. OTHER THAN SMALL [ ] c. DISADVANTAGED [ ] g. SERVICE-DISABLED VETERAN-OWNED
[ ] d. WOMEN-OWNED [ ] e. HUBZone [ ] f. EMERGING SMALLBUSINESS

12. F.O.B. POINT: Destination

13. PLACE OF: a. INSPECTION b. ACCEPTANCE
14. GOVERNMENT B/L NO.
15. DELIVER TO F.O.B. POINT ON OR BEFORE (Date): As stated in SOW
16. DISCOUNT TERMS: NET 30

17. SCHEDULE (See reverse for Rejections)

ITEM NO. (a)	SUPPLIES OR SERVICES (b)	QUANTITY ORDERED (c)	UNIT (d)	UNIT PRICE (e)	AMOUNT (f)	QUANTITY ACCEPTED (g)
	TASK ORDER NO. 007 entitled **"TRACE IAT MODEL DEVELOPMENT"** under NRC ID/IQ Contract No. NRC-04-07-094 In accordance with Section G4, Task Order Procedures, this action definitizes TASK ORDER NO. 007. This effort shall be performed in accordance with the Statement of Work (Encl. 1) and the terms and conditions of Contract No. NRC-04-07-094. DUNS #: 072051394 TASK ORDER NO. 007 shall be effective October 1, 2009 through September 30, 2011 with a total cost ceiling of $213,117.00. Reference is made to your email proposal dated 8/31/2009 in response to this effort and Purdue SPS Development Number: 00022631.					

18. SHIPPING POINT
19. GROSS SHIPPING WEIGHT
20. INVOICE NO.
17(h) TOTAL (Cont. pages)

SEE BILLING INSTRUCTIONS ON REVERSE

21. MAIL INVOICE TO:
a. NAME: Department of Interior
National Business Center
b. STREET ADDRESS (or P.O. Box): Attn: Fiscal Services Branch - D2270
7301 W. Mansfield Avenue
c. CITY: Denver d. STATE: CO e. ZIP CODE: 80235-2230

17(i). GRAND TOTAL: OBLIGATED: $20,000.00

22. UNITED STATES OF AMERICA BY (Signature)
23. NAME (Typed): Heriberto Colón, Jr.
Contracting Officer
TITLE: CONTRACTING/ORDERING OFFICER

NRC-04-07-094 NRC TASK ORDER 007

A.1 CONSIDERATION AND OBLIGATION--TASK ORDER

(a) The total estimated amount of this Task Order (ceiling) for the products/services ordered, delivered, and accepted under this contract is [redacted].

(b) The amount presently obligated with respect to this Task Order is [redacted]. This obligated amount may be unilaterally increased from time to time by the Contracting Officer by written modification to this contract. The obligated amount shall, at no time, exceed the Task Order ceiling as specified in paragraph (a) above. When and if the amount(s) paid and payable to the Contractor hereunder shall equal the obligated amount, the Contractor shall not be obligated to continue performance of the work unless and until the Contracting Officer shall increase the amount obligated with respect to this contract. Any work undertaken by the Contractor in excess of the obligated amount specified above is done so at the Contractor's sole risk.

9/22/09

Mary Millsaps
Assistant Director, Sponsored Programs

STATEMENT OF WORK FOR **NRC TASK ORDER NO. 007** UNDER
CONTRACT NO. **NRC-04-07-094**

Contract Title:	**TRACE Interfacial Area Transport Model Development**
Contractor:	Purdue University, Thermal Hydraulics Institute (THI)
Principal Investigator:	Dr. Seungjin Kim, PSU
Period of Performance:	**10/01/2009 – 09/30/2011**
NRC project Manager(s):	Andrew Ireland, Tel. (301) 251-7553 Andrew.Ireland@nrc.gov

Purdue SPS Development Number: 00022631

I. BACKGROUND

The USNRC's system thermal-hydraulic analysis code TRACE (TRAC RELAP Advanced Computational Engine) is being developed to provide a best-estimate accident analysis capability for operating pressurized and boiling water reactors as wall as the next generation of evolutionary water reactor designs. To improve the numerical model for two-phase flow used by TRACE, the USNRC initiated the interfacial area transport (IAT) program. Recent and ongoing NRC sponsored research into IAT has produced data for a number important phenomena and conditions.

