Nuclear Energy University Program
Research Performance Progress Report

PROJECT TITLE: **(Project 15-8761) Computational and Experimental Benchmarking for Transient Fuel Testing**

Federal Grant / Cooperative Agreement Number (CID): **DE-NE0008441**

2nd Quarter FY2016 Report

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Signature of Submitting Official			

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Government Use Only:	
Project Number	15-8761
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Nuclear Energy University Program
Research Performance Progress Report - Accomplishments

WP Number:	NU-15-OR-OSU_-0701-01	Project Number:	15-8761	Project Title:	(Project 15-8761) Computational and Experimental Benchmarking for Transient Fuel Testing

1. ACCOMPLISHMENTS (Mandatory):

What was done? What was learned?

a. What are the major goals of the project?

Our integrated team has defined a work scope which will lead to the following objectives and outcomes:

• Objective 1 – A comprehensive evaluation of existing TREAT Facility neutronics data using the next generation reactor core neutronics codes. This will be performed in accordanc with established guidelines per the International Handbook of Evaluated Reactor Physics Benchmark Experiments (IRPhEP). Objective 1 will yield a fully characterized reactor core with dynamic input and feedback from the U.S. Nuclear Regulatory Commission (NRC) (via advisory board member participation) which may be utilized to support the safety case for the TREAT Facility restart.

• Objective 2 – A complete thermal hydraulic characterization of existing sodium loop experimental data will be performed and documented using American institute of Aerospace and Astronautics Association (AIAA) validation hierarchy paradigm. Objective 2 will result in a documented basis for developing future sodium flow loops to be utilized within the TREAT Facility; these bases will be created by the industry user that is planning on employing such flow loops within the TREAT Facility in the near future (TerraPower, LLC).

• Objective 3 – The collection of and benchmarking against new experimental thermal hydraulic data of a representative TREAT Facility water flow loop using the six guiding principles of good validation experiments identified by Oberkampf. The outcome of Objective 3 will yield a documented water flow loop design and demonstration that is representative of a prototypic configuration for the TREAT Facility to provide operational information and benchmarking data; and a fully benchmarked thermal hydraulic model of the water flow loop that may be utilized for future TREAT Facility water flow loop safety analyses.

• Objective 4 – A comprehensive instrumentation plan for the TREAT Facility that objectively aligns with the technical and functional requirements resulting from accomplishing Objective 1 and supplemented by Objectives 2 and 3. The result of Objective 4 will be a documented and demonstrated basis for the selection and arrangement of in-pile instruments within the TREAT Facility that satisfy the needs for both steady state and transient test conditions.

b. What was accomplished under these goals?

TASK 1

The objective of Task 1 is a comprehensive evaluation of the neutron physics data of the existing TREAT Facility using the next generation reactor core neutronics codes. The deliverable will be a neutronics benchmark based on TREAT in accordance with established guidelines per the International Handbook of Evaluated Reactor Physics Benchmark Experiments (IRPhEP), and a solution of the benchmark with the following three code systems: 1. U.S. NRC PARCS/AGREE code, 2. Monte Carlo Codes SERPENT, MCNP5, and OPENMC, 3. DOE / NEAMS PROTEUS Code. The following progress was made on this objective during the last month.

Task 1.1 - The focus of Task 1.1 during the previous quarter was on the development of a steady state neutronics benchmark of the TREAT Minimum Critical and M8CAL cores. During the quarter, a SERPENT model was completed for the Minimum Critical Core (MCC) with the SERPENT code and sensitivities were completed on the various modeling parameters identified by Bess et al. in “Baseline Assessment of TREAT for Modeling and Analysis Needs,” INL/EXT-15-35372. The key parameters were identified for the Minimum Critical Core and sensitivities were performed as shown in Table 1.

1. Boron contamination in the Fuel graphite
2. “Graphitization” of the Fuel graphite
3. Number of ZIRC clad dummy assemblies
4. Boron/Fe contamination in the Reflector graphite
5. ENDF/B library version

Case keff Diff (pcm)
Base:
5.9ppm Boron
59% Graphitization
ENDF/B-7.1
267ppm Fe
16 Zr Assemblies
1.01846±23pcm -
Changes from Base:
7.6ppm Boron
600 ppm Fe
1.00130±19pcm 1716
Changes from Base:
100% Graphitization
1.00394±23pcm 1452

c. What opportunities for training and professional development has the project provided?

