JAMES MADISON UNIVERSITY®

20|SENIOR
19|SYMPOSIUM

SCHOOL OF INTEGRATED SCIENCES

MAKING THE **CONNECTIONS**

Integrated Science and Technology

Intelligence Analysis

Geographic Science

Biotechnology

On behalf of James Madison University's School of Integrated Sciences (formerly the Integrated Science and Technology Department), welcome. Although our name has changed, our mission has not. We are still graduating talented, project-ready students who are focused in the areas of Integrated Science and Technology, Geographic Science, Intelligence Analysis, and Applied Biotechnology.

I am proud to serve as school director, as we celebrate our 23rd year of this unique capstone experience.

Throughout this book, you will discover the enormous breadth of work accomplished by our students in conjunction with their sponsors and advisors. Each of the 63 capstone teams describe their work applying science and technology in unique ways to solve some of our most pressing issues in society.

Our students have worked countless hours toward creative solutions to a wide variety of complex problems. Specific capstone topics are inspired by student ideas, posed by capstone sponsors, or guided by academic advisors. These problems are carefully crafted into capstone projects aimed at answering the questions raised, while giving our students the opportunity to combine their undergraduate knowledge with experiential learning. These projects showcase the integration of science, technology, systems thinking and domain-specific methodologies.

As I am sure you will agree, our future is in good hands.

Linda Thomas, J.D., Ph.D.
Director, School of Integrated Sciences

JMU
School of
Integrated Sciences

CISE
COLLEGE OF INTEGRATED
SCIENCE & ENGINEERING
JAMES MADISON UNIVERSITY

ACKNOWLEDGEMENTS

Our annual event would not be possible without the generous support of our donors and project sponsors:

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Deloitte
Devil’s Backbone Brewery
Differential Dynamics Corporation
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Ryan Luckay (’10)
Klebert Feitosa, JMU Physics Department
Forio
Paul Goodall
Grace Farms
JMU’s Alternative Fuel Vehicle Laboratory
JMU’s Center for Global Engagement
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Shenandoah National Park
TearSolutions, Inc.
Jake Lemon, Trout Unlimited
Vine & Fig
Virginia Department of Environmental Quality
Wise Foundation
Wood’s Edge Farm
Virginia Department of Historic Resources

CONTENTS

INTEGRATED SCIENCE AND TECHNOLOGY

The Integrated Science and Technology degree program prepares students to tackle a wide range of real-world problems. Students gain a broad foundation in various science and technology areas, learn to think holistically to address complex problems, and dive more deeply into one or more problem areas including Applied Biotechnology, Energy, Environment, Information and Knowledge Management, Production System, and Telecommunications, Networking, and Security. Exceptional versatility, an ability to see the big picture, and a strong grounding in the social context of problems distinguishes ISAT students from other technically focused majors.

A POLITICAL ECOLOGY OF "HIGH IMPACT LEARNING" THROUGH STUDY ABROAD

Presenters

Maja Jankowska, Jackie Pickford, Richard Selamaj, Julia Wood

Advisors

Jennifer Coffman, Maria Papadakis

Sponsor

JMU's Center for Global Engagement

A collage of the places where team members studied as part of their project: Maja in Thailand (top right), Richard in Tanzania (bottom right), Jackie in Malta (top left), and Julia in Virginia (bottom left).

The number of U.S. undergraduates studying abroad has increased dramatically in the past few decades, with one in ten U.S. undergraduate students earning academic credit abroad (IIE Open Doors, 2018). Considered a "high impact learning" experience, study abroad programs generally also have high environmental impacts due to the large carbon footprint of international travel. This project focuses on participation in specific study abroad programs to quantify per capita environmental impacts of international study and compare to the impact of studying in the United States for an equal amount of time. Three students studied abroad in three different programs—one in Laos and Thailand, one in Malta, and one in Tanzania—while the fourth student remained in Virginia. During these weeks and using a mixed methods approach, each student measured and recorded quantitative and qualitative data that were then used to draw conclusions about the environmental impact of international studies.

A PROSPECTUS FOR WIND POWER DEVELOPMENT AT COW KNOB

Presenters

Dylan Granados, Tess Jacobson, Zachary Lasek, Jonny Lizama, Brian Miles, Aaron Sortore

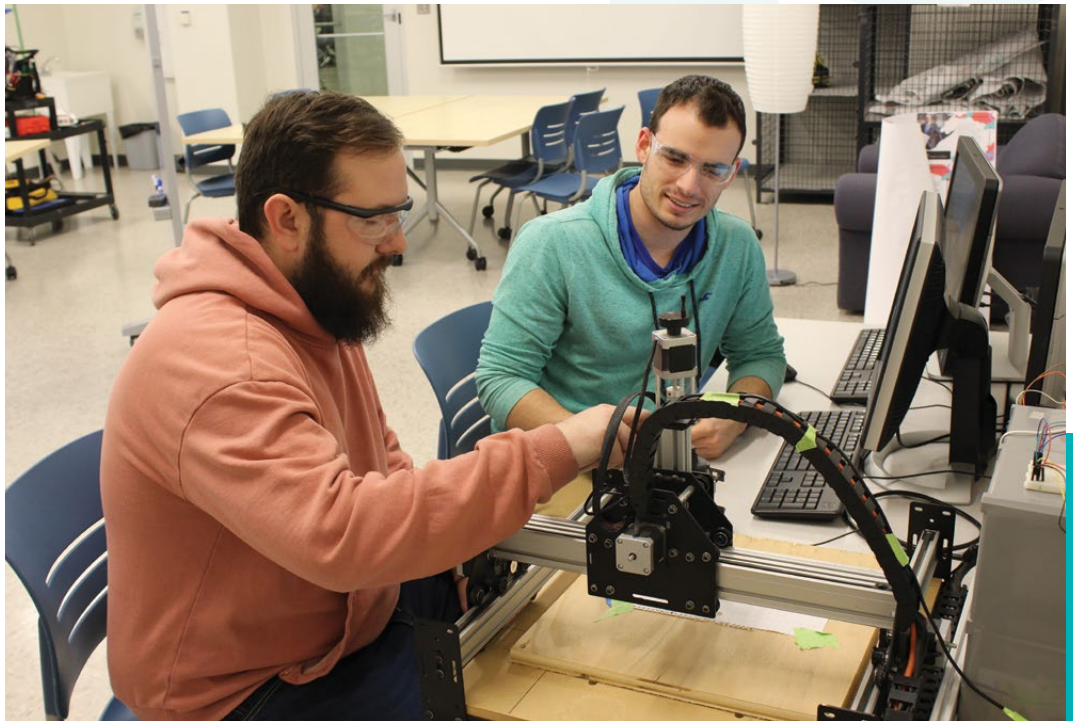
Advisor

Jonathan Miles

The team is presenting their research and modeling to county officials and gathering feedback as part of the wind farm permitting process.