Interfacial area transport experiments in large diameter pipes have been conducted to simulate the void fraction in the chimney region of advanced boiling water reactor (BWR) designs, for example the ESBWR. Additional tests have simulated void fraction characteristics within rod bundles and the interfacial area transport within channels undergoing boiling and condensation. All of these tests have been conducted in response to a code modeling limitation discovered during code assessments. However, while a large IAT database now exists and additional data is being produced, little progress has been made to incorporate IAT models into the TRACE code. This Task Order will evaluate the IAT experimental database and develop models and correlations suitable for incorporation into TRACE. An interfacial area transport equation (IATE) will be implemented in a version of TRACE and assessed with a broad variety of cases.

This Scope of Work (SOW) outlines the tasks necessary to improve TRACE by developing and implementing interfacial area transport models. Evaluation of the existing IAT data will be done and a pilot code will be developed that will contain IATE models. This pilot code will be compared to the experimental data as well as the base TRACE code to show the difference between conventional treatment in a code such as TRACE and what can be obtained if an IATE is used. Recommendations for additional IAT experiments will also be developed in this Task Order that will be used in the creation of more focused experimental programs.

II. OBJECTIVES

The primary objectives of this Task Order are to:

1. Develop a pilot code for the prediction of IAT phenomena in simple upflow as well as transients and complex geometry.
2. Compare the current TRACE code to the IAT data and the pilot code.

3. Evaluate the available IAT data to determine the appropriate treatment of the IATE and to assess if additional IAT experiments need to be performed.

III. WORK REQUIREMENTS

This work consists of the five individual tasks. Tasks 1 and 4 involve development of a pilot IATE code and comparing that code to IAT experimental data. Task 2 entails comparison of the base TRACE code to the data and contrasting the results to the pilot code. Tasks 3 and 5 involve evaluating the existing experimental data and making recommendations for IATE treatment and additional experimentation.

The result of the five tasks will be an appropriate IATE model that is suitable for incorporation into the TRACE code. Therefore, thorough documentation of each task will be necessary for the eventual implementation of the IATE models into TRACE and the addition of the models into the TRACE Theory Manual. In addition, the evaluation of the available IAT data will be used in the creation of more focused experimental programs, so the investigations should be thorough and well documented.

Task 1: Pilot Code (TRACE Sub-version) Development

Using a one- or two-group model in a pilot code, the contractor shall demonstrate that source and sink terms behave reasonably in comparison to a simple experiment. The experiment can be bubbly flow in a tube in upflow. This pilot code can be the TRACE multiple bubble field code version developed by Schilling[1], or it can be based on a version of TRACE with additional fields activated.

Deliverables	Completion Date
Letter report on pilot code and comparisons with experimental data.	9 months after award

Task 2: Comparison of TRACE 5.0 to IAT Data

The contractor shall compare TRACE 5.0 to IAT data for the same experiment used in Task 1. Purpose is to show the difference between conventional treatment in a code such as TRACE and what can be obtained if an IATE is used. This Task should be performed concurrently with Task 1.

Deliverables	Completion Date
Letter report on TRACE 5.0 comparisons to data	10 months after award

[1] James W. Schilling, "An Implementation and Evaluation of a Dynamic Flow Regime Model for Dispersed Bubble Phases within the Computer Code TRACE," MS Thesis, The Pennsylvania State University, July 2007.

Task 3: Recommendations on the Treatment of the IATE

The contractor shall make a recommendation on implementation of a one-group or a full two-group treatment of IATE for near term versions of TRACE based on a review of existing data. The contractor shall determine if there is current data sufficient for a two-group model, what significant new experimentation need to be done for development of a two-group treatment.