UM graduate student Matt Neumann who has been performing TREAT calculations received summer internship to work with Jim Parry at TREAT. In-core instrumentation design and testing creates synergistic oppoprtunities between this IRP and ultrasonic sensor deveopment effort supported by INL's Nuclear Science User Facilities (NSUF). Collaboration between MIT and INL staff provide professional development opportunities for young research staff. OSU participated in the biannual Transient Testing Program Review at the INL which provided a 'big-picture' educational opportunity to confirm that this IRP's work compliments in the appropriate places and activities those efforts which are taking place within the Transient Testing Program.

d. How have the results been disseminated to communities of interest?

UM has coordinated a discussion on the TREAT Monte Calculations being performed at INL on the TREAT restart effort and at ANL on the TREAT LEU conversion effort. This has helped resolved some of the differences in the calculations. OSU collaborated and participated in the Biannual meeting for the IRP project led by Professor Corradini of the University of Wisconsin. This meeting was held at the Ohio State University and led to clear collaborative opportunities between Task 3 activities from this project and the work that Professor Corradini's team is doing.

e. What do you plan to do during the next reporting period to accomplish the goals?

The six month IRP review meeting will be held at UM and will be attended by personnel from 4 national laboratories (INL, ANL, ORNL, BNL), 4 universities (UM, OSU, UW, MIT), and the DOE and industrial partner, TerraPower. The OSU test loop will be completed in design and a review of the concept will take place with all Task 2.2 stakeholders to confirm that the loop's configuration feasibly satisfies the technical and functional requirements defined within the scope of work. The sodium loop benchmark problem description will be developed in draft form and destributed for review to all Task 2.1 stakeholders for input in its contents. Coordinate with UW-led IRP on TREAT instrumentation design efforts at the upcoming workshop to be hosted by University of Michigan.

Nuclear Energy University Program
Research Performance Progress Report - Products

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PRODUCTS: Mandatory

What has the project produced?

Publications are the characteristic product of research. Agencies evaluate what the publications demonstrate about the excellence and significance of the research and the efficacy with which the results are being communicated to colleagues, potential users, and the public, not the number of publications. Many projects (though not all) develop significant products other than publications. Agencies assess and report both publications and other products to Congress, communities of interest, and the public.

a. Publications, conference papers, and presentations

Nothing to Report

b. Website(s) or other Internet site(s)

The project website continues to be updated and maintained as the project evolves.

c. Technologies or techniques

Nothing to Report

d. Inventions, patent applications, and/or licenses

A new concept for an indirectly heated element has been developed by OSU and Harris Thermal Transfer Products which is presently going through a technology development review to identify whether it is appropriate for patent application issue.

e. Other products

Nothing to Report

Nuclear Energy University Program
Research Performance Progress Report - Participants

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Who has been involved?

Agencies need to know who has worked on the project to gauge and report performance in promoting partnerships and collaborations. The following information on participants must be provided:

Students (add or delete rows as needed)

First Name	Last Name	Project Role	Nearest Person Month	Expected Graduation Year	Organization	Citizenship	Major	Funding Support	Collaborated with Individual in foreign country?	Country of foreign collaborator	Travelled to foreign country?	Duration of stay	Contribution to the Project
Matt	Neumann	Graduate		2019		United States	Nuclear Engineering						Mr. Neumann has performed both Monte Carlo and deterministic calculations on the TREAT code.
Hunter	Smith	Graduate		2019		United States	Nuclear Engineering						Ms. Smith is performing the UQ analysis on TREAT
Thomas	Moore	Graduate		2017		United States	Nuclear Engineering						Mr. Moore has been assigned the task of performing computational tasks tied to the sodium loop benchmark work
Emory	Brown	Graduate		2019		United States	Nuclear Engineering						Mr. Brown is performing the design calculations to support the design of the water flow loop under Task 2.2
Nick	Kucynski	Graduate		2019		United States	Nuclear Engineering						

Collaborators (add or delete rows as needed)

