IGEM Grant Report

☐ Progress (due Jan. 1)   ☑ Annual (due Jul. 31)   ☐ (due Aug. 31)

IGEM Grant #23-001   Principal Investigator – Prof. Michael Haney

Submission Date – 2023.07.31   Primary Institution – University of Idaho

Library of Reconfigurable Immersive Attack and Defend Scenarios for Cybersecurity Research and Workforce Development

Section 1: Summary of project accomplishments for the reporting period and plans for the upcoming reporting period.

- Built a new Reconfigurable Attack-Defend Instructional Computing Laboratory (RADICL) at the University Place campus in Idaho Falls. This novel, immersive environment is integrating physical processes, full-scale enterprise IT systems, and Internet-scale cyber-attacks on-demand to offer researchers, students, and trainees a controlled live-fire environment like no other currently available. The laboratory will be a hybrid virtual and physical environment allowing access from across the state through the Idaho Cyber Range.

- Development began of the laboratory focused on power system communication and control systems. We have expanded our relationships with industry partners, including Schweitzer Engineering Laboratories, Westinghouse (now WESCO), Datacast Technologies, and Edge Velocity to begin integrating their technologies into the laboratory. This includes significant donations from the vendors to complement Idaho's investments through the HERC IGEM program. We have also used matching funds provided by the university to procure the real-time digital grid simulator and have begun initializing it.

- Produced four journal publications, five conference papers, and used our expertise to deliver a report to the U.S. House of Representatives regarding the cybersecurity of the electric distribution system, to be made public in the coming months. We have also submitted five additional funding proposals based on the preliminary research performed in the laboratory, including to DOE Cybersecurity, Energy Security and Emergency Response (CESER) for nearly $3mil. We have also been successful in securing an additional $100,000 per year from our partnership with the INL for our work in the lab focused on grid data transport and security.

- Introduced a framework for effectively and quickly detecting malicious USB peripherals in the Cyber-Human-Physical Systems (CHiPS) lab. This research aims to provide authentication for USB devices, to detect and prevent USB-laden attacks. The proposed solution adopts side-channel analysis as its core analysis methodology.

- Began using the new RADICL spaces and equipment to train college students, active professionals, and high school students and teachers in an immersive research environment. Hosted events include the first Idaho Cyber Range Day in April 2023, Computing, Programming, and Engineering merit badges offered to a local Scouting troop, and the Cybercore Advanced Day Camp.

Publications

(1) Taegan Williams, Tiffany Fuhrmann, and Michael Haney (2022), "Low-cost CTF Platform for Industrial Control Systems Education," 26th Colloquium for Information Systems Security Education (CISSE 2022), 14 November, 2022.

(2) Tiffany Fuhrmann, Taegan William, and Michael Haney (2022), "Cyber-physical Shooting Gallery: Gamification to Address the IT-OT Gap in Cybersecurity Education," 26th Colloquium for Information Systems Security Education (CISSE 2022), 14 November, 2022.

(3) R.A. Borrelli, Samuel Root, Porter Throckmorton, Jonathan Tacke, Jacob Benjamin, and Michael Haney, "Cyber Hardening of Nuclear Power Plants with Real-time Nuclear Reactor Operation Simulation," Journal of Progress in Nuclear Energy, (accepted and in revision).

(4) Sam J. Root, Porter Throckmorton, Jonathan Tacke, Jacob Benjamin, Michael Haney, R. A. Borrelli (2023). Cyber Hardening of Nuclear Power Plants with Real-time Nuclear Reactor Operation – 1. Preliminary Operational Testing. Progress in Nuclear Energy 162, 104742.

(5) Sam J. Root, Porter Throckmorton, Michael Haney, R. A. Borrelli (2022). Simulated boron shimming cyber-attack on pressurized water reactor. Phoenix, Arizona: Proc., American Nuclear Society Winter Meeting.

Proposals submitted

(1) R. A. Borrelli (PI), Michael Haney (co-PI) - University of Idaho. Cyber-informed design, education, and training for cyberthreat resiliency with real-time nuclear reactor simulation. University of Idaho. Operation: Resubmission Support. $34,122. 2022.04.30 - 2022.09.30.