Deliverables	**Completion Date**
Letter report on the available IAT data and the IATE treatment recommendation.	12 months after award

Task 4: Pilot Code Comparison to a Range of Cases

The contractor shall consolidate and debug the IATE model so that the pilot code can be compared against a broader range of test cases, including transients. The contractor shall devise a set of test problems to exercise the coding. These test problems should range from simple geometries to "mild" transients so that debugging is simplified. The objective of this Task is to produce an update that can incorporate the IATE into one of the latest versions on TRACE.

Some suggested assessment cases:

a. Bubbly flow in a pipe in downflow.
b. Bubbly flow in a horizontal pipe.
c. Bubbly flow in a horizontal pipe with an offtake. (A TEE with side pipes oriented vertical up, down, and sideways.)
d. Bubbly flow through an orifice. (Flow that sees a large area change resulting in a large pressure drop.)
e. Blowdown from a large tank. (How does the model behave during flashing?)
f. Single phase flow with heat addition sufficient to cause subcooled and saturated flow boiling.
g. Bubbly flow in rod bundle (Purdue tests).

Deliverables	**Completion Date**
Letter report on the comparison of the pilot code to the range of test cases.	18 months after award
Documentation of the IATE such that it can be incorporated into the TRACE Theory Manual.	20 months after award

Task 5: Review of Experimental Data

Following the developmental assessment in Task 4, the contractor shall review the available experimental data and the comparisons to data from the simulations. The review shall identify major problem areas in the assessments where additional information would be useful. The review of the data should consider the thermal-conditions, geometries, and results of existing tests and make recommendations on where new tests are necessary.

Deliverables	Completion Date
Letter report on the review of experimental data and recommendations for additional tests.	24 months after award

IV. 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 contractor to ensure that these quality criteria are adequately addressed throughout the course of the research that is performed. The NRC project manager and technical monitor will review all research products with these criteria in mind.

V. REPORTING REQUIREMENTS

1. Monthly Letter Status Report (MLSR)

A MLSR should be submitted to the NRC Project Manager by the 20th of the month following the month to be reported with copies provided to the following:

Project Manager (Andrew Ireland, Mail Stop C3-A07M)
Technical Monitor (Stephen M. Bajorek, Mail Stop C3-A07M)
Division Management Analyst, (TBD, Mail Stop)
Contracting Officer, (Mail Stop: TWB-01-010M)

The MLSR shall identify the title of the project, the job code, the Principal Investigator, the period of performance, the reporting period, summarize each month's technical progress, list monthly spending, total spending to date, and the remaining funds. Any administrative or technical difficulties which may affect the schedule or costs of the project shall be immediately brought to the attention of the NRC project manager.

VI. DELIVERABLES AND DELIVERY SCHEDULE

1. Letter report on pilot code and comparisons with experimental data (Task 1) to be delivered nine months following the award date.

2. Letter report on TRACE 5.0 comparisons to data (Task 2) to be delivered 10 months following the award date.

3. Letter report on the available IAT data and the IATE treatment recommendation (Task 3) to be delivered 12 months following the award date.

4. Letter report on the comparison of the pilot code to the range of test cases (Task 4) to be delivered 18 months after the award date.

5. Documentation of the IATE suitable for incorporation into the TRACE theory manual (Task 4) to be delivered 20 months following the award date.

6. Letter report on the review of experimental data and recommendations for additional tests (Task 5) to be delivered 24 months following the award date.

VII. MEETINGS AND TRAVEL REQUIREMENTS

For domestic travel, the contractor is expected to attend two annual meetings at the NRC in Rockville, MD, for research review. The trips will be of approximately two days duration. All trips have to obtain approval from the NRC project manager in advance.

VIII. PERIOD OF PERFORMANCE

The period of performance of this task order is **October 1, 2009 through September 30, 2011**.

IX. TECHNICAL DIRECTION

Technical direction will be provided by the NRC Project Manager:

Andrew Ireland
U.S. Nuclear Regulatory Commission
Mail Stop: C3-A07M
Washington, D.C. 20555-0001
Phone: (301) 251-7553
Fax: (301) 251-7436
Email: (Andrew.Ireland@nrc.gov)