IDAHO GLOBAL ENTREPRENEURIAL MISSION

FY2018 ANNUAL REPORT

IGEM

The Idaho Global Entrepreneurial Mission (IGEM) is a unique program that invests public funds in advanced university research and capacity building to further economic development initiatives across the state. The IGEM grant program uses a three-pronged approach to support a statewide entrepreneurial and commercialization pipeline to bring to market advances in agribusiness, computer science, medical and veterinary research, advanced energy initiatives, and other areas that are equally vital to the state's economy. In the first six years of operation, IGEM has been successful in advancing important research projects, funding strategic research capacity projects and propelling innovations that position Idaho industries in new and profitable markets.

This annual report provides an update on the IGEM program, funded projects and successes over the past fiscal year and life of the program.

IGEM PROVIDES THREE DISTINCT FUNDING OPPORTUNITIES:

IGEM – COMMERCE
$1 MILLION

Managed by Idaho Commerce under the direction of the IGEM Council.

Funds research ventures where industry and university partnerships work together to bring viable products and technologies to market.

IGEM – HERC
$2 MILLION

Managed by the State Board of Education (SBOE) and administered by the Higher Education Research Council (HERC).

Invests funds to support infrastructure and advance key capacities at Idaho's research universities.

IGEM – CAES
$2 MILLION

Managed by the SBOE and administered by the Center for Advanced Energy Studies (CAES).

Leverages the partnerships between Idaho's three public research universities, the University of Wyoming, and the Idaho National Laboratory to fund advanced energy projects and initiatives.

The IGEM-Commerce grant program funds research initiatives, where university investigators and private sector business experts partner together to bring viable technologies to market. By funding university research that can advance private sector products and services developed in Idaho, IGEM commercialization grants are a powerful resource in the growth of Idaho's economy. Through its support of commercialization partnerships, IGEM makes an investment in developing new business ventures, creating new products and high-value jobs, while supporting the research capacity of Idaho's universities.

At the helm of the IGEM-Commerce program is the IGEM Council, a twelve-member body appointed by the Governor as prescribed in Idaho Code section 67-4726. The IGEM Council's diverse and experiential make-up consists of the brightest business, research, policy, strategy and financial minds in the state.

IGEM-Commerce, having completed its sixth year, is proud to provide a succinct update on past and current projects.

IGEM COUNCIL

The IGEM Council is a twelve-member council appointed by the Governor as prescribed in Idaho Code section 67-4726.

Membership of the IGEM Council includes:

- Four (4) representatives from the private sector;
- One (1) representative from the State Board of Education;
- One (1) representative from the Idaho National Laboratory (INL) or the Center for Advanced Energy Studies (CAES);
- One (1) representative each from Boise State University, Idaho State University, and the University of Idaho;
- One (1) representative from the Idaho Senate
- One (1) representative from the Idaho House of Representatives; and the
- Director of Idaho Commerce.

This twelve-member Council thoroughly vets IGEM grant proposals to mitigate risk and maximize the return on investment. The IGEM Council's fiscal stewardship and strategic direction advance IGEM's overall intended goal of economic prosperity through investments in technological advancements and innovation.

2018 MEMBERS:

- **Dr. David Hill**
  Chair, State Board of Education
- **Bill Gilbert**
  Vice Chair, The CAPROCK Group
- **Von Hansen**
  AlertSense
- **Rick Stott**
  Superior Farms
- **Mike Wilson**
  Consultant
- **Dr. Noël Bakhtian**
  Center for Advanced Energy Studies (CAES)
- **Dr. Janet Nelson**
  University of Idaho
- **Dr. Mark Rudin**
  Boise State University
- **Dr. Neels Van der Schyf**
  Idaho State University
- **Senator Kelly Anthon**
  Idaho Senate
- **Representative Luke Malek**
  Idaho House of Representatives
- **Bobbi-Jo Meuleman**
  Idaho Commerce

IGEM-COMMERCE GRANT PROGRAM

The chart below provides an overview of the IGEM-Commerce grant program. With $1 million in annual funding, Idaho Commerce utilizes $50,000 for program administrative costs, leaving $950,000 for grant awards. To date, IGEM-Commerce has funded 27 projects, resulting in over $5.8 million invested in university and industry research partnerships.

Fiscal Year	Applications	Applications Funded	Funds Requested	Funds Awarded
FY2013	18	7	$3,088,169	$844,093
FY2014	20	4	$3,506,145	$972,371*
FY2015	14	3	$3,044,732	$950,000
FY2016	18	6	$4,149,029	$1,104,830*
FY2017	14	4	$3,628,640	$979,569*
FY2018	14	3	$5,375,198	$950,000
Total	**98**	**27**	**$22,791,913**	**$5,800,863**

*Supplemental funding provided by Idaho Commerce

The program's largest grant award was in the amount of $427,173 with the smallest being $46,146. Over the past six years, the average grant request has steadily increased to $243,968. The average award size is $214,846.

Fiscal Year	Average Application Request	Applications
FY2013	$171,565	18
FY2014	$175,307	20
FY2015	$234,210	14
FY2016	$230,502	18
FY2017	$259,189	14
FY2018	$383,943	14
Avg. Request	$243,968	16
Avg. Award	$214,846	