First Name	Last Name	Nearest Person Month	Organization	Citizenship	Collaborated with Individual in foreign country?	Country of foreign collaborator	Travelled to foreign country?	Duration of stay	Contribution to the Project
Volkan	Seker			Turkey					Dr. Seker is assisting in supervising the students and performing calculations
Thomas	Downar			United States					Dr. Downar is the Organization Lead at the University of Michigan
Bill	Martin			United States					Dr. Martin is the Task Lead on Task 1.2
Brian	Woods			United States					Dr. Woods is the Task Lead on Task 2.1
Lin-wen	Hu			United States					MIT Principal investigator- Overseeing workat MIT including neutronics code benchmark as part of Objective 1 and Objective 4 In-core irradiaitons a
David	Carpenter			United States					Leading work as part of Objective 4 - In-core irradiaitons at the MIT reactor and development of the TREAT in-core insturmentation plan.
Kaichao	Sun			China					Leading the experimental sub-tasks in Objective 4 and delivering steady-state Monte Carlo solutions in Objective 1.

Organizations (add or delete rows as needed)

Organization Name	Location	Contribution to the Project					More Detail on Partner and Contribtion
		Financial Support?	In-Kind Support?	Facilities?	Collaborative Research?	Personnel Exchanges?	
Oregon State University	Corvallis, OR	Yes		Yes			Project and Task 2 Lead Organization
University of Michigan	Ann Arbor, MI	Yes		Yes			Task 1 Lead Organization
Massachusetts Institute of Technology	Cambridge, MA	Yes		Yes			Task 3 Lead Organization
Idaho National Laboratory	Idaho Falls, ID	Yes		Yes			Collaborating on Tasks 1, 2, and 3
Argonne National Laboratory	Argonne, IL	Yes					Collaborating on Task 1
Oak Ridge National Laboratory	Oak Ridge, TN	Yes					Collaborating on Task 2
Harris Thermal Transfer Products	Newberg, OR	Yes					Collaborating on Task 2
TerraPower, LLC	Bellevue, WA		Yes				Collaborating on Task 2

Nuclear Energy University Program
Research Performance Progress Report - Impacts

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IMPACT: Mandatory

What is the impact of the project? How has it contributed?

a. What is the impact on the development of the principal discipline(s) of the project?

A clear benchmark problem which is thoroughly detailed, using state-of-the-art codes will provide both immediate and future benefit for reactor physicists who which to benchmark their codes.

The development of a water flow loop and the resulting data will produce data which will be readily used to improve future in-pile experiments placed within the TREAT Facility.

Work towards the development of an integrated plan for the deployment of instrumentation in TREAT will benefit all users of the reactor.

b. What is the impact on other disciplines?

An improvement to our mechanistic understanding of a tightly coupled nuclear reactor system, such as the TREAT Facility extends fundmantel science through expansions in math theorey and a variety of other attributes.

c. What is the impact on the development of human resources?

Large integrated programs such as this project, bring multiple institutions together and create excitement within the community. This is explicitly shown through the contributions of graduate students who are contributing to the project. Additionally, several students who are funded on this IRP during the academic year are spending their summer internships at the INL and specifically working on the TREAT project.

d. What is the impact on physical, institutional, and information resources that form infrastructure?

The project supports activities on computer clusters and laboratory spaces, it supports the MIT Research Reactor, and a new experiment at OSU.

e. What is the impact on technology transfer?

Significant progress has already been made regaurding previously developed technology and the discimination of this information from one collaborating institution to another. This integrated project enables these activities in an ideal setting.

f. What is the impact on society beyond science and technology?

A better understanding of the TREAT Facility through the outcomes accomplished from within this contract will enable its restart in a high-impact and more efficient manner. Furthermore, the design of future experiments may be improved as well.

g. What dollar amount of the award's budget is being spent in foreign country(ies)?

Zero Dollars

Nuclear Energy University Program
Research Performance Progress Report - Changes/Problems

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CHANGES/PROBLEM: Mandatory

The PI is reminded that the grantee is required to obtain prior written approval from the Contracting Officer whenever there are significant changes in the project or its direction. Requests for prior written approval must be submitted to the Contracting Officer (submission via Fedconnect is acceptable). If not previously reported in writing, provide the following additional information, if applicable: Changes in approach and reasons for change; Actual or anticipated problems or delays and actions or plans to resolve them; Changes that have a significant impact on expenditures; Significant changes in use or care of animals, human subjects, and/or biohazards.