As the renewable energy generation industry has matured, it has become increasingly technologically feasible and economically competitive, thus creating opportunities for Virginia to expand its utility-scale renewable energy portfolio. This project explores the complexity of wind farm development in Virginia, while addressing concerns among relevant stakeholders in the community and industry at each step in the development process. Deliverables associated with this project include a robust financial analysis, site analysis, and engagement with key stakeholders. The long-range goal of this effort is to advance Rockingham County in particular toward utility-scale wind development and to stimulate interest in such a project through extensive public outreach and communication with potential future participants.

A SUSTAINABILITY DECISION MAKING ARCHITECTURE FOR CYBERMANUFACTURING



Presenters

Joseph Siler, Scott Layne

Advisors

Hao Zhang, Ahmad Salman

Joe and Scott are looking for the best mounting location for the temperature sensors. The sensors will help monitor and make decisions based on limitations set by the system.

Cybermanufacturing, a new era in the manufacturing industry, uses computerized systems and the Internet of Things. Our project explores the sustainability decision making dynamics in cybermanufacturing systems. The proposed sustainability assessment and decision making framework examines economic, environmental, and safety & health performances of manufacturing processes and systems and utilizes assessment results and decision making algorithms to generate timely responses in manufacturing control. Our project contributes to cybermanufacturing research by developing a framework for enabling manufacturing equipment make cognitive decisions towards sustainability.

AN ANALYSIS OF THE PHYSICAL PROPERTIES OF INDUSTRIAL HEMP

Presenter

Hunter Hoggard

Advisors

Wayne S. Teel, Shelly Thomas

Hunter is conducting tensile testing on industrial hemp fibers to determine if the addition of inoculated biochar to the soil has any affects on the physical properties of hemp.

Hemp, one of the first plants to be spun into usable fiber, is used to make a variety of commercial and industrial products. This project focused on analyzing the growth rate, biomass, and tensile strength of industrial hemp with the addition of inoculated biochar to the soil. The soil amendment serves as a fertilizer, and a way to mitigate nutrient loss from the soil due to the nutrient retentiveness of biochar. The goal of the experiment is to determine if inoculated biochar influences the growth and tensile strength of industrial hemp by harvesting, measuring, and testing the dry stalks to obtain an accurate biomass. Using data acquired during the process, in addition to published data, a systems model was developed to see how the incorporation of industrial hemp into American agriculture can affect the economy, environment, and the citizens of the United States.

AN IOS APP FOR ENVIRONMENTAL PURPOSES: PRESERVATION OF CHESAPEAKE BAY

Presenters

Alexander Jacquay, Matthew Roper

Advisors

Dr. Samy El-Tawab, Dr. Carole Nash

Alex and Matt are using their newly developed iOS mobile app to mark an archaeological site.

The Chesapeake Bay is slowly losing its archaeological wonders to erosion. The preservation of such sites is becoming harder as the sea levels rise and the number of lost sites increase. This project attempts to aid archaeologists in their efforts to protect valuable information and artifacts through the development of an iOS application. The iOS mobile app allows members of the Chesapeake Bay community to connect with each other. Users can post pictures of archaeological sites with embedded GPS location, view postings chronologically, and comment on other user's posts.

AQUAPONICS: TROUBLESHOOTING THE WOOD'S EDGE FARM SYSTEM

Presenter
Juliana Kaiser

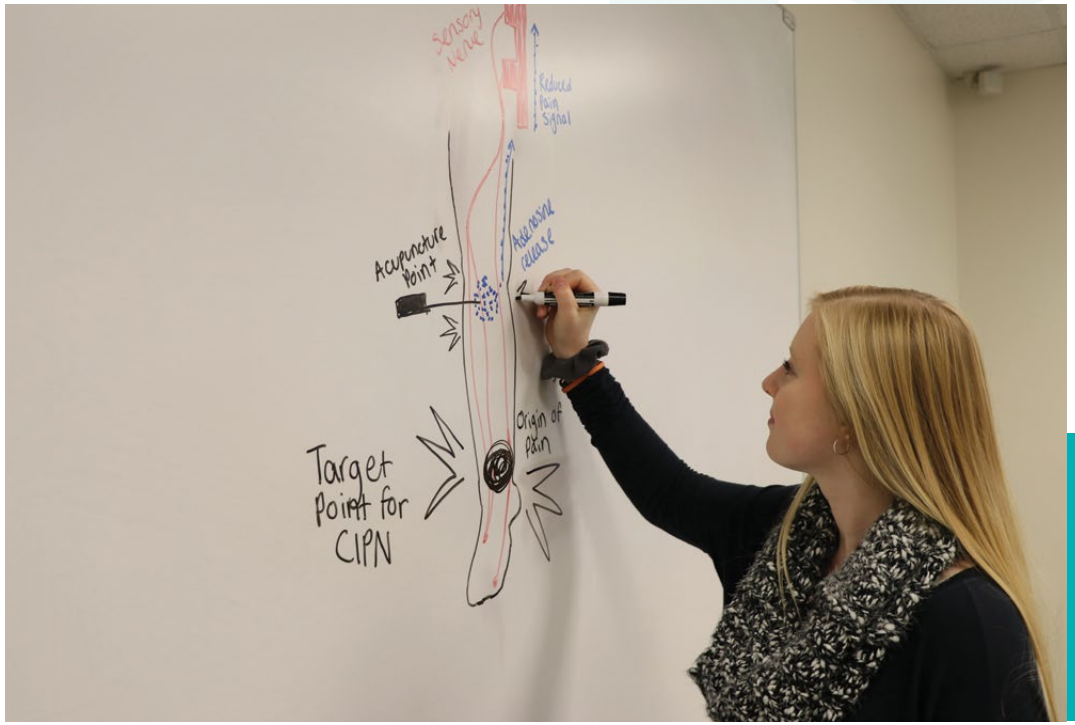
Advisor
Wayne S. Teel

Sponsor
Wood's Edge Farm

Juliana is examining greens grown in an aquaponic system at Wood's Edge Farm.