FY2018 GRANT AWARDS

A GENERAL-PURPOSE GONIOMETER

Boise State University

Grant Amount: $368,772

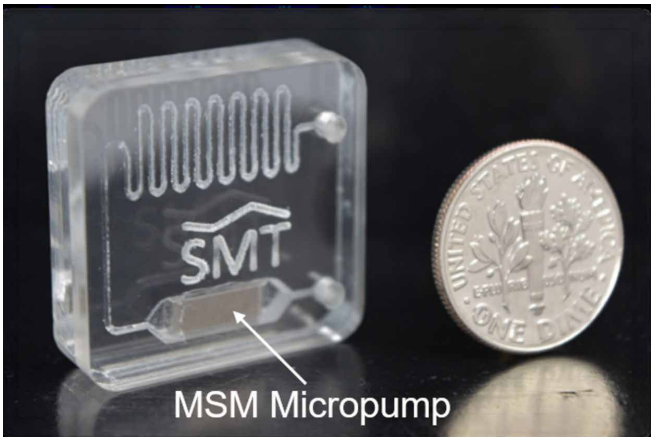
This project will support design and development of a market ready, general-purpose, portable infrasound goniometer. The goniometer will be able to detect natural phenomena sounds as well as differentiating man-made sounds and their sources. This project began as a PhD student's research project and was funded by the Idaho State Board of Education Incubation Fund for initial prototype redesign. This project combines PhD-level research at Boise State University with the real-world product development, supply chain, manufacturing and distribution, and expertise of the industry partner, WMDTech, to take this product idea to market. WMDTech has hired Austin Davis (Electrical Engineering Major, Class of 2017-2018) as an Electrical Engineer for their in-house design of electrical subsystem and firmware coding. Austin participated in the infrasound project when funded by the Idaho State Board of Education Incubation Fund. Multiple systems have been built and are currently running successful tests in Boise and Utah.

ALUMINUM CASK FOR USED FUEL COOLING

University of Idaho & Boise State University

Grant Amount: $237,898

Faculty in the Nuclear Engineering program at the University of Idaho in Idaho Falls at the Center for Advanced Energy Studies partnered with faculty at Boise State University in the Materials Science Department to design a used fuel cooling cask that could be deployed on nuclear reactor sites both domestically and internationally in order to alleviate the dwindling space in used fuel pools. The research team is partnered with Sakae Casting Company, located in Idaho Falls, Idaho and headquartered in Japan. The project team will utilize Sakae's unique aluminum casting techniques to fabricate 'cold' plates; a water-cooled plate that enables efficient heat removal. IGEM funds have supported the development of a prototype cask design, including experimental testing of boron loading into the aluminum casting process, neutron shielding of the used fuel and heat removal. Sakae has provided several experimental plates for heat removal testing. The current project will produce design information for Sakae to fabricate a prototype for full scale testing. Premier Technology, Inc., in Blackfoot, Idaho, has agreed to assemble the prototype.



DEVELOPMENT OF A MAGNETIC SHAPE MEMORY (MSM) MICRO-PUMP

Boise State University

Grant Amount: $343,330

This project will support development of a working Magnetic Shape Memory (MSM) Micro-pump prototype for volume production. The industry partner, Shaw Mountain Technology, LLC, (SMT) is a Boise State University startup company founded in 2015 by Distinguished Professor and former Chair of the Materials Science and Engineering Department, Dr. Peter Müllner. SMT was founded with the primary purpose of commercializing MSM technology and this technology is the flagship product of SMT. SMT received funding from the National Science Foundation Small Business Technology Transfer (NSF STTR) Phase I grant for the development of the MSM Micro-pump. The research proposed in this project will replace the driving mechanism, currently an electromotor and permanent magnet assembly, with a more compact and energy efficient electromagnetic system. This will improve the performance of the MSM Micro-pump and remove all mechanical parts from the system, thereby making it a pumping device without any moving parts.

IGEM - COMMERCE IN PROGRESS PROJECTS

REMOTE SENSING OF ALFALFA CROP BLOOM

Boise State University

FY2017 Grant Amount: $194,000

This project allows Boise State University's Department of Geosciences to apply its experience and expertise in remote sensing data collection and analysis to provide protocols and prediction models to the industry partner, Kairosys, Inc., that will form an important part of the suite of solutions it is developing for managed pollination. Boise State University is using imaging technology based on spectroscopy science for monitoring alfalfa as it progresses through its flowering cycle. Based on the success of the project, S&W Seed Company has joined as a new industry partner. In partnership with S&W, sensors were deployed in several alfalfa fields and a predictive model is under development. S&W has provided additional data to the project and, along with the founders of Kairosys, are actively engaged on the product development of the predictive model.

FLEXIBLE SENSORS ASSISTING MINIATURIZED AIR SCRUBBER FOR PROTECTING STORED POTATOES

Boise State University & Idaho State University

FY2017 Grant Amount: $413,681

This IGEM grant has led to a multi-institution effort to develop an integrated miniaturized air scrubber and cloud-enabled wireless distributed sensor network to monitor and control potato storage environments. The Boise State University team has developed and tested temperature, gas and humidity sensors in a laboratory environment. The team is also developing a web-based client application to provide user interfaces to view the real-time readings of different sensors physically present in the storage facility. Idaho State University has tested the Idaho Hydro Tech (IHT) (formerly Isaacs Hydropermutation Technologies) Humigator™; an air scrubber developed to remove mold spores, bacteria and viruses from air.

Initial analysis indicates that the Humigator™ is effective in removing bacteria from air. Based on these results, researchers at Idaho State University have collaborated with Mr. Blake Isaacs, CEO of IHT, to redesign the Humigator™ unit and to develop a smaller model that may have applications beyond the potato storage market. Testing and collection of data with Boise State University sensors in actual Idaho State University lab environments is underway.

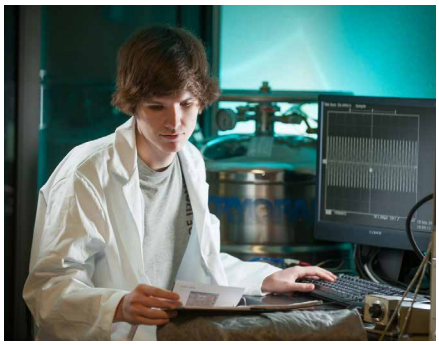
This integrated solution will significantly reduce potato waste in storage, and should enable IHT to increase their share of the potato storage market. While each component of the integrated system has unique capabilities, their integration marks an important advancement in agricultural technologies.