a. Changes in approach and reasons for change

Nothing to Report

b. Actual or anticipated problems or delays and actions or plans to resolve them

Continued efforts to acquire documentation from Argonne National Laboratory were found to be unsuccessful. This required the engagement of this project's program manager at the DoE level to attempt to engage the appropriate individuals for access to information. The response provided by ANL was a willingness to collaborate and provide documentation, however, this was at a cost of $40K. The large cost associated with transfering Department of Energy documents from one BEA laboratory to another far exceeded the available fiscal resources of this project's budget and therefore required a complete re-evaluation of appropriate to satisfying task outcomes within Task 2.1. After a further survey effort of documents within the INL, it was found that there are a number of Hanford Engineering and Development Laboratory tests that will provide sufficient detail to successfully accomplish all scope of work detailed within Task 2.1. Because of the lack of communication between Argonne National Laboratory and the IRP Team, Task 2.1 has fallen slightly behind schedule, however a path-to-success has been developed and implemented to make-up for the lost time.

c. Changes that have a significant impact on expenditures

Nothing to Report

d. Significant changes in use or care of human subjects, vertebrate animals, and/or Biohazards

Nothing to Report

e. Change of primary performance site location from that originally proposed

Nothing to Report

Nuclear Energy University Program
Research Performance Progress Report - Cost and Schedule Status

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Milestone Status Chart

Milestone / Activity	Status	Total Budget	Start Date	Finish Date	% Comp	Revised Finish Date	Actual Finish Date	Narrative
Final Report	On Schedule	$0	10/1/2015	12/29/2018	0%			
Submission of SS Benchmark for Peer Review	On Schedule	$360,000	10/1/2015	9/30/2016	50%			
Submission of TR Benchmark for Peer Review	On Schedule	$700,000	10/1/2016	9/30/2018	0%			
Organize and Document Data for Two Candidate TH Sodium Loop Benchmark Problems	Expected Late	$100,214	10/1/2015	3/30/2016	75%	9/30/2016		Delays in acquiring information associate
Submission of TH Sodium Loop Benchmark for Peer Review	On Schedule	$473,118	4/1/2016	9/30/2018	0%			
Submission of TH Water Loop Benchmark for Peer Review	On Schedule	$1,396,668	10/1/2015	9/30/2018	14%			
Develop TREAT Core Instrumentation Plan	On Schedule	$337,992	10/1/2015	9/30/2016	48%			
Submission of Detailed Final Instrumentation Report	On Schedule	$632,008	10/1/2016	9/30/2018				
0	On Schedule	$0	1/0/1900	1/0/1900	0%			
0	On Schedule	$0	1/0/1900	1/0/1900	0%			
0	On Schedule	$0	1/0/1900	1/0/1900	0%			
0	On Schedule	$0	1/0/1900	1/0/1900	0%			
0	On Schedule	$0	1/0/1900	1/0/1900	0%			
0	On Schedule	$0	1/0/1900	1/0/1900	0%			
0	On Schedule	$0	1/0/1900	1/0/1900	0%			
0	On Schedule	$0	1/0/1900	1/0/1900	0%			
0	On Schedule	$0	1/0/1900	1/0/1900	0%			
0	On Schedule	$0	1/0/1900	1/0/1900	0%			

Funding and Cost Status

Total Available (BAC)		Uncosted $
$4,000,000		$3,876,650
Cumulative Planned Value	**Cumulative Value Earned**	**Cumulative Actual Cost**
$4,000,000	$643,706	$123,350

Cost Variance

FY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Cumulative Value Earned													
2016			$321,852			$643,706			$0			$0	$643,706
2017			$0			$0			$0			$0	$0
2018			$0			$0			$0			$0	$0
2019			$0			$0			$0			$0	$0
Cumulative Actual Costs													
2016			$39,774			$123,350			$0			$0	$123,350
2017			$0			$0			$0			$0	$0
2018			$0			$0			$0			$0	$0
2019			$0			$0			$0			$0	$0
Cost Variance													
2016			$282,078			$520,356			$0			$0	$520,356
2017			$0			$0			$0			$0	$0
2018			$0			$0			$0			$0	$0
2019			$0			$0			$0			$0	$0
Cost Variance %													
2016			88%			81%			0%			0%	81%
2017			0%			0%			0%			0%	0%
2018			0%			0%			0%			0%	0%
2019			0%			0%			0%			0%	0%

Cost Variance Explanation:

Ramp-up in work, has led to a slower spend-down rate than initially anticipated, however the spend-down rate will increase slightly over quarter 4 of year 1 and make-up for this reduced initial rate.