(2) R. A. Borrelli (PI), Michael Haney (co-PI), Lee Ostrom (co-PI) - University of Idaho. Nuclear Power Plant Cyber-Risk Assessment with Real-Time Reactor Operations. U.S. Nuclear Regulatory Commission Notice of Funding Opportunity (NOFO), Research and Development Grant, Fiscal Year 2023 $499,036. 2024.06.01- 2027.05.31. [*in review*]

(3) Dakota Roberson (PI), R. A. Borrelli (co-PI), Michael Haney (co-PI), Brian Johnson (co-PI) - University of Idaho, Hany Abdel-Khalik (co-PI) – Purdue University, Arthur Deacon (co-PI) - Datacast Technologies, Inc., Steve Bukowski (co-PI) - Idaho National Laboratory. Securing Grid Edge Devices through Distributed Intelligence Synthesis. Department of Energy Cybersecurity, Energy Security, and Emergency Response (CESER). $2,900,000. 2024.01.01 - 2026.12.31. [*in review*]

Section 2: High-level summary of budget expenditures for the period just completed. If budget is underspent at time of report, explain why and plans for expending funds.

- Funding of $693,000 for FY23 is split between UI and co-PIs to manage ($300,000 subaward to ISU, $393 allocated to UI.)

- Overall this project remains ahead of schedule and on budget. At the end of the first year of the grant, due to reasons documented and explained in the detailed expenditure report, at the end of the fiscal year, we had $16,000 that remained unencumbered and was carried forward to year two.

- Student and faculty support, post-doctoral fellow search, and related human capital expenses are all on target.

- Focus during this initial grant reporting period has been on acquisition of equipment, materials, supplies, and renovation of available facilities

During the first year of this grant effort, our focus has been on the renovation of existing laboratory

spaces and acquisition of materials and equipment to enable future training and research. The budget plan explicitly called for the support of one full-time graduate student, and several specific purchases. We have successfully combined our funds with other sources and strategically addressed facilities upgrades,including expanding into an additional laboratory space of 600 square feet for "Balance of Plant" and power substation equipment, which will be connected via networking in the next reporting period. We were also able to engage additional students to support these efforts, as discussed in Section 4 of this report. These resources combined to make our team more successful and ahead of schedule.

Facilities, materials, and equipment under this FY23 HERC IGEM grant specifically fall under one of several categories. In order to support the backbone of our "cyberspace" environment, we have created a private cloud environment to support the reconfigurable virtual spaces for cybersecurity and energy research and training. This was done first through the acquisition of refurbished computing equipment to expand our existing environment. Secondly we had a significant outlay of $100,000 to purchase new cloud computing equipment. Combined, the computing capacity is many times greater than previously available. Ongoing efforts and support from this grant will be allocated to improve our network equipment connecting our separate lab spaces to one another and to the Idaho Cyber Range.

Next, we focused on the acquisition of the materials and supplies to begin building our "Cyber Shooting Gallery". This environment will consist of 20 or more platforms of small-scale cyber-physical systems for students to design, attack, defend, and reconfigure. Three initial prototypes have been completed. We are facing significant supply-chain constraints, specifically with the Raspberry Pi computers we hoped to employ, which has forced us to reconsider some design elements. Nonetheless, our initial prototypes were unveiled and met with great enthusiasm at the "BSides Idaho Falls 2022" cybersecurity conference and can be seen in this article: https://www.postregister.com/news/local/more-than-200-attend-idaho-falls-cybersecurity-conference/article_664ec6f2-4666-11ed-a46e-3f8e96e066a2.html

Additionally, we have acquired both information technology (IT) and operations technology (OT) equipment to outfit sixteen student "workstations" that feature state-of-the-art computing capabilities as well as industry-leading cyber-physical control systems. Our spending in this area is complete at $315,000. The details of this research and training equipment are included in the attached spreadsheets under Section 6 of this report.

The major equipment acquisition for this first year of grant funding was for the RTDS Technologies real-time data simulator for electric grid operations research. This purchase was made possible by $76,000 from this grant matched by funds from other sources. Additional equipment made available through partnership with Schweitzer Engineering Labs has helped enhance the complexity and realism of simulations for cybersecurity research.

The balance of our expenditures falls either under materials and supplies or salary and related expenses. These expenses are on budget and in accordance with the HERC IGEM requirements and the UI's Office of Sponsored Programs and are included in the attached spreadsheets under Section 6 of this report.