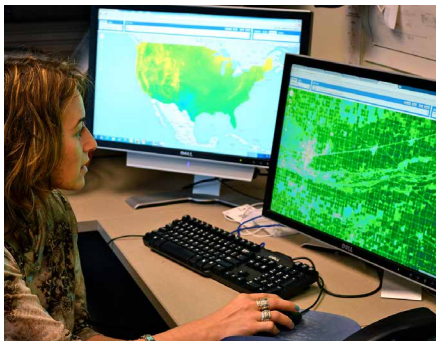
EVALUATION OF THE ANKLE ROLL GUARD'S EFFECTIVENESS TO IMPROVE CLINICAL BENEFIT

Boise State University

FY2016 Grant Amount $148,927

Ankle Roll Guard ™ has developed a new, innovative orthopedic product, Armor1, that prevents injury by limiting excessive inversion of the ankle. Boise State University is quantifying the Armor1's effectiveness and comparing its ability to prevent excessive ankle inversion with existing orthopedic products. The preliminary quantitative data demonstrates that Armor1 provides similar prevention of





excessive inversion as existing orthopedic products but may allow the wearer more natural ankle motions and better physical performance. Using this data, Ankle Roll Guard™ has initiated negotiations with several medical device distributors.

TIME-OF-FLIGHT SPECTROSCOPIC REFLECTOMETER

Boise State University

FY2017 Grant Amount: $260,435

Boise State University has developed a spectroscopic time-of-flight reflectometer (STOFR) to assist their industry partner, Fiberguide Industries, Inc., with the manufacturing and quality control of a new revolutionary process called the RARe Motheye Fiber process which reduces and eliminates reflection from the end of an optical fiber. The instrument measures optical reflection from RARe Motheye Fiber™ over a wide range of wavelengths from near UV to near infrared. STOFR is capable of measuring reflections less than 0.1% and is insensitive to optical alignment, an important factor in the manufacturing environment. An instrument with such a broadband capability and high sensitivity does not exist on the current commercial market. STOFR has been in field operation since July 2018. Fiberguide has created 3 new positions related to RARe Motheye Fiber™ manufacturing and a production volume of apx. 10,000 fibers / month in 2018 and expects 100,000 fibers / month by 2020. The revenue generated by RARe Motheye Fiber™ is expected to exceed $1 million in 2020.

IGEM - COMMERCE COMPLETED PROJECTS

HOPLITE SKATE ARMOR™ COMPARATIVE ANALYSIS

Idaho State University

FY2017 Grant Amount $111,453

The central focus of the project was the testing of a hockey safety device called HOPlite Skate Armor™, developed by Fi-Ber Sports, that was to be worn over a standard hockey skate. HOPlite Skate Armor™ is a patented two-piece composite plastic foot protector intended to reduce foot-related injuries for hockey players. An Idaho State University research team was charged with the development of a consistent delivery system capable of accelerating a hockey puck to 100 mph and recording the velocity of the puck prior to its impact with the protective device. The mission was to record impact data and video from the puck collisions with the HOPlite Skate Armor™ device for analysis. The final research report contains detailed information allowing for anyone to easily replicate the testing process. The puck launching system has applications for other safety devices as well, and can accelerate a puck to 190 mph. With the impact film data and high-speed video provided by the Idaho State University research team, Fi-Ber Sports will be able to conduct an in-depth analysis of the reaction of the material used in the construction of HOPlite Skate Armor™. This data could allow for HOPlite Skate Armor™ to become the industry standard in foot safety equipment for hockey players.

SMART RAISED PAVEMENT MARKINGS (RPM) INTEGRATION WITH TRAFFIC SIGNAL CONTROL SYSTEMS

University of Idaho

FY2016 Grant Amount $299,651

The University of Idaho and the National Institute for Advanced Transportation Technology (NIATT) have validated solar-powered, battery operated, LED illuminated, Smart Raised Pavement Marking (RPM) models and documented their safety benefits in different applications. Partnered with Evolutionary Markings Inc., an Idaho-based company, IGEM funding supported the development of real-time communication and data exchange between RPM devices and different traffic control systems, connected vehicles and autonomous vehicles. A test installation of the technology was featured in the September edition of the

journal for the Washington State Institute of Transportation Engineers. In addition, the project team has been assigned projects to address traffic challenges in Idaho.

6,000 WATT SPLIT PHASED GALLIUM NITRIDE HIGH FREQUENCY INVERTER

University of Idaho

FY2016 Grant Amount $178,178

The University of Idaho in collaboration with Inergy Solar, the industry partner, have engineered and manufactured a new 6,000 Watt Split Phased Gallium Nitride High Frequency Inverter. The development of this inverter augments Inergy Solar's current product offering by advancing development toward a complete home solar solution. In addition to the gallium nitride focus, this project's research has also included emphasis on network cybersecurity protection for this off-grid energy source. The project is continuing to refine the design for increased power loads.

Since the completion of the IGEM development project, Inergy Solar has sold hundreds of Kodiak battery power units across the globe. The power inverter that the University of Idaho helped engineer allows a stack of Kodiak batteries to be charged at once, adding flexibility, durability and power to the existing Inergy Solar systems. Inergy Solar anticipates doubling the size of their Pocatello, Idaho workforce in the coming year.

SENSOR ADAPTER FOR MACHINE-TO-MACHINE (M2M) MARKET

Boise State University

FY2016 Grant Amount $211,098

With IGEM funding, Boise State University has developed a sensor device protocol adapter to improve the collection, modification and delivery of remotely-sensed GPS, vehicle diagnostics and other related data. The sensor adapter fills a critical gap in the delivery of data from diverse sensors to the growing internet Platform as a Service (PaaS) marketplace, allowing sensor agnostic and carrier agnostic delivery of data to the cloud for use by a wide variety of applications. Marshall GIS, the industry partner, is currently in negotiations with Boise State University to license the technology.

