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**

4th Quarter FY2016 Report

Report Submitted to	DOE-NE	**Submission Date**	10/30/2016
DUNS Number	53599908	**Reporting Period End Month**	Sep FY16
Principal Investigator	Wade Marcum	**PI E-mail**	marcumw@onid.orst.edu
PI Title	Associate Professor	**PI Phone**	541.737.3018
Name of Submitting Official		**E-mail**	
Submitting Official Title		**Phone**	
Recipient Organization	Oregon State University		
Recipient Address	B308 Kerr Administration Building; Oregon State University; Corvallis OR 97331		
Project Start Date	10/1/2015		
Project End Date	9/30/2018		
Signature of Submitting Official			

Submit to INRREPORTS@INL.GOV and psdrept@id.doe.gov
Message Subject Line: DE-NE0008441, 4th Quarter FY2016 Report.

Government Use Only:	
Project Number	15-8761
Work Package ID	NU-15-OR-OSU_-0701-01

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?

1. The Steady-state TREAT benchmark was submitted on time. The original plan was for two benchmark cores, but in order to accommodate a wider range of available measured data a third core was added to the benchmark specifications.
2. All Monte Carlo calculations were completed. Deterministic calculations on M8CAL with PARCS and PROTEUS are awaiting modifications to the cross section generation code and additional computing resources, respectively.
3. Completed the TREAT Instrumentation Plan.

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

1) New devices such as MPFDs and fiber optic probes may enable real-time, local measurement of flux and temperature with reliability and spatial resolution around the TREAT experimental positions that was previously not possible.
2) This enhanced capability benefits general the reactor operations as well as the experimentalists and modelers by giving a more complete reconstruction of the in-core environment during steady-state and transient operation.

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

1) Teleconferences between MIT and INL/TREAT research staff to communicate our plans and receive direct feedback on TREAT Instrumentation Plan.

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

1. Objective 1 activities will be focused on –
a. Complete deterministic calculations with PARCS and PROTEUS.
b. Continue development of transient models for the cores used in the steady-state benchmark to support the transient benchmark analysis which comprises the scope of work during years 2 and 3 of this project.
2. Coordinate with INL for reviewing TREAT Instrumentation Plan and refine the recommendations and incorporate their comments

Nuclear Energy University Program
Research Performance Progress Report - Products

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

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

Three papers submitted for the ANS International Mathematics and Computation conference to be held in South Korea, April, 2017:

1. “Calculation of TREAT Minimum Critical and M8CAL Core Benchmarks with SERPENT,” Volkan Seker, Matt Neumann, Hunter Smith, Thomas Downar
2. “Uncertainty Analysis of the TREAT Minimum Critical Core”, Haining Zhou, T. Downar
3. ”Sensitivity Analysis Technique of Non-linear Problems Based on Fourier Analysis,” Haining Zhou, Thomas Downar

4. D. Carpenter and L. Hu, TREAT Core Instrumentation Plan, September, 2016, MIT Nuclear Reactor Laboratory

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

The project website continues to be updated and maintained as the project evolves. It may be found at the following: http://research.engr.oregonstate.edu/treat-irp/. The site now includes all published information provided and presented during the first biannual meeting. Website for the Annual Meeting hosted at MIT: https://treat16.mit.edu/

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

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

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
Haining	Zhou	Graduate	12	2019	University of Michigan	United States	Nuclear Engineering						Uncertainty Quantification
Hunger Smith		Graduate	4	2019	University of Michigan	United States	Nuclear Engineering						Neutronic Modeling and Analysis
Nick	Kucynski	Graduate	4	2019	University of Michigan	United States	Nuclear Engineering						Benchmark Specifications Preparation
Thomas	Moore	Graduate	12	2017	Oregon State University	United States	Nuclear Engineering						performing computational tasks tied to the sodium loop benchmark work
Emory	Brown	Graduate	12	2019	Oregon State University	United States	Nuclear Engineering						performing the design calculations to support the design of the water flow