Section 3: Demonstration of economic development/impact, including the following as applicable: patents, copyrights, plant variety protection certificates received or pending; technology licenses signed, start-up businesses created, and industry involvement; private sector engagement; jobs created; external funding; any other pertinent information.

The initial economic impact of our first year of funding under this HERC IGEM effort can be summarized:

- Multiple journal and conference papers published in initial period.

- Multiple external funding opportunities currently submitted or in development.

- Multiple engagements with private sector partners as well as other academic and research institutions.

- Post-doctoral fellowship positions created to be filled in future reporting period.

External funding has been secured from multiple sources as a result of initial efforts based on this HERC IGEM grant fund, including with the Department of Energy and private partnerships. We have made a significant impact on the national discussion regarding the cybersecurity of the electric grid, as Dr. Roberson was the lead technical contributor to a report to the U.S. House of Representatives, via DOE CESER, on the subject. He has also participated in high-level meetings on the topic representing INL through his joint appointment at the national level and is working to secure further funding to continue growing these efforts at UI-Idaho Falls.

Commercialization efforts of our initial research has begun in the first year. An Idaho-based cybersecurity startup, Datacast Technologies, has begun working on commercializing their product based on the work we are doing in the laboratory and the partnerships developed therein. Curtiss-Wright in Idaho Falls has also expressed interest in collaborating with us towards developing a prototype of our USB monitor setup. They aim to adopt an extension of the concept to test for malicious USB drives inside their airgapped facilities. This collaboration may open opportunities for submitting more proposals.

The co-PIs of this grant are all involved in the ongoing development efforts of the Idaho Cyber Range to make the Idaho Falls-based laboratories and equipment interoperable with research laboratories and training facilities across the state, including at the Idaho National Laboratory's Cybercore Integration Center and the Center for Advanced Energy Studies. Additionally, we are now working with Montana State University on the development of training and education curriculum for hands-on cyber-physical systems security. We have begun regular meetings with industry partners including SEL, Siemens, Intel, Wesco, Western Services Corp, Mickelsen Farms, CLOAKED Cybersecurity, Shadowscape, and CourseOps to form an advisory group for our efforts.

Section 4: Number of faculty and student participants as a result of funding, and brief description of student efforts.

- 1 Master's student directly funded in initial reporting period,

- 1 PhD student directly funded in next reporting period (Spring 23).

- 12 additional undergraduate and graduate students directly involved in supporting initial project efforts.

- 7 principle investigators supported by this grant.

Several students were supported over the course of the project, and most of them have published papers as a result of their efforts. Our students have helped to design, acquire, build, configure, and implement all of our laboratory spaces, capabilities, and equipment described in this report. Future HERC IGEM funding will substantially shift from equipment and materials acquisition to

student education and research involvement by directly supporting multiple graduate students and post-doctoral fellows each year.

Section 5: Updated details and/or progress on the long-term sustainability plan for the project and description of future plans for project continuation or expansion.

- Multiple federal and state grant proposals submitted, under review, or planned (currently over $8 million under review).

- Multiple levels of engagement with private industry partners for workforce training needs.

The RADICL and related research laboratory and training facilities are designed to enable sustained education, research, and workforce development in Idaho Falls. This involves significant engagement with our industry partners, the Idaho National Laboratory, and the campuses across the state of Idaho connected via the Idaho Cyber Range, as well as through current and planned external funding from federal and state funding agencies. Initial plans for sustained growth and expansion of our capabilities include several grant proposals recently submitted or currently under development. We have also begun development of our model for industry engagement and workforce training opportunities. Recently, the co-PIs, led by Dr. R.A. Borrelli, submitted a robust grant proposal to the National Science Foundation entitled "Cyber-informed Design, Education, and Training for Energy Resiliency with Real-time Nuclear Reactor Operation." This grant proposal for $1.2 million will provide for expansion of our nuclear power plant simulation environment, including licensing fees for our current simulator software, expansion of hardware and supporting equipment, and the funding of many students in several disciplines (e.g. computer science, computer engineering, nuclear engineering, electrical engineering) to continue the development of this important platform. The preliminary results necessary to submit a viable NSF grant of this size were made possible by the students and equipment funded during this initial period of the HERC IGEM grant. Additional grant proposals in development and expected to be submitted in the upcoming reporting period include grants led by Dr. Roberson to the Department of Energy's Nuclear Energy University Programs(NEUP) program (invited proposal for $800,000), as well as the DoE's Office of Cybersecurity, Energy Security, and Emergency Response (CESER), by Dr. Kolias to the NSF's Computer and Information Science and Engineering (CISE) Directorate, and Dr. Haney's proposals to the Department of Homeland Security and Cybersecurity and Infrastructure Security Agency's (CISA) programs. The team led by Dr. McBride also has current and planned proposals to the Department of Labor and Department of Education for ongoing workforce development efforts.