TECHNOLOGY DEVELOPMENT FOR EFFICIENT PROVISION OF UAS PRODUCTS

University of Idaho

FY2016 Grant Amount $161,524

The University of Idaho, along with assistance from Z Data Inc., has developed software tools to assist Empire Unmanned (EU) in handling enormous amounts of data acquired during unmanned aerial system (UAS) flights. The ability to process, visualize and disseminate large volumes of gathered data enables EU to expand its product offering.

DATA ANALYTICS FOR PRECISION AGRICULTURE

Boise State University

FY2015 Grant Amount $343,072

Boise State University worked with Simplot to develop a data analytics solution for agronomic decision making based on historic farm and crop yield data. The goal of this project was to leverage Simplot's existing data to give growers new tools and resources they need to optimize their yields. Researchers automated the process of matching the multi-spectral photosynthetic images for Simplot, so they can be used to produce predictive models for their network of growers. A collaborative research agreement between Boise State University and Simplot has been executed, with an affirmed first right to license the technology to Simplot.

COMMERCIALIZATION OF NEW AQUATIC ANIMAL HEALTH PRODUCT

University of Idaho

FY2016 Grant Amount $105,452

This project was an inaugural recipient of IGEM funding in FY2013. Since the initial investment, this project has successfully progressed toward the commercialization of a fish vaccine to combat Cold Water Disease (CWD). Idaho is the national leader in trout production, accounting for over 70% of all commercial (food fish) rainbow trout. Commercial aquaculture production contributes over $110 million to Idaho's economy. Due to this secondary round of funding, an exclusive license has been successfully negotiated and executed. Final Federal Drug Administration approval processes are currently underway. The multinational pharmaceutical company that licensed this vaccine has recently completed testing and reporting on effective dosages. USDA approval is anticipated; currently the company is preparing submissions to the USDA covering the rate of reversion to virulence after

vaccination, and the rate at which the vaccine passes through the body of the fish and back into the water.

2E-HEXENAL FUNGICIDE

University of Idaho

FY2014 Grant Amount $296,917

At the University of Idaho, researchers tested an organic compound called 2E-Hexenal as a fungicide for stored potatoes. Converted to and applied in a gaseous state, this new approach to eradicate fungi would be industry changing. University of Idaho has partnered with SunRain Varieties LLC, Agri-Stor Inc. and AMVAC to study the effectiveness of this fungicide in post-harvest tubers. The project shifted from large-scale potato trials to smaller-scale trails, which incurred cost savings. Those savings were utilized to conduct additional research on the use of 2E-Hexenal in onion storage facilities, which has successfully demonstrated a dramatic reduction in crop losses due to postharvest pathogens. The product is now patented, and SunRain Varieties, LLC has been reimbursing University of Idaho for the patent expenses as they continue to work to roll out a commercial product.

This year, the University of Idaho negotiated a commercial license to its intellectual property rights in 2E-Hexenal, for registration and use in the United States, Canada, Brazil, Chile, Mexico, and parts of Europe. Launch of a registered, licensed commercial product is anticipated no later than 2022.

RISE ANALYTICS

Idaho State University

FY2014 Grant Amount $300,000

Idaho State University partnered with ON Semiconductor for analytical research in the development and improvement of semiconductor products. The IGEM award allowed for the acquisition and installation of Scanning Electron Microscope and Energy Dispersive Spectroscopy (SEM/EDAX) equipment. The equipment is located in the Eames Advanced Technical Education and Innovation Complex, in the newly remodeled Material Analysis and Microscopy Laboratory (MAML). The equipment positioned in MAML has fostered collaboration between Idaho State University and multiple industry partners as well as numerous governmental agencies.

EXPANDING PRECISION AGRICULTURE MARKET OPPORTUNITIES WITH UNMANNED AIRCRAFT SYSTEM SENSORS

Idaho State University

FY2015 Grant Amount $179,755

This project utilized hyper-spectral imaging via Unmanned Aircraft Systems (UAS) to advance precision agriculture. Idaho State University and Simplot Company worked together to advance remote sensing applications in the evaluation of multi-platform data collection using UAS. Researchers have discovered a detection methodology that identifies the Potato Virus Y (PVY). The detection of PVY is critical for potato growers. The project team secured additional grant funding through the Idaho State Department of Agriculture Specialty Crop Grant program and ran field tests through the 2018 growing season with the intent of gathering additional data and refinement of their approach to detect the PVY crop threat. This past year Idaho State University has successfully submitted a provisional patent application and will formalize the full patent application this coming year: Delparte, D. & Griffel, L. (2017). Assessing Spectral Signatures to Detect and Control Infected Plants. U.S. Provisional Patent App. Ser. No.: 62/597, 636.

HIGH SPEED DIGITAL PACKAGE MEASUREMENT & MODELING FOR NEXT GENERATION MEMORY MODULES

University of Idaho

FY2013 Grant Amount $150,000

Partnered with Micron, this project allowed for speedier development and design on next generation memory modules with the acquisition of the Vector Network Analyzer. The acquisition of the Vector Network Analyzer, not only helped Micron but it also prepares University of Idaho students with hands-on education on the latest industry equipment. Additionally, the Micron Foundation gifted $1 million to University of Idaho to fund an endowed professorship in microelectronics in the College of Engineering. This gift has helped University of Idaho's efforts to better position itself as a leader in microelectronics education and research.

N-E-W TECH™: INNOVATION AT THE NUTRIENT, ENERGY, WATER NEXUS

University of Idaho

FY2015 Grant Amount $427,173

This project validated and brought to scale a new reactive filtration water treatment platform. The new technology removes biological contaminants in the water, using treated Biochar and a catalytic oxidation process that destroys most compounds of concern such as hormones and pharmaceuticals. N-E-W TECH™, now Nexom™ received the Phase One award in the $10 Million Everglades Foundation George Barley Clean Water Science Prize in Miami in December 2016. The Lower Boise River Watershed Council has requested a proposal for a demonstration scale N-E-W TECH™ water treatment system to address the phosphorus pollution issues in the Treasure Valley.