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	5	University of Michigan	Turkey					Dr. Seker is assisting in supervising the students and performing calculations
Thomas	Downar		University of Michigan	United States					Dr. Downar is the Organization Lead at the University of Michigan
Bill	Martin		University of Michigan	United States					Dr. Martin is the Task Lead on Task 1.2
Scott	Wildeman	3	University of Michigan	United States					Neutronics Methods Development
Brian	Woods	2	Oregon State University	United States					Dr. Woods is the Task Lead on Task 2.1
Wade	Marcum	2	Oregon State University	United States					Dr. Marcum serves as the PI for this IRP
Lin-wen	Hu	3	Massachussetts Institute of	United States					MIT Principal investigator- Overseeing workat MIT including neutronics code benchmark as part of Objective 1 and Objective 4 In-core irradiaitons at
David	Carpenter	3	Massachussetts Institute of	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	3	Massachussetts Institute of	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

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

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

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

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

The issuance of contracts for all subcontractors was delayed during the first quarter of FY16. This delay resulted in a delay in billing and expenditures. While all organizations have maintained a very proactive effort to remain timely in their deliverables, small delays in all respective tasks have resulted in a large total sum in delayed expenditures project-wide. This results in a request for carry-over into the next fiscal year for all organizations which will be necessary in order to satisfy the objectives and fulfill the commitments made within the scope of work over the three year project period.

c. Changes that have a significant impact on expenditures

No direct changes have been made during this previous quarter, however, as discussed above, a cumulative delay in the expenditure of this contract has led to the impact of total encumbrances during the first project fiscal year, which will be requested and necessary to be carried-over into the second fiscal year of this project.

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

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

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	UPDATE NEEDED	$360,000	10/1/2015	9/30/2016	100%		9/30/2016	*If complete, please send deliverable with your quarterly report.
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	UPDATE NEEDED	$100,214	10/1/2015	3/30/2016	90%	11/30/2016		*If complete, please send deliverable with your quarterly report.
Submission of TH Sodium Loop Benchmark for Peer Review	On Schedule	$473,118	4/1/2016	9/30/2018	21%			
Submission of TH Water Loop Benchmark for Peer Review	On Schedule	$1,396,668	10/1/2015	9/30/2018	28%			
Develop TREAT Core Instrumentation Plan	UPDATE NEEDED	$337,992	10/1/2015	9/30/2016	100%		9/30/2016	*If complete, please send deliverable with your quarterly report.
Submission of Detailed Final Instrumentation Report	On Schedule	$632,008	10/1/2016	9/30/2018	0%			

Funding and Cost Status

Total Available (BAC)		Uncosted $
$4,000,000		$3,489,259
Cumulative Planned Value	**Cumulative Value Earned**	**Cumulative Actual Cost**
$4,000,000	$1,277,395	$510,741

Cost Variance

FY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Cumulative Value Earned													
2016			$321,852			$618,653			$940,508			########	$1,277,395
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			$248,880			$510,741	$510,741
2017			$0			$0			$0			$0	$0
2018			$0			$0			$0			$0	$0
2019			$0			$0			$0			$0	$0
Cost Variance													
2016			$282,078			$495,303			$691,628			$766,654	$766,654
2017			$0			$0			$0			$0	$0
2018			$0			$0			$0			$0	$0
2019			$0			$0			$0			$0	$0
Cost Variance %													
2016			88%			80%			74%			60%	60%
2017			0%			0%			0%			0%	0%
2018			0%			0%			0%			0%	0%
2019			0%			0%			0%			0%	0%

Cost Variance Explanation:

There are several primary references for the present perception of underspent funds, however all funds have been encumbered and will be billed within the near out-months. The primary contributes attribute to (1) The hardware procured by Harris Thermal Transfer products was just recently made and will show up on the next few months invoices. this will expend a substantial amount of their respective subcontract on this project; (2) OSU has salary allocated for the post-doc. during the first year of the project a search was conducted for the post-doctoral research assistant. A hire was just made with a start-date of October 24, 2016 and will begin to expend this funding, (3) an adjustement to the contract line-items was made to enable electrical upgrades in the high-bay building that will house the experimental facility for Task 2.2, these will be encumbered in the next quarter, and (4) a subcontract is presently being executed to support the experimental facility under Task 2.2 for control system.