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: **DE-NE0008441**

1st Quarter FY2016 Report

Report Submitted to	DOE-NE	**Submission Date**	1/30/2016
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Project Start Date	10/2/2015		
Project End Date	10/1/2018		
Signature of Submitting Official			

Submit to INRREPORTS@INL.GOV and psdrept@id.doe.gov
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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?

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. SERPENT Monte Carlo Code, 3. DOE / NEAMS PROTEUS Code. The following progress was made on this objective during the first quarter of the project.

Task 1.1 - The focus of Task 1.1 was on the development of a steady state neutronics benchmark of the TREAT Minimum Critical and M8CAL cores. The initial effort was focused on building a Monte Carlo model of the Minimum Critical core with the SERPENT code and examining the sensitivity of the solution to the various modeling parameters identified by Bess et al. in “Baseline Assessment of TREAT for Modeling and Analysis Needs,” INL/EXT-15-35372. Consistent with the conclusions in the Bess report for their infinite plate study, a strong sensitivity of the k-eff was observed to several of the uncertain modeling parameters. The following specific conclusions were observed for the Minimum Critical Core:

1. Boron contamination in the Fuel graphite - If the boron contamination in the fuel graphite is assumed to be 7.6ppm which is consistent with the original specifications in ANL-6115 by Iskendarian, 1960, then the k-eff of the core is very close to critical (k-eff = 1.00125). However, if the boron contamination is reduced to 5.9 ppm as specified in the 2015 Bess report then the core calculation is observed to be significantly supercritical (k-eff = 1.01800)

2. ZIRC clad dummy assemblies - In the minimum critical core there was uncertainty as to the number of Zr-clad reflector assemblies which were used in the outer region adjacent to the core. The difference between all 40 assemblies being Zr clad and none of the assemblies being Zr clad is about 800 pcm in the Monte Carlo k-eff of the core.

3. Fuel Graphitization - The core k-eff is very sensitive to the percentage of fuel that has been graphitized. The difference between assuming 100% of the fuel is graphitized compared to the 59% recommended in the Bess report is about 1500 pcm in the Monte Carlo k-eff of the core.

4. Boron/Fe contamination in the Reflector graphite - The core k-eff is also very sensitive to the contamination of the reflector graphite. The difference between assuming a 1ppm and 2ppm contamination is about 600pcm in the Monte Carlo k-eff of the core.

There were smaller sensitivities in other modeling parameters consistent with those reported in the Bess report. The plans during the next month will be to complete the sensitivity studies on the 3-D Monte Carlo models to finalize a “reference” core condition of the Minimum Critical Core and to complete the UQ analysis with the DAKOTA code. The same procedure will then be used on the M8CAL core.

Other activities on Task 1.1 were related to the development of the deterministic models of TREAT using the PARCS code at UM and the PROTEUS code by C. Lee at ANL. Progress has been made on both of these modeling efforts.

Task 1.2 – Some preliminary work was performed on Task 1.2 at UM related to the development of a transient neutronics benchmark of TREAT. Efforts by W. Martin were directed

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

A project kickoff meeting was held at the Idaho National Laboratory which provided a highly collaborative opportunity for all participants to learn about the past-, present-, and future direction of the TREAT Facility.

Collaboration with INL staff and TREAT site visit have enhanced understanding of a unique US irradiation capability, and initiated plans for additional professional collaboration and proposals for future work.

Collaboration with UM and ANL on neutronic benchmark study has extended the knowledge preparation in a comprehensive manner.

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

While preliminary results are being shared among collaborating institusions with respect to the accomplishments made within each task, no formal techanical presentation of information was made to the public community.

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

Continue to further expand upon the reactor physics benchmark analysis for the steady state cases.

Complete a one-line design of the water flow loop concept and have supporting design basis calculations for this design.

Develop sufficient detail and literature to begin the computational benchmark for the sodium flow loop.

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 has been published to the internet: http://research.engr.oregonstate.edu/treat-irp/

c. Technologies or techniques

Nothing to Report

d. Inventions, patent applications, and/or licenses

Nothing to Report

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:

Participants (add or delete rows as needed)

First Name	Last Name	Project Role	Nearest Person Month	Citizenship	Major	Contribution to the Project	Funding Support	Collaborated with Individual in foreign county?	Country of foreign collaborator	Travelled to foreign country	Duration of stay
Matt	Neumann	Graduate	3	United States	Nuclear Engineering	Mr. Neumann has performed both Monte Carlo and deterministic calculations on the TREAT code.	IRP Project	No		No	
Haining	Zhong	Graduate	3	United States	Nuclear Engineering	Ms. Zhong is performing the UQ analysis on TREAT	IRP Project	No		No	
Volkan	Seker	Collaborator	3	Turkey	Nuclear Engineering	Dr. Seker is assisting in supervising the students and performing calculations	IRP Project	No		No	
Thomas	Downar	Collaborator	3	United States	Nuclear Engineering	Dr. Downar is the Organization Lead at the University of Michigan	UM	No		No	
Bill	Martin	Collaborator	3	United States	Nuclear Engineering	Dr. Martin is the Task Lead on Task 1.2	UM	No		No	
Wade	Marcum	Collaborator	3	United States	Nuclear Engineering	Dr. Marcum is the Principal Investigator of the IRP Project	OSU	No		No	
Brian	Woods	Collaborator	3	United States	Nuclear Engineering	Dr. Woods is the Task Lead on Task 2.1	OSU	No		No	
Thomas	Moore	Graduate	3	United States	Nuclear Engineering	Mr. Moore has been assigned the task of performing computational tasks tied to the sodium loop benchmark work	OSU	No		No	
Emory	Brown	Graduate	3	United States	Nuclear Engineering	Mr. Brown is performing the design calculations to support the design of the water flow loop under Task 2.2	OSU	No		No	
Lin-wen	Hu	Collaborator	3	United States	Nuclear Engineering	MIT Principal investigator- Overseeing workat MIT including neutronics code benchmark as part of Objective 1 and Objective 4 In-core irradiaitons at the MIT reactor and development of the TREAT in-core insturmentation plan.	IRP	No		No	
David	Carpenter	Collaborator	3	United States	Nuclear Engineering	Leading work as part of Objective 4 - In-core irradiaitons at the MIT reactor and development of the TREAT in-core insturmentation plan.	IRP	No		No	
Kaichao	Sun	Collaborator	3	China	Nuclear Engineering	Leading the experimental sub-tasks in Objective 4 and delivering steady-state Monte Carlo solutions in Objective 1.	IRP	No		No	

Organizations (add or delete rows as needed)

Organization Name	Location	Partner's Contribution to the Project	Financial Support	In-kind Support	Facilities	Collaborative Research	Personnel Exchanges	More Detail on Partner and Contribtion
Oregon State University	Corvallis, OR	Project and Task 2 Lead Organization	$1,420,000	$0				
University of Michigan	Ann Arbor, MI	Task 1 Lead Organization	$880,000	$0				
Massachusetts Institute of Technology	Cambridge, MA	Task 3 Lead Organization	$880,000	$0				
Idaho National Laboratory	Idaho Falls, ID	Collaborating on Tasks 1, 2, and 3	$180,000	$0	TREAT Facility			
Argonne National Laboratory	Argonne, IL	Collaborating on Task 1	$180,000	$0				
Oak Ridge National Laboratory	Oak Ridge, TN	Collaborating on Task 2	$100,000	$0				
Harris Thermal Transfer Products	Newberg, OR	Collaborating on Task 2	$360,000	$0				
TerraPower, LLC	Bellevue, WA	Collaborating on Task 2	$0	$439,000				

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.

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

The dissemination of information from Argonne National Laboratory regarding the detail of previous sodium loop tests performed in the TREAT Facility has been much slower and drawn out than origionally anticipated or initially lead on.

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 Fin
Final Report	On Schedule	$0		12/29/2018	0%		
Submission of SS Benchmark for Peer Review	On Schedule	$360,000		9/30/2016	25%		
Submission of TR Benchmark for Peer Review	On Schedule	$700,000		9/30/2018	0%		
Organize and Document Data for Two Candidate TH Sodium Loop Benchmark Problems	On Schedule	$100,214		3/30/2016	50%		
Submission of TH Sodium Loop Benchmark for Peer Review	On Schedule	$473,118		9/30/2018	0%		
Submission of TH Water Loop Benchmark for Peer Review	On Schedule	$1,396,668		9/30/2018	7%		
Develop TREAT Core Instrumentation Plan	On Schedule	$337,992		9/30/2016	10%		
Submission of Detailed Final Instrumentation Report	On Schedule	$632,008		9/30/2018	0%		
0	On Schedule	$0		1/0/1900	0%		
0	On Schedule	$0		1/0/1900	0%		
0	On Schedule	$0		1/0/1900	0%		
0	On Schedule	$0		1/0/1900	0%		
0	On Schedule	$0		1/0/1900	0%		
0	On Schedule	$0		1/0/1900	0%		
0	On Schedule	$0		1/0/1900	0%		

Funding and Cost Status

Total Available (BAC)		Uncosted $
$4,000,000		$3,960,226
Cumulative Planned Value	**Cumulative Value Earned**	**Cumulative Actual Cost**
$0	$321,852	$39,774

Cost Variance

FY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Tot
Cumulative Value Earned													
2016			$321,852			$0			$0			$0	
2017			$0			$0			$0			$0	
2018			$0			$0			$0			$0	
2019			$0			$0			$0			$0	
Cumulative Actual Costs													
2016			$39,774			$0			$0			$0	
2017			$0			$0			$0			$0	
2018			$0			$0			$0			$0	
2019			$0			$0			$0			$0	
Cost Variance													
2016			$282,078			$0			$0			$0	
2017			$0			$0			$0			$0	
2018			$0			$0			$0			$0	
2019			$0			$0			$0			$0	
Cost Variance %													
2016			88%			0%			0%			0%	
2017			0%			0%			0%			0%	
2018			0%			0%			0%			0%	
2019			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 slight quarter 4 of year 1 and make-up for this reduced initial rate.