Successfully licensed to Nexom™, this technology continues to make strides in the water treatment market. New installations utilizing this innovative technology are producing sparkling clean water for cities and towns across the United States and Canada.

COMMERCIALIZATION OF NEW AQUATIC ANIMAL HEALTH PRODUCT

University of Idaho

FY2013 Grant Amount $124,021

This project allowed for trials on a new fish vaccine and a probiotic feed additive aimed at reducing fish losses in aquaculture facilities due to Cold Water Disease (CWD). The iron limited vaccine yielded successful results. This formula work will be used for final regulatory approval with the FDA. Additional funding was awarded in FY2016 to aid in the commercialization of this aquatic vaccine.

CANINE HIP IMPLANT

Boise State University

FY2014 Grant Amount $110,454

A new implant, the Bionic Hip System™, has been developed by MWI to improve the standard of care for treating hip osteoarthritis by reducing cost, improving canine mobility and lowering complications. Boise State University characterized the mechanical performance of the implant. MWI has submitted a utility patent on the technology and West Vet is currently developing instruments to use the bionic hip implants in canines. The Bionic Hip implant successfully completed over a million cycles of wear testing, and the findings were published in the Journal of Orthopedic Research. This study also led to the development of a new technique to measure abrasive wear in hip implants, which was published in the Wear Journal. The undergraduate working on this project was awarded an NSF graduate fellowship and is now completing her PhD at Boise State University. The next step for this project is to implant these devices in a small sample size of canines.

AUTOMATED QUANTITATIVE DETECTION OF E.COLI O157:H7 AT BEEF PROCESSING FACILITIES

University of Idaho

FY2013 Grant Amount $78,076

The project examined if there was a better process to detect and determine the strains of E. coli within the beef processing system. While the project was successful in decreasing the detection time, the new process was not sufficient for commercial use at a beef processing plant. The process did recognize six strains that are considered adulterants in fresh ground beef products. Additionally, beef trim contaminated with E. coli O157:H7 could be identified in approximately 18 hours, which is about 24 hours faster than other generic methods.

CONDUCT PRECLINICAL STUDIES ON POTENTIAL ANTICANCER AGENTS

Boise State University

FY2013 Grant Amount $80,986

The project focused on the analogs of doxorubicin and mitomycin C, two compounds that have an important role in the treatment of a variety of cancer types. Use of these two compounds has declined due to side effects, including myelosuppression and the onset of irreversible acute cardiotoxicity. Research efforts to gain knowledge on doxorubicin and mitomycin C's mechanism of toxicity have provided tangible results. Researchers discovered favorable

results from one of the analogs, GPX-160. They found it to be a more stable analog and a patent has been submitted on GPX-160, with two initial manuscripts following 1) synthesis and anticancer activity and 2) mechanic studies. Gem Pharmaceuticals has contributed over $100,000 in sponsored research toward this partnership.

INNOVATIVE PESTICIDE APPLICATION TECHNOLOGY SYSTEM

University of Idaho

FY2013 Grant Amount $46,146

The project allowed for field tests to be conducted to quantify the effectiveness of the new pesticide spraying technology compared to conventional spraying. GenZ Technology, the industry partner, learned from field tests that the new spraying technology performed better than existing technology. This new pesticide application system has been used for strawberry and lettuce crops. This project has raised $2 million in capital for the industry partner from angel funds and has also hired 8 new employees. GenZ Technology was also a Regional Winner of the 1776 Challenge Cup and invited to compete at the Global 1776 Challenge Cup competition.

SURFACTANT SOLUTIONS

Boise State University

FY2014 Grant Amount $265,000

Boise State University partnered with BHS Specialty Chemical Products to create renewable chemicals by converting oils into surfactants for use in products marketed to industrial food processing, personal care and petroleum industries. Researchers were successful in creating surfactants from pure oil feedstocks, as well as developing a method to make surfactants from high grade vegetable oil waste. Likewise, researchers were able to use low grade vegetable oils from food production facilities as feedstock for surfactant synthesis. BHS was bought out by DuBois Chemicals in 2017 and further development of this technology was terminated.

DETERMINE COMMERCIAL VIABILITY OF MICROBIAL INDUCED CALCITE PRECIPITATION (MICP)

University of Idaho

FY2013 Grant Amount $114,864

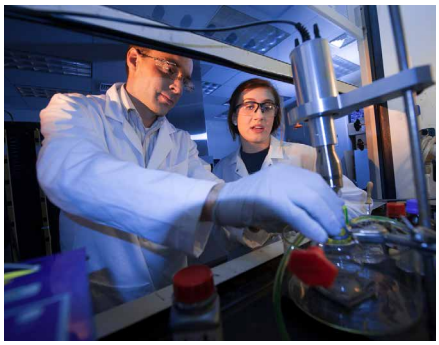
The project allowed an assessment to be made on the viability of MICP, a process that uses microorganisms already present in the soil to form calcite. A new Idaho company BioCement Technologies, Inc. has been created as a result of this new product and a license of this technology has been negotiated with the University of Idaho. In addition to receiving IGEM grant funds, this project has also received National Institute of Health (NIH) Small Business Investment Research (SBIR) funding. The SBIR Phase 1 grant awarded $53,968 for a 6-month study to reduce the mobility of lead (Pb) in soils at sites in and near Kellogg, Idaho. This technology has been patented in the United States, New Zealand, Australia, and Canada. BioCement Technologies has 12 road stabilization pilot projects resulting in company revenue. BioCement continues to market and test the technology in various locations, and for several use cases.

NANOFABRICATION INFRASTRUCTURE SUPPORT

Idaho State University

FY2013 Grant Amount $250,000

The project allowed for the acquisition of a Dualbeam-Nanomachine Center. The Dualbeam system provides both high resolution imaging and nano-machining capabilities in a single component. This tool enables the University to provide ultra-precise machining and nanofabrication capabilities that meet the needs of its industry, educational and research partners. The machinery is also located in the Material Analysis and Microscopy Laboratory (MAML) in the Eames Complex. The equipment positioned in MAML has fostered collaboration between Idaho State University and multiple industry partners as well as numerous governmental agencies.



IGEM - HERC

IGEM – HIGHER EDUCATION RESEARCH COUNCIL (HERC)

IGEM-HERC funds are used to support Idaho public institutions of higher education research and development of projects that foster expertise, products and services resulting in state economic growth. Priority is granted to those proposals that can show a strong collaborative effort among institutions as well as the private sector or exhibit high potential for near term technology transfer to the private sector. IGEM-HERC funded projects may receive funding for up to three years, contingent on annual review and satisfactory progress toward approved performance measures.

The institutions report to HERC each year on the status of their projects, including progress toward key objectives, budget expenditures, economic impact and commercialization potential. The awards granted in FY2018 included the third year of a three-year award for the Boise State University Computer Science Program, the third year of a three-year award to Boise State University for Enhancing Capabilities in Nanotechnology and Microfabrication, and the second year of a three-year award for University of Idaho for security management of cyber physical control systems. IGEM-HERC awards are granted through a competitive process that is open to each of the three research institutions. The process incorporates an independent review of proposals and an evaluation component for identifying the project success and economic benefit to the state.

University of Idaho Security Management of Cyber Physical Control Systems ($700,000)

Cyber-attacks and intrusions are nearly impossible to reliably prevent given the openness of today's networks and the growing sophistication of advanced threats. Knowing the vulnerabilities is not adequate, as the evolving threat is advancing faster than traditional cyber solutions can counteract. Accordingly, the practice of cyber security should focus on ensuring that intrusion and compromise do not result in business damage or loss through more resilient solutions. The University of Idaho is creating a platform to facilitate and build complementary and multidisciplinary research and development capabilities to address these pressing problems. The platform will incubate innovative products and services for safeguarding cyber physical control systems (CPCSs) that are ubiquitous and underpin key sectors of Idaho's economy. Early participation of industry will aid in vetting promising technologies. Better methods for assessment combined with more resilient systems design will safeguard against potentially immense economic impact currently being faced by Idahoan stakeholders.

Objective outcomes include:

1. **Strengthen capacity by adding key faculty and enhancing laboratories**
   In this second year of the project, The University of Idaho has been able to hire two new faculty members, in addition to the two hired in year one. The hiring took longer than originally planned due to a very competitive job market for cybersecurity faculty. To compensate, additional portions of time were assigned for three faculty and the principle investigator to keep schedule for meeting project objectives. Substantial progress has been made especially on deploying the new video technology infrastructure along with continued laboratory enhancement projects, additional industry collaborations, and research results.

2. **Strengthen collaboration with Idaho industry and Idaho Universities**
   The project team had numerous on-going and one-time collaborations with industry and other universities. Collaborators include Idaho National Laboratory, ABB Corporation Corporate Research, University of Illinois,

Argonne National Lab, Bonneville Power Administration, Avista Corporation and Schweitzer Engineering Laboratories.

3. Foster technology transfer and commercialization through technology incubation

During this second year, 11 proposals were accepted, and 12 proposals were submitted for research in this area. The team also had 30 papers or book chapters accepted and/or published. Four papers have been submitted and the team is preparing two more and had four presentations.

4. Strengthen and expand the workforce

The project team has progressed with this objective with internships at Idaho National Laboratory and Pacific Northwest National Laboratory. Students participated in the live cyber defense competition "NICCDC: NIATEC Collegiate Cyber Defense Competition" organized by NIATEC at Idaho State University.

Boise State University Computer Science at Boise State University – An Investment in Idaho's Future ($700,000)

The focus of the Boise State University project is to continue the strategic forward momentum of the Computer Science department to expand research, industry collaboration and teaching capacity. Four strategies were identified to achieve this goal.

1. Sustain current faculty lines and continue forward trajectory

The current IGEM grant supports five faculty (one full professor, one associate professor, and three assistant professors). These faculty have taken leadership roles within the department including leading the efforts to create the program.

Another strong impact of the IGEM-HERC grant has been the additional hiring the department did in the previous year. Using the eight faculty members provided by the Idaho Legislature and other funding, the department successfully hired eleven faculty in less than one year! In each case, the faculty hired were among the top choices in the respective areas. Boise State University retained all the faculty that were hired last year, which is better than many CS departments at other universities.

All of the faculty supported by IGEM-HERC has been permanently funded by Boise State University starting in Fall 2018 at the end of the IGEM-HERC funding.

Overall, the department now stands at 26 faculty members, an increase in size of over 325% from five years ago when it had only eight faculty.

2. Increase partnerships with local companies to facilitate knowledge development and transfer

The CS Department continues to increase its formal and informal connections with industry and the IGEM-HERC hires are integral to the following initiatives and connections. The new downtown location has been particularly conducive to growing partnerships with industry.

3. Increase research

The rate of research grant submissions continues to increase, with 47 grant proposals submitted in 2017-2018. Compared to the three years before the first IGEM award (2010-2012), the total research funding in the six years since then (2013-2018) has increased by 59%. (This does not include the two IGEM awards.)

The interdisciplinary PhD in Computing program was started in Fall 2016. The PhD program now has 30 students, up from 15 last year. It involves faculty from multiple departments across the campus. The PhD program has the potential to significantly increase the research profile of the department and college and to draw top-notch talent to come to Boise State University and potentially end up in local industry.

Last year, with additional Idaho Legislature funding, the department had started the work to create the CLICS (Cyber Lab for Industrial Control Systems) lab. The CLICS lab is now operational in the new space in the adjoining US Bank building, in downtown Boise. The lab has state-of-the-art equipment for process control testbed and smart grid testbed.

4. Enhancing the Student Pipeline

In Fall 2018, the project is starting its third year in the City Center Plaza building in downtown Boise. This new location provides computer science students with an unparalleled opportunity for internships and other interactions with industry in a modern and inviting learning environment. The new location is already lead to an increased interest from potential students, both in-state and out-of-state, in the Computer Science department.

The undergraduate program continues to grow each year with 714 students in Fall 2018. The total number of students (majors, minors, graduate students) is now

more than 900. Last year 98 bachelors and 10 masters students graduated, for a total of 108 graduates. A long-standing goal of getting to more than 100 graduates has been achieved!

The Computer Science major continues to be one of the largest majors for incoming freshmen in Fall 2018. Around 90% of the graduates continue to stay in Idaho. Combined with the fact that 35% of BSU students are from out of state, that is a remarkable accomplishment where it is very competitive to get computer science students to stay.

Boise State University Enhancing Capabilities in Nanotechnology and Microfabrication at Boise State ($500,000)

The overall goal of this IGEM project was to support the Idaho semiconductor and microelectronics industry by enhancing relevant infrastructure, equipment, expertise and educational programs at Boise State University. Augmenting nanotechnology and microfabrication capabilities in the Idaho Microfabrication Laboratory (IML) was a specific focus. The IML is a recharge center containing the largest university clean room in Idaho (approximately 2,500 square feet) as well as the adjacent 900 square foot Additive Manufacturing Laboratory. The facility is equipped to perform deposition, etching, micro- and nano-scale patterning, and physical and electrical characterization of many different types of materials.

Extraordinary growth of the IML occurred during the three-year grant period due to the tremendous support provided by IGEM-HERC. This progress is evidenced by multiple metrics:

- Total IML student usage hours quadrupled over the grant period, climbing from 654 in FY2015 up to 2627 in FY2018.
- The number of active student users logging billable hours approximately doubled, from 19 in FY2013, to 23 in FY2014-2015, to 39 in FY2018.
- Faculty utilization increased from 13 in FY2013 to 24 in FY2018.
- The number of grant proposals submitted requiring IML equipment or resources increased from 11 in FY2014 to 33 in FY2018.
- The number of hours charged to external users increased from effectively zero in FY2014 to approximately 170 hours (from six different organizations) in FY2018. The grant also permitted hiring of new faculty and staff and supported multiple PhD students. The IML is now positioned as a critical facility for a growing number of internal and external users performing a wide variety of research.

The initial IGEM proposal outlined four strategies aimed at cultivating innovative research and development opportunities centered on the IML. Specific details regarding the outcomes from each strategy are outlined below:

1. **Perform infrastructure improvements, capacity-building equipment acquisition and hire additional staff to increase operational efficiency and support capability of the IML**

   The appearance, functionality and utilization of the IML has completely transformed over the duration of this IGEM-HERC grant. Equipment purchased as part of the project has not only significantly increased safety, but also research output through reduction and (in some cases) elimination of scheduling conflicts by different users. One example is the purchase of separate chemical processing stations for acids, bases, and solvents, which allows three or more users to safely perform tasks and experiments simultaneously. In contrast, the IML previously had a single chemical bench, for which safety dictated that only one class of chemical could be used at a time. Additional deposition, etching, and metrology tools were also purchased and are now a critical component of many user processes.

   Equipment used for semiconductor processing and microfabrication often cannot be simply purchased and placed on a desk or tabletop. The complex equipment typically requires very specific facility connections, and many factors must be considered in the process of installation. Chief among these are the facility connections to the tool and ensuring that liquid waste or ventilation effluents are compatible with environmental regulations and safety standards. Broad expansion in these infrastructure systems was therefore undertaken as part of the project, including:

- Additional 100 Ampere (208 Volt 3-phase) power service completed in conjunction with Department of Public Works replacement of the building transformer.
- An ultra-pure nitrogen distribution system throughout the clean room supplied by a high capacity liquid dewar tank.
- De-ionized water line extension and replacement.
- Doubled thermal capacity of the chilled water system (in conjunction with a Facilities, Operations, and Maintenance project).

- Improved vacuum system.
- Numerous improvements to the ventilation and exhaust system to create more balanced flow and positive pressure in the clean room. While the impact of these upgrades is difficult to quantify, they are critical for continued growth and expansion of IML capabilities well into the future.

Finally, the grant funded the hiring and two years of salary for a technical support engineer who troubleshoots equipment issues, performs safety inspections and maintenance, and trains users. Having experienced staff who is able to constantly monitor the equipment, assist users and perform process qualification is crucial to sustained success of the facility in terms of research impact and revenue.

2. Expand expertise in three strategic research areas of strength through a tactical new faculty hire and subsequent support

The initial proposal called for the hiring of a new Electrical and Computer Engineering (ECE) tenure-track faculty with preferred emphasis in one of three emerging research areas. These areas were identified as flexible and printed electronics, thin-film and 2-dimensional (2D) materials, and neuromorphic computing. The faculty member hired with IGEM-HERC support (Dr. Harish Subbaraman) has already received significant external funding and has been performing impactful flexible and printed electronics research in the IML. The creation of this faculty position also helped facilitate numerous local, regional, and national research collaborations.

3. Increase industry partnerships and research collaborations with Boise State by providing straightforward access and technical support to the IML

Over the duration of the project, use of the IML by external organizations has increased from effectively zero hours in FY2014 to over 170 equivalent hours in both FY2017 and 2018. With some equipment rates exceeding $100/hour and additional surcharges for precious metal use, this corresponds to approximately $19,000 in revenue per year, coming from five different local companies. It amounts to 37% of the overall revenue of $51,000 generated by user fees. IML leadership, the ECE department, and the College of Engineering continues to work toward further expansion of mutually beneficial partnerships and agreements.

4. Create additional education and training opportunities in the areas of nanotechnology and microelectronics for industrial partners and students

The educational aspects of this IGEM-HERC project were an outstanding success. As previously described (and also detailed in section 4), the number of student users and student use hours increased dramatically during the project period. At the same time, the number of students enrolling in courses utilizing the IML also increased.

In Fall 2017, the ECE 440L/540L (Introduction to Integrated Circuit Processing) course had 12 students enrolled. In Spring 2018, a new ECE 497/597 (Memristor Fabrication) class had 18 students enrolled. In this class, students utilized the IML extensively to implement a full resistive memory device fabrication process flow. The MSE 280 (Intro to Materials Lab Practice) course in Spring 2018 had 15 students involved in projects that use the IML in some capacity for materials development. In addition, ECE 621 (Electrical Characterization of Semiconductor Materials and Devices) was added to the curriculum and was last offered as ECE 697 in Fall 2016 with enrollment of nine students. The course is complementary to the IML and has a lab component in which devices fabricated in the IML are tested and characterized. Additional offerings of ECE 441L/541L (Advanced Silicon Processing) and ECE 442L/542L (Photolithography) are planned in the upcoming two years, both of which will use the IML extensively. Many employers consider these types of hands-on learning activities to be very positive experiences.

IGEM - CAES

The Center for Advanced Energy Studies is a research and education consortium between Boise State University, Idaho National Laboratory, Idaho State University, University of Idaho and University of Wyoming.

APPROACHING 10 YEARS OF OPERATIONS, CAES DELIVERS REFRESHED STRATEGIC PLAN

On Feb. 20, 2009, the Center for Advanced Energy Studies (CAES) opened the doors to a new, state-of-the-art research and education facility. During its first 10 years, CAES has solidified collaborations between Idaho National Laboratory and the public research universities in Idaho and Wyoming, resulting in millions of dollars of federal research funding awards focused on solving challenges in multiple energy sectors.

In 2018, CAES assessed its existing strategic objectives, sought feedback from stakeholders on its mission and focus areas, and delivered a revised strategic plan on September 30, 2018. The new strategic plan rests heavily on research, education, and industry collaborations as its three foundational pillars. In addition, five relevant focus areas in nuclear energy, advanced manufacturing, energy-water nexus, cybersecurity, and innovative energy systems will drive investments and capability enhancements.

CAES COMPLETES HIRING OF NEW LEADERSHIP TEAM

In May 2017, Idaho National Laboratory appointed Dr. Noël Bakhtian as the new CAES director. In the time since her appointment, additional leadership team members have joined the organization. In November, CAES selected Anita Gianotto as its chief operations officer, and hired Ethan Huffman to oversee communications and legislative affairs. In March, Jeff Benson was hired as a business operations specialist to oversee CAES' contractual relationships with its affiliated universities, while Jana Pfeiffer was hired in April as a research operation lead overseeing CAES laboratory and research facilities. Finally, Leah Guzowski has been hired to be the director of industry research and development overseeing relationships with CAES' private industry customers. These individuals join an existing team of university faculty, staff, students and INL researchers who are working on CAES projects across Idaho and Wyoming.

CAES LAUNCHES VISITING SUMMER FACULTY PROGRAM

In June, CAES launched its first annual Visiting Summer Faculty program. The program aims to foster interaction and networking between university faculty and Idaho National Laboratory researchers with the goal of developing a joint funded research proposal of value to both organizations. CAES provided funding for six faculty members from CAES-affiliated universities to spend a week at INL working with a laboratory researcher on a proposal. The six collaborative teams worked on their proposals throughout the summer and returned to CAES in August to present their research whitepapers and proposals and seek feedback. Faculty members participating this year included Dr. Mike Hurley from Boise State University, Dr. Jon Brant from the University of Wyoming, and Dr. David Arcilesi, Dr. Mike McKellar, Dr. Dakota Roberson, and Dr. Michael Haney from the University of Idaho.

CAES HOLDS COLLABORATIVE PLANNING MEETINGS

In 2018, CAES sponsored an array of successful collaborative research planning meetings with top leadership and key research staff from Idaho National Laboratory and the four CAES-affiliated universities. The collaborative meetings allowed technical experts to discuss shared capabilities, review federal funding opportunity announcements, and draft whitepapers and proposals to seek federally funded research and development grants. Some of the CAES meetings included: an Isotope and Materials Roadmap Meeting with the Idaho Accelerator Center, a Grid Scale Energy Storage and Molten Salts Meeting at the University of Wyoming, a Global Materials Working Meeting at Boise State University, a joint Nuclear Energy University Programs Meeting in Idaho Falls, a Carbon Conversion Meeting at the University of Wyoming, and the 8th Annual Energy Policy Research Conference at Boise State University.

CAES DIRECTOR NAMED ONE OF BUSINESS INSIDERS' TOP FEMALE ENGINEERS

In celebration of Women in Engineering Day, Business Insider published a list of the 39 most powerful female engineers of 2018. CAES Director Dr. Noël Bakhtian was named the 11th most powerful female engineer of the year. Bakhtian, whose prior work experience includes technical and advisory positions with NASA, the U.S. Department of Energy, and the White House Office of Science and

Technology Policy, was appointed CAES director in May 2017. Business Insider is one of the most widely read business and technology websites in the world with more than 80 million monthly visitors. In naming each awardee to the list, the website noted "these are women with engineering backgrounds who are running big business units at important companies, are building impressive up-and-coming technologies, or acting as leaders and role models in the tech communities."

CAES BY THE NUMBERS

Investments:

- **$3 million** State of Idaho annual investment in CAES
- **$608,000** Idaho National Laboratory's allocated investment to support joint appointments with CAES affiliate universities

Outreach:

- **1101** visitors experienced the CAES Computer-Assisted Virtual Environment (CAVE) 3D data immersion research environment
- **48** workshops, seminars, and speeches sponsored by CAES

Student Impact:

- **92** students from CAES-affiliated universities interned at Idaho National Laboratory
- **Nine** students from CAES affiliated universities were offered graduate fellowships at Idaho National Laboratory
- **Five** students from CAES-affiliated universities were awarded postdoctoral appointments at Idaho National Laboratory

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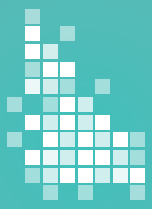

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