We have begun to organize an advisory group to expand on the engagement we have with our community and industry partners across the region. With the development of our multiple spaces, our private cloud computing environment, our shooting gallery, and the data created and collected for running multiple reconfigurable cyber wargame scenarios, we expect to engage and train a wide variety of industry professionals in different roles and critical infrastructure industries. This engagement will allow for a revenue stream to sustain our staff, equipment, software licensing and other operating expenses indefinitely.

Section 6: Expenditure Report – Attach an expenditure report as a separate document showing expenses toward the original budget submitted for this project. The expenditure report does not count toward the page limit. A written summary of budget expenditures should be provided in Section 2 of this report.

Title: ISBOE IGEM HERC: Secure Cyberspace   **NO F&A**
Funding Agency: IGEM HERC
PI: Dr. Michael Haney

Budget Category	Budget	Activity	Commitments as of 07/31/2023
10 - Senior/Key Personnel	**$35,517.54**	**$30,341.25**	**$0.00**
Faculty - Academic Year - Dr. Haney			
Faculty - Summer - Dr. Haney			
Faculty - Academic Year - Dr. Borrelli			
Faculty - Summer - Dr. Borrelli			
Faculty - Academic Year - Dr. Roberson			
Faculty - Summer - Dr. Roberson			
Faculty - Academic Year - Dr. Kolias			
Faculty - Summer - Dr. Kolias			
Other Personnel	**$15,195.40**	**$15,195.40**	**$0.00**
Grad Student - Academic Year (G. Makrakis)			
Grad Student - Academic Year (T. Williams)			
12 - Irregular Help	**$12,289.92**	**$4,407.48**	**$0.00**
Grad Student - Summer (J. Tacke)			
Grad Student - Summer (G.Makrakis)			
11 - Fringe	**$11,466.21**	**$9,852.30**	**$0.00**
Fringe - Faculty - Academic Year			
Fringe - Faculty - Summer			
Fringe - Grad Student - Academic Year			
Fringe - Grad Student - Summer			
30 - Operating Expenses	**$39,133.52**	**$39,438.24**	**$318.36**
40 - Capital	**$189,765.52**	**$110,547.32**	**$76,051.95**
45 - Small Equipment	**$78,487.89**	**$67,580.71**	**$7,902.44**

70 - Tuition	**$11,144.00**	**$11,144.00**	**$0.00**
Subaward with Idaho State University	**$300,000.00**	**$155,817.32**	**$144,182.68**
Total Direct and Indirects Costs	**$693,000.00**	**$444,324.02**	**$228,455.43**

Available 07/31/2023	# Hrs	# Students	$/Hr	Budget Remaining	Total
$5,176.29					
	0.00		$0.00	$0.00	$0.00
	0.00		$0.00	$0.00	$0.00
	0.00		$0.00	$0.00	$0.00
	0.00		$0.00	$0.00	$0.00
	0.00		$0.00	$0.00	$0.00
	80.00		$64.69	$5,175.20	$5,175.20
	0.00		$0.00	$0.00	$0.00
	0.00		$0.00	$0.00	$0.00
$0.00					
	0.00	0	$24.00	$0.00	$0.00
	0.00	0	$20.41	$0.00	$0.00
$7,882.44					
	160.00	1	$20.79	$3,326.40	$3,326.40
	0.00	1	$24.00	$0.00	$0.00
$1,613.91					
	31.0%			$0.00	$0.00
	31.0%			$1,604.31	$1,604.31
	2.5%			$0.00	$0.00
	2.5%			$83.16	$83.16
-$623.08				$0.00	$0.00
$3,166.25				$0.00	$0.00
$3,004.74				$10,031.48	$10,031.48

$0.00	$0.00	$0.00
$0.00	$0.00	$0.00
$20,220.55	**$20,220.55**	**$20,220.55**
		$0.00