Soil depletion, overtaxed ecosystems, and food scarcity are growing issues due to an increasing world population. This project explores aquaponics, a system that combines hydroponics and aquaculture. The combination of growing leafy herbaceous greens and fish, usually tilapia, in a single sustainable system uses the waste of the fish as nutrients for the plants. Aquaponics serves as a partial solution to complex food production issues. This system is optimal for urban use, food deserts, or in regions where traditional farming is not an option due to climate change, which causes extreme weather leading to a surplus of rain or drought or in areas where soil depletion or overtaxed ecosystems cannot sustain crops. The custom designed aquaponics system at Wood's Edge Farm is currently battling problems with excess nutrients and sediment, resulting system blockages, and minor structural issues. Adding a settling tank, biochar filter, and repairing the lining of the fish tank addresses the system's problems.

BARRIERS TO ACUPUNCTURE FOR CHEMOTHERAPY-INDUCED PERIPHERAL NEUROPATHY



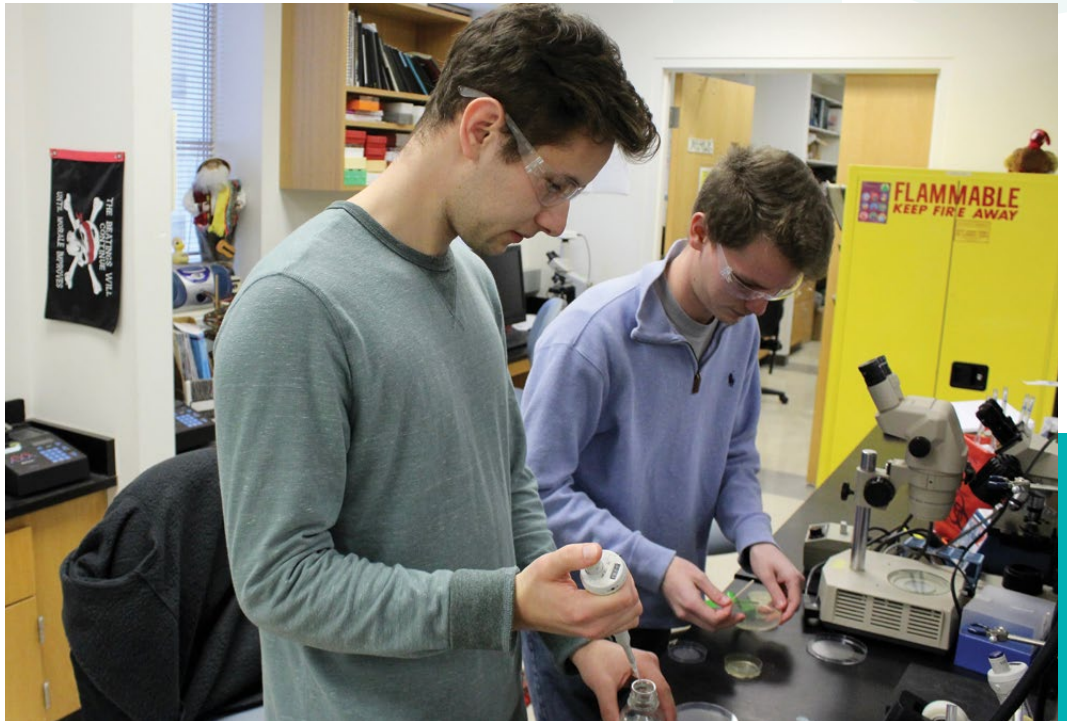
Presenter
Margaret Simpson

Advisor
Amanda Biesecker

Margaret is researching the use of acupuncture as a treatment for chemotherapy-induced peripheral neuropathy and determining the barriers for those undergoing treatment.

Chemotherapy-Induced Peripheral Neuropathy affects up to 80% of chemotherapy patients in the United States. Without a known cure, some patients turn to acupuncture as a treatment. This project explores the use and effectiveness of acupuncture for this disease and addresses the barriers preventing more patients from receiving it. Using survey results from acupuncturists in Virginia, we were able to compare the barriers and effectiveness of acupuncture between professionals and current clinical research. Our preliminary conclusion indicates the two most significant barriers for patients in Virginia are the cost for treatment and a lack of referrals from oncologists. Potential suggestions for overcoming these barriers will be identified.

BIOINFORMATIC ANALYSIS AND PURIFICATION OF BACILLUS PHAGE ENDOLYSINS



Presenters

Jackson McNeal, Zach Sevison

Advisor

Louise Temple

Jackson and Zach are running their liquid culture through an affinity column to separate the protein of interest from the other components of the cells.

Bacteriophage therapy has been an area of academic and medical interest for over 100 years, but has never taken hold in Western medicine practices. With antibiotic resistance continuing to grow among various disease-causing bacteria, medical researchers are looking for new sources of treatment. As alternatives to current antibiotics are being researched, our project focuses on bacteriophage-derived endolysin proteins as a potential solution to bacterial infection. We have used both bioinformatic techniques, as well as wet lab techniques to identify, purify and test the lytic activity of Bacillus phage endolysins on various strains of Bacillus bacteria.

BURNSHIRE HYDROELECTRIC: A CASE FOR SUSTAINABLE MINI-HYDROPOWER

Presenters

River Albo, Charles Bednarek, Bryce Butler, Ted Scherer, John Williams

Advisor

Carole Nash

Sponsor

Burnshire Hydroelectric, LLC

The team is working with Burnshire Hydroelectric, LLC, in Woodstock, Virginia to assist in the 'low impact' certification process and test the capability of inverter technology to sustain energy output at varying flow rates.

A challenge to the economic viability of small-scale hydroelectric plants, many of which still exist in rural America, is their capability to generate power under variable conditions of river flow while mitigating environment impact. Our project with Burnshire Hydroelectric, LLC, a mini-hydropower facility in Woodstock, Virginia, addresses these challenges by testing a new, more flexible inverter technology. Our team evaluated the inverter by running field tests for different flow rates, thereby generating comparative data for the output of the new technology vs. non-inverter output. We were also involved in a LIHI (Low Impact Hydropower Institute) certification effort, researching and writing sections of the application to document the low-impact of Burnshire's operations while opening doors to green energy markets. With the inverter technology and LIHI certification, Burnshire can become a model for the economic viability and environmental sustainability of small-scale hydropower.

CITIZEN SCIENCE ON VIRGINIA'S EASTERN SHORE

Presenter
Maren Luper

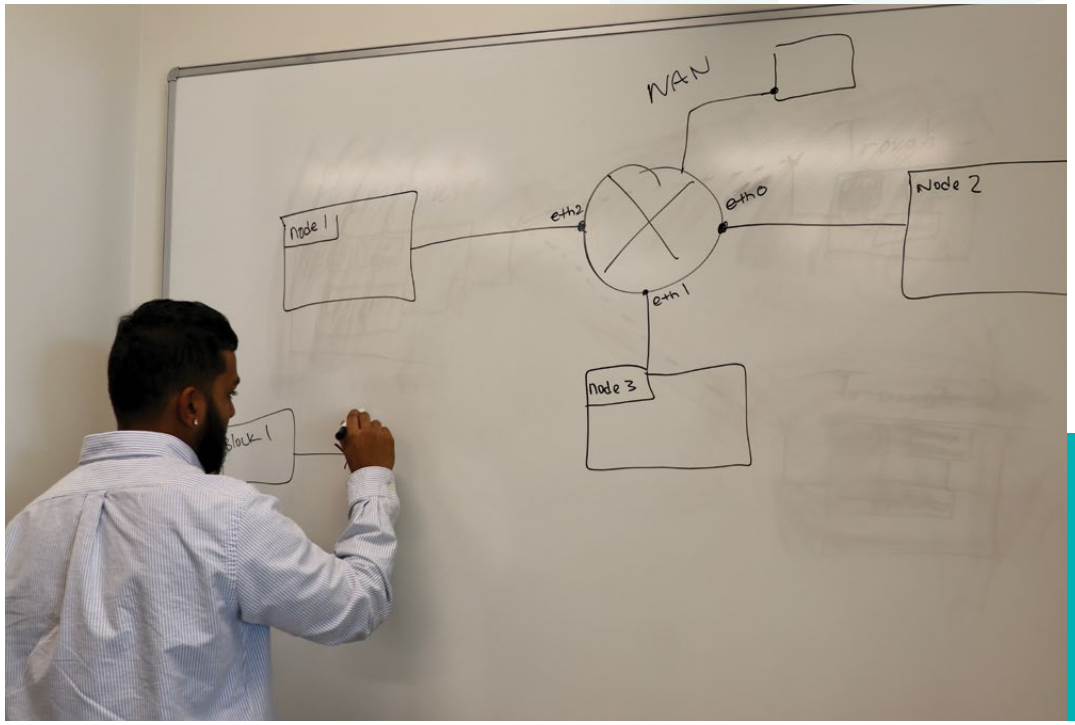
Advisor
Carole Nash

Sponsor
Virginia Department of Historic Resources

Maren is working with the Virginia Department of Historic Resources to develop a citizen science-based monitoring program that documents the impacts of climate change -- and especially sea level rise -- on heritage resources. Her regional focus is Virginia's Eastern Shore.

The shorelines of Virginia's coastal regions are seeing significant erosion associated with sea level rise and subsidence. A consequence of this climate change impact is the loss of cultural heritage sites that represent the coast's earlier occupants and provide community identity for contemporary residents. This project, designed for Virginia's Eastern Shore, employs citizen science — wherein the general public assists scientists and researchers with data collection — to document heritage resources. The creation of a mobile app that will allow residents to record basic information on site condition follows new examples from the UK, where citizens actively participate in monitoring coastal damage and documenting significant structures at risk. The integration of the collected data into Virginia's V-CRIS (Cultural Resource Information System) geodatabase is also explored.

DEMONSTRATION: DECENTRALIZED APPLICATIONS IN BLOCKCHAIN PRIVATE ENVIRONMENT



Presenters

Ryan Rambilas, Zach Shaver

Advisor

Emil H. Salib

The team is setting up a router to build a private network and test their blockchain application.

Bitcoin and the technology behind it, Blockchain, has become increasingly popular - and it is changing the world of currency. Our project explores the use of Blockchain in other applications. Using the Ethereum platform, we created and configured a private Blockchain environment on our own built and managed network (isolated from the uncontrolled public Blockchain environment). This separated us from the main Ethereum Blockchain environment, making it easier to explore, study and incorporate our own decentralized applications. We disovered that Blockchain technology can affect applications such as voting, and medical records exchange. It has the potential to change many transaction- and ledger-based industries and community interactions.

DERML: A MACHINE LEARNING MOBILE APP THAT ASSISTS IN SKIN CANCER DETECTION

Presenter

Joy Williams

Advisor

Anthony A. Teate

Joy is using her app to examine a mole on her forearm. The probability that the mole is cancerous will be determined after a picture is taken.

Each year in the United States, over 5.4 million cases of nonmelanoma skin cancer are treated. Fortunately, skin cancer is the easiest cancer to cure if diagnosed and treated early; however, early detection is not always easy. The aim of this project is to develop a solution for early skin cancer detection that is readily available to 70%-80% of smart phones users. derML is a mobile application developed for the Android platform that uses machine learning and image recognition technology with Google's TensorFlow framework to find patterns in pictures of skin moles, lesions, or other anomalies. The intent is for the algorithms to accurately predict if a given image of a skin anomaly is cancerous or benign and deliver that information to the user through an easy-to-use app.

DESIGN AND IMPLEMENTATION OF A GENERALIZED BLOCKCHAIN

Presenters

Sakshi Desai, Chris Feeney, TJ Langhorne

Advisor

Anthony A. Teate

The team is developing a dynamic blockchain and containerizing it over multiple Raspberry Pi's to understand the proof of concept.

Blockchain is a distributed transaction and data management technology that was originally developed for Bitcoin cryptocurrency. Blockchain, at its core, is a secure distributed database of records known as a ledger and contains a record of all transactions that have taken place since the blockchain's instantiation. By keeping record of each transaction, a Blockchain can insure the information's origin and the authenticity of the data being exchanged. The goal of our project is to develop a generalized blockchain model using the Python programming language that can then be adapted for a variety of applications. We intend to deploy a distributed voting application using Amazon Web Services (AWS) and containerizing it using flask on multiple raspberry pi's.

DESIGNING THE USER INTERFACE FOR A FOREST FIRE MANAGEMENT DEVICE

Presenters

Austin Fairchild, Christopher Jones

Advisor

Steven Frysinger

Sponsor

Shenandoah National Park

Chris and Austin are presenting a mockup of the data collection application they designed for the Shenandoah National Park forest fire management team.

In three weeks, the Rocky Mount Fire burned over ten thousand acres of forest, making it the worst fire in Shenandoah National Park history. This project aims to design a user interface for a multifunctional mobile application that focuses on predicting and preventing forest fires. The application will allow employees and researchers at the Shenandoah National Park to easily access past data and collect new data in real time. Using the interaction design process, we remodeled the current procedure by giving employees easier access to data inputs they need and a more efficient way to save and access data.

DEVELOPMENT OF A DIAGNOSTIC TOOL FOR DRY EYE ASSOCIATED OCULAR DISEASES

Presenter
Ethan Tyler

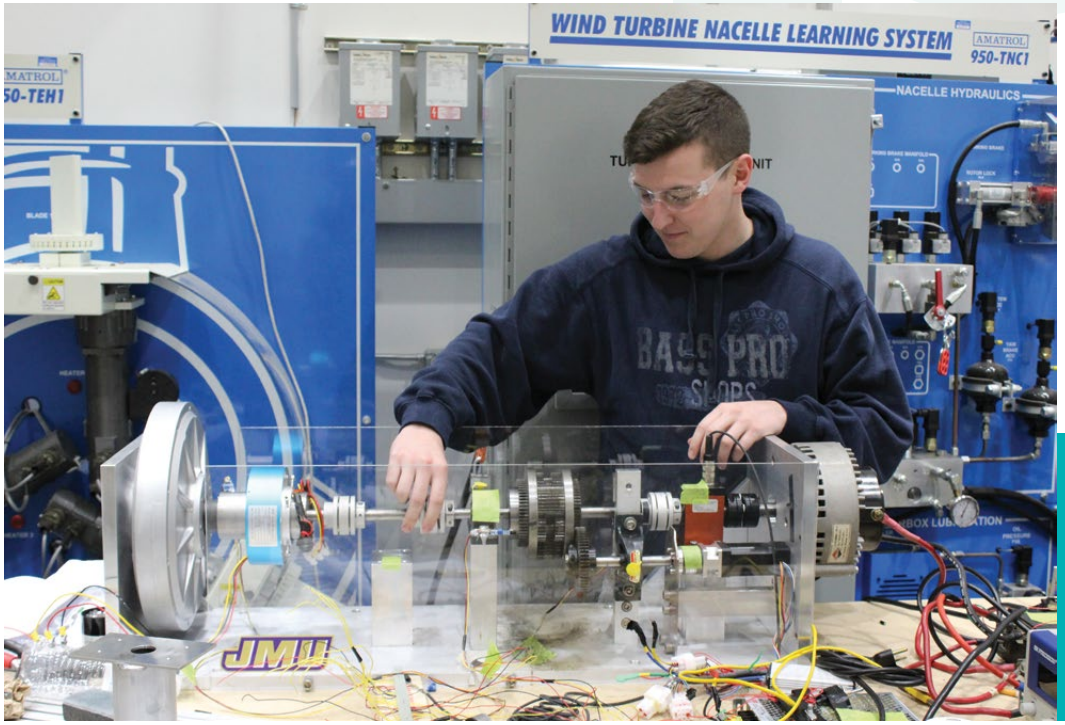
Advisor
Robert McKown

Sponsor
TearSolutions, Inc.

Ethan is developing an immunoassay as a diagnostic test to quantitate levels of the human tear protein lacritin which has been reported to be reduced in patients diagnosed with dry eye associated ocular diseases.

Sjögren's syndrome (SS) is an autoimmune disease with early clinical symptoms of decreased tear secretion that can become systemic with serious complications. As many as four million Americans are living with SS and there is no cure for this disease. SS is often undiagnosed or misdiagnosed because there are no diagnostic tests to confirm the disease. Identification of key tear proteins disrupted by SS may provide biomarkers for diagnosis and potential new drugs for treatment. Lacritin is a tear protein recently reported to be reduced in patients diagnosed with SS. The purpose of this research is to determine if lacritin is a biomarker for the diagnosis of SS and if topical application of lacritin can restore secretory properties in patients suffering from SS. A prototype tear lacritin diagnostic assay has been developed and will be tested with tear samples collected from patients with SS during a human clinical trial.

DEVELOPMENT OF NOVEL GEARBOX WITH TRANSGEAR



Presenters

Andrew Jenkins, Joseph Timmins

Advisor

Jonathan Miles

Sponsor

Differential Dynamics Corporation

Andrew is fabricating a prototype transgear to be incorporated into the powertrain of a small wind turbine.

Wind energy accounts for more than 7% of the total power generated in the United States and this percentage is rising each year. Most utility-scale wind turbines reply on power electronics to condition the power produced and regulate frequency; however, there may be limits to how large a turbine for which power electronics are suitable. The purpose of this project was to create a gear system that allows the rotor of a wind turbine to rotate at variable speed while delivering torque at a constant speed to the generator, in order to facilitate connection to the grid without the need for power electronics. We explored a mechanical alternative for frequency regulation of large wind turbines by incorporating a gearbox that uses a transgear which resulted in a functioning prototype.

DRAG REDUCTION ON CORRUGATED SURFACES

Presenter

Jacob Sortore

Advisor

Karim Altaii

Sponsors

Klebert Feitosa, JMU Physics Department

Jacob is working with the fluid lab wind tunnel to study drag reduction on corrugated surfaces.

Drag reduction is desired in many applications such as transportation and the wind turbine industry. There are large energy costs and inefficiencies because of the drag on a system. In collaboration with the Physics Department at JMU, the goal of this project is to lower drag by roughening the surface - similar to how the dimples in a golf ball lowers its drag. Using Solidworks, an Ultima 3D Printer, and JMU's wind tunnel, our project aims at designing several dimpled surfaces and testing them against a smooth surface to identify if drag is being lowered. The tentative conclusion of the project is that dimpled surfaces will lower drag at certain speeds and additional design may be required to find the ideal dimpled surface for a specific speed.

ENSURING QUALITY DURING THE EXPANSION OF DEVIL'S BACKBONE BREWING COMPANY

Presenters

Grant Drohat, Brendan Nulty, Alex Petze, Jacob Painter

Advisor

Chris Bachmann

Sponsors

ISAT Alumni Coey Jenkins, Director of Quality - Devils Backbone Brewery

The "Brew Crew" is working with Chief of Quality at Devils Backbone, Coey Jenkins, to optimize the breweries current bottling process in Lexington, Virginia.

As the Devil's Backbone Brewery Company has grown and expanded (following their acquisition by Anheuser-Busch), maintaining the quality of their beer has become a top priority. Our project focuses on assessing the performance of their automated bottle filling system to ensure the highest possible filling speed without compromising quality. To do this, several key parameters were measured including: Total Packaged Oxygen, Total Oxygen, and Carbon Dioxide. These parameters were measured for each of the 20 filler heads on the automated bottling system when filling a variety of different beverages. This data was used to develop tolerances for different types of beer and to determine performance characteristics for each individual filler head. The final deliverable includes a maintenance and operating schedule for Devil's Backbone Brewery that ensures the quality of their beer remains consistent as they continue to expand.

ENVIRONMENTAL MONITORING USING A DRONE-ENABLED WIRELESS SENSOR NETWORK

Presenters

Brooke Potter, Gina Valentino, Laura Yates

Advisors

Tom Benzing, Ahmad Salman

The team is using a drone to remotely capture water quality data from a sensor placed within a stream.

Water quality is traditionally monitored by manually collecting of stream samples. Limiting factors such as time and money often result in less oversight of impaired water bodies, significantly threatening stream health and related ecosystem services. 84% of US rivers and streams are not monitored, resulting in significant lapses in available data (United States Environmental Protection Agency, 2004). Such lapses reduce the efficiency and effectiveness of monitoring, restoration, and conservation efforts. The objective of this study is to employ an unmanned aerial vehicle (UAV) to remotely collect data from Boones Run, a potentially impaired tributary of the South Fork of the Shenandoah River near Elkton, Virginia. Stream conditions will be monitored prior to restoration using wireless sensor nodes to collect the data from the stream and securely transmit it to a server for analysis via a UAV. This process is compared to traditional data collection in terms of efficiency.

FEASIBILITY OF TINY HOUSE LIVING

Presenters

Daniel Benish, Caleb Smith, Tikhon Ivanov

Advisor

Steven Frysinger

The team is examining a tiny home to better understand how to implement design features.

Current trends in the United States housing market show an increase in the average square footage of homes, which directly corresponds to an increase in average housing prices. This is causing home ownership rates to decline, creating a dire need for affordable housing. Our project identifies and addresses the problems with current living trends and the feasibility, advantages, and societal impacts of downsizing. It explores how tiny homes can play a major role in addressing affordable housing issues, current environmental issues, and ecological footprint concerns of the United States. Our goal is to present tiny house living as a realistic future and explain the needs and challenges of our current consumer culture.

FEASIBILITY STUDY OF SOLAR PHOTOVOLTAIC FOR JMU WARSAW PARKING DECK

Presenter

Conner Saunders

Advisor

Tony D. Chen

Sponsor

JMU Facility Management

Conner is conducting a survey to see if it is feasible to add solar to the rooftop of JMU's Warsaw Parking Deck.

The purpose of this capstone project is to assess the feasibility of a 30-kW photovoltaic (PV) electricity generation system on the rooftop of Warsaw Parking Deck on James Madison University's (JMU) campus in Harrisonburg, Virginia. The potential power production from the PV system will be estimated through analysis of the climate information and utilizing PV systems modeling software such as RETScreen® and Solmetric SunEye™. In this feasibility analysis, three designs — each with different capacity and selection of PV panels — will be modeled and simulated to determine the optimal system for the university.

FILTERING GREYWATER FOR USE IN EDIBLE LANDSCAPING IN HARRISONBURG, VA

Presenter
Luke Boswell

Advisor
Jennifer Coffman

Sponsor
Vine & Fig

Luke conducts percolation tests to inform the design of a greywater irrigation system at Vine & Fig.

As the population of Harrisonburg, Virginia, has grown over the past few decades, so has the demand for water. Household water reuse helps reduce the strain of increased demand on the local water system, and recycling options can decrease operations costs from local wastewater treatment plants. This can help homeowners save on utility costs. Greywater, water that comes from sinks, laundry machines, and showers, can be recycled for such purposes as irrigation for gardens, including food production. The objective of this project is to design and test biochar filters for a greywater irrigation system for food production at the Vine & Fig. Biochar can remove organic pollutants from water, such as those found in some personal care products, pharmaceuticals, pesticides, and more. Biochar serves as a more "environmentally friendly" filtration medium than store-bought filters, as it is locally produced and, post-filter, becomes a soil amendment. This research project's studies of greywater impacts on food crops builds on data collected by previous researchers.

GREENHOUSE GAS INVENTORY ANALYSIS FOR THREE VIRGINIA CITIES

Presenter

James Short

Advisor

Rod MacDonald

James is conducting an analysis to help reduce greenhouse gas emissions from buildings and transportation sources.

In October of 2018, Harrisonburg City Council granted permission to the Environmental Performance & Standards Action Committee (EPSAC) to begin developing their Environmental Action Plan to implement sustainable and climate-friendly initiatives in Harrisonburg, Virginia. An essential part of the Environmental Action Plan is a greenhouse gas inventory, which will gather emissions data from residential, commercial, municipal, and transportation-related sources within Harrisonburg to serve as a baseline to track future reduction goals. To prepare EPSAC to undertake a greenhouse gas inventory, this project analyzes the previous inventories for Blacksburg, Fairfax, and Arlington, Virginia. The analysis includes a comparison of the goals and methods of the three Virginia cities and involves the modeling of data sets used in their analysis. The goal of this project is to aid EPSAC in structuring the Harrisonburg greenhouse gas inventory in the best way possible.

HYBRID RENEWABLES FOR TRANSPORTATION VEHICLES

Presenters

Brent Davis, Keith Short

Advisor

Tony D. Chen

Keith and Brent are installing a thin-film type of photovoltaic panel and a miniature wind turbine on a model car.

The current demand for solar panels and wind turbines is growing. Greenhouse gases (GHGs) are destroying our atmosphere and transportation is one of the main producers of these GHGs. In this project, we plan to install a thin-film type of photovoltaic panel and a miniature wind turbine on a model car. The goal of this project is to create a vehicle that can harness energy while sitting still with the solar panel and also harvest energy when moving with the wind turbine. The wind turbine will have to be placed in one of the vortex regions in the back of the vehicle to avoid adding any more drag force to the vehicle. Minimizing drag force is a key factor in placing the wind turbine and will be the main field of study for this project.

INCREASING FUEL ECONOMY AND REDUCING EMISSIONS IN MODERN ENGINES USING E10

Presenters

Kevin Frautschi, Cordell McCurry, Salar Hajaii

Advisor

Chris Bachmann

Sponsor

JMU Alternative Fuel Vehicle Laboratory supported by the Wise Foundation

The team is gathering data from an exhaust gas analyzer and dynamometer during a testing session.

Blending ethanol into gasoline is common practice in the United States as part of a government initiative to reduce dependency on foreign oil, environmental impact, and the cost of fuel. Unfortunately, most internal combustion engines are not properly tuned to run on ethanol or ethanol blends. Using a modern, fuel-injected 2011 Harley Davidson Sportster engine, we assessed the fuel-loss incurred with 10% ethanol blends (E10). Our team researched possibilities to improve energy efficiency and decrease vehicle emissions by re-tuning the vehicle's on-board computer. These optimizations can be easily replicated and applied to other fuel-injected, spark ignition vehicles. If applied throughout Virginia and Nationwide, this simple re-tuning strategy would yield significant fuel savings and substantial reductions in harmful exhaust gas emissions.

INTEGRATION OF AUTONOMOUS PLATOONING IN FREIGHT TRANSPORTATION

Presenters

Tucker VonCannon, Bradley Saxman, AJ Stiles, Jimmy Longest, Jack Pickerell, Alex Martin, Joel Tigges, Philip Stratos

Advisors

Chris Bachmann, Emily York, Samy El Tawab, Shannon Conley

Sponsor

ISAT Alumni Ryan Luckay

The team is conducting an energy analysis on potential energy savings that will come from freight transportation platooning using the JMU wind tunnel. The team is also creating a proof-of-concept to demonstrate platooning using two 1/8th scale RC-Cars.

Currently, there are 7.3 million people employed in the trucking industry. The trucking industry transports 70.1% of total domestic tonnage throughout the United States; however, autonomous vehicles are expected to transform the way goods are transported. Our project investigated the potential benefits and challenges of commercial autonomous vehicles used for freight transportation. To do this, an energy analysis examining potential energy savings of vehicle platooning was conducted using the JMU wind tunnel. Two 1/8th scale proof-of-concept autonomous vehicles were designed and constructed, and a scenario analysis of the social, political, and economic implications of widespread autonomous vehicle adoption was performed. It is evident that there are both positive and negative impacts associated with deploying autonomous commercial trucks on a large scale throughout America's roadways.

INVESTIGATION OF SCROLL EXPANDERS FOR DATA CENTER LOW-GRADE HEAT RECOVERY

Presenters

Grayson Stubenhofer, Taylor Dean

Advisor

Tony D. Chen

Taylor and Grayson are testing a Tesla turbine-generator to be installed in a low heat recovery system using the Organic Rankine cycle.

Almost two-thirds of the total primary energy supply (TPES) in the US is rejected and lost through conversion as waste heat. Thus, heat recovery systems have become an attractive component in solving the modern carbon conundrum. This project explores the utilization of a 1-kW scroll expander in an Organic Rankine cycle (ORC) system to produce useful work output from a low-grade waste heat source such as data center hardware. The project investigates the use of different working fluids for system optimization using EES® by f-chart. Research and development of ORC systems is a promising component in the shift to adopting a more energy conscious model in our future society.

ITROUGH: A SUSTAINABLE APPROACH TO LIVESTOCK WATER TROUGH MONITORING

Presenters

Matthew Chamberlain, Kabeer Mehdi

Advisor

Emil H. Salib

Sponsor

Paul Goodall

The team is working on a way to remotely monitor water troughs through the use of cyber-physical systems. This system aims to improve the efficiency of farms and reduce excess runoff from entering our waterways.

As farmers embrace environmental stewardship, many plan to improve surface water quality by excluding cattle and establishing riparian buffers along streams and rivers. This requires establishment of mechanical watering systems for the cattle. Our project aims to develop a remote monitoring system that alerts the farmer in the event of a watering system failure. Using Zigbee/Xbee wireless units, the water level and ambient temperature at the troughs are collected and sent to an RPi unit in a designated water pump house. Water pressure and ambient temperature in the pump house are also collected and the aggregated data are stored on the RPi unit in the pump house. If any measurement falls outside of a preset range, an SMS notification message is sent to the farmer's cell phone alerting him to the type of malfunction.

LIFE CYCLE ASSESSMENT OF LARGE CHILLER EQUIPMENT MANUFACTURING

Presenters

Emillo Byrd, Benjamin Netzel

Advisor

Hao Zhang

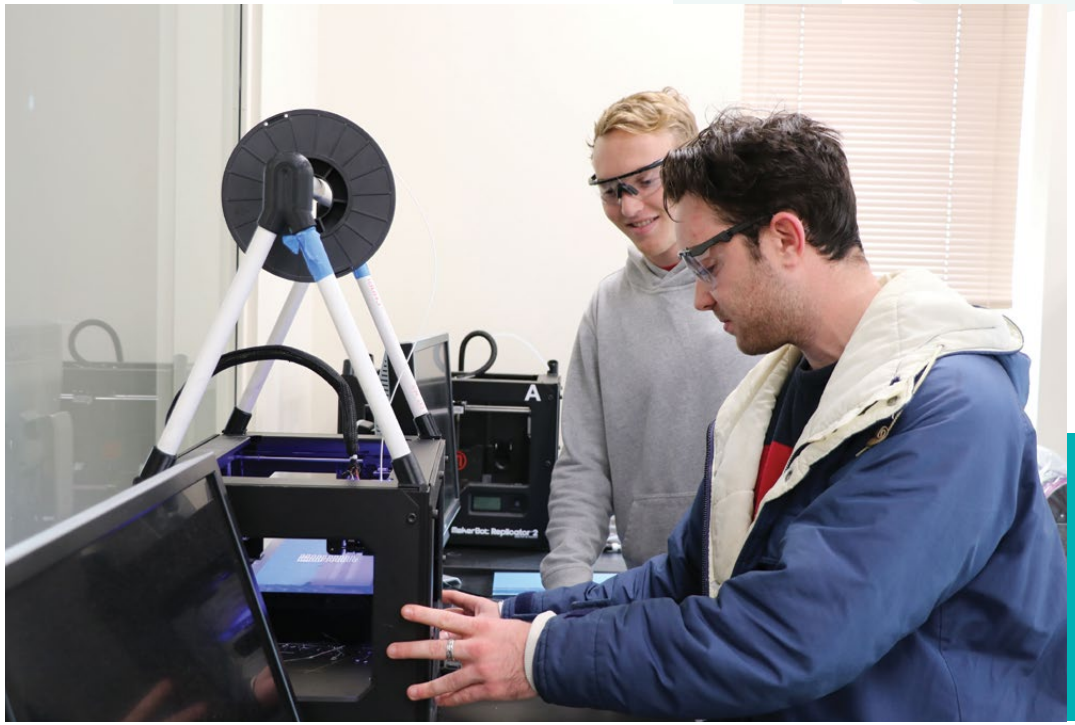
Sponsor

Daikin

The team is analyzing the life cycle of chillers to determine ways to reduce their environmental impact while increasing their sustainability.

Chemical compounds in our most widely used refrigerants such as chlorofluorocarbons (CFCs) are a major source of destruction to the lower atmosphere. The heating, ventilation, and air conditioning (HVAC) industry has been striving to increase equipment efficiency by reducing the use of CFCs and energy consumption through a redesign of energy efficient condensers, evaporators, and compressors. The objective of our research is to understand the life cycle environmental impact of chiller equipment with two bearing systems, oil bearing and magnetic bearing compressors. Life cycle assessment results reveal that about 76% of GHG emissions comes from energy consumption during the use stage, followed by refrigerant with 24%. Material use and manufacturing activities contribute to less than 1% during a chiller's 30 years life. Our results show that when designing chiller equipment, improvement should to be focused on increasing energy efficiencies of compressors and seeking alternative refrigerants that cause less environmental impact.

LIGHTWEIGHT STRUCTURE MATERIAL SYSTEM DESIGN FOR ADDITIVE MANUFACTURING



Presenters

Owen Gagnon, Brenton Whanger

Advisor

Hao Zhang

The team is using a 3D printer to build prototypes of their bio-mimetic structures (Auxetic, Bone Tissue, and Giant Lily Pad).

Product designers have been inspired by structures from nature materials such as bone, honeycomb and lattice to reduce material use and cost. These complex structures can now be easily made by layer by layer additive manufacturing. Lightweight designs have significant potential in industrial application such as vehicles, aerospace equipment, and devices such as phones and laptops. Our project takes a systems approach for the design of lightweight structure material systems. The system approach consists of four dimensions including unit structures, functionality, material layers, and physical properties. A case study was conducted based on auxetic, bone, and giant lily pad structures for the lightweight material design. The results of this research offers new insights into the design, manufacture and application of smart lightweight structures in engineering fields.

MADISON CONSERVATION CORPS

Presenters

Joseph Timmins, Micauly Torrey

Advisor

Morgan C. Benton

The team is measuring the energy usage of homes in the Harrisonburg area.

Madison Conservation Corps is a student founded organization focused on mitigating the effects of climate change through the conservation of energy. We aim to help people understand why and how they can help their community by providing free and efficient energy audits to residential homeowners in the valley. Our service provides students with hands-on professional experience while also reducing fossil fuel consumption and greenhouse gas emissions. This process not only saves our clients money but helps to provide a more environmentally sustainable future.

MAKER SPACES: CONCEPTS TO REALITY

Presenters

Jake Boltz, Phillip McGowan, Will Roussel, Jonathan Sarker

Advisor

Rebecca Simmons

After conducting phone interviews with makerspaces from across the country, the team examines similarities and differences to identify factors critical to makerspace success.

Maker spaces are collaborative workspaces designed to foster learning, innovation and collaboration. Our project identifies the opportunities and challenges faced by existing maker spaces in the United States, as well as looking ahead to the next generation of the Maker Movement. Through research acquired from local and regional maker spaces across the country, we determined the limiting factors of a successful maker space and factors that influence the ability of a maker space to succeed in today's Fourth Industrial Revolution. Our research provides insight on expectations in the new maker movement along with establishing a baseline for existing maker spaces.

MANUFACTURING CURRICULUM PACKAGE DEVELOPMENT FOR VALLEY HIGH SCHOOLS

Presenter

Andrew Lough

Advisors

Rebecca Simmons, Cindy Klevickis, Jerry Ridgeway

Andrew is working with high school educators to develop a manufacturing curriculum package that addresses employers needs.

As America's economy continues to grow and the baby boomer generation retires, there is a critical need for skilled workers in the manufacturing sector. To address this need, it is important to teach high school students the skills employers are looking for. This will prepare students to move directly into jobs upon graduation. Using a project-based approach, a manufacturing curriculum course package was developed for high school educators that addresses these needs and is flexible for schools with financial and administrative limitations. The curriculum also teaches students how to build a portfolio that applies previous class knowledge and experience. Students can submit their portfolio with job applications to trade schools or to traditional colleges.

MOBILE PYROLYSIS KILN FOR MAKING BIOCHAR FROM FOREST WASTE

Presenter

Desmond Gray

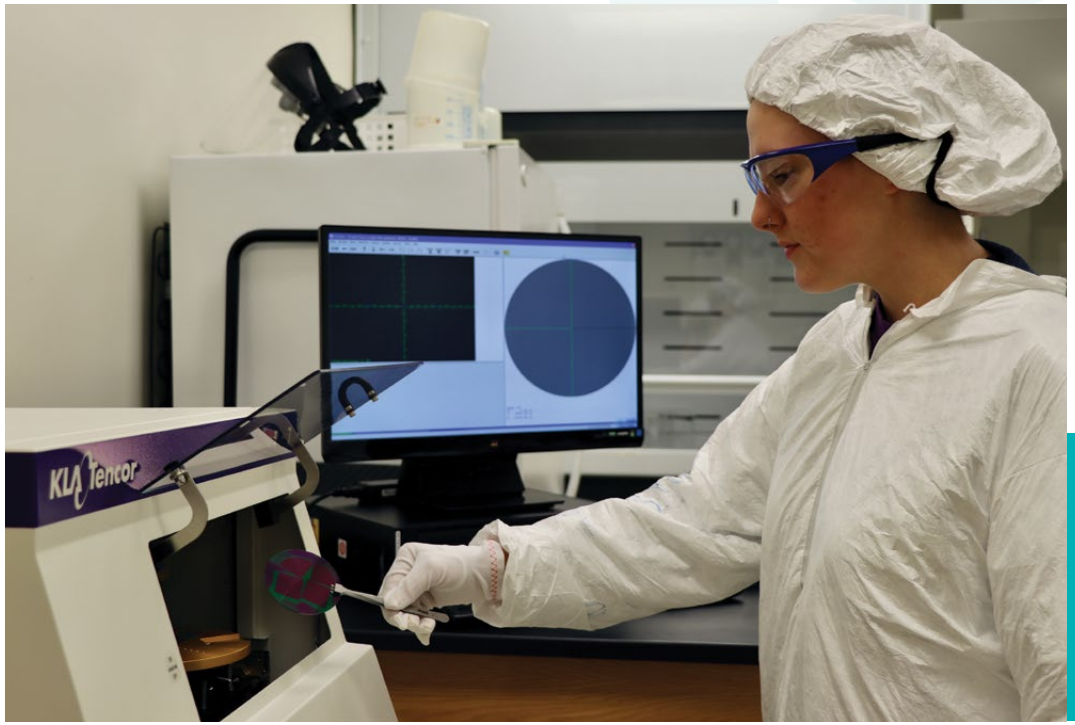
Advisor

Wayne S. Teel

Desmond is examining a Hillside plot where he applied biochar as a soil amendment.

Across the west, wildfires have rapidly increased in number and severity. Our project explores a way to address this problem that can be easily and quickly implemented. We developed a small-scale pyrolysis system that uses a conical, metal kiln, which can be brought directly to feedstock sources, such as forests with a large on the ground biomass load susceptible to fire. This eliminates the need to collect the biomass and ship it using fossil fuel powered transport to a separate location for biochar production. Widespread but local implementation of this technology will help integrate biochar use broadly in society and increase general knowledge of its properties while reducing fire risk.

RENEWABLE HYDROGEN PRODUCTION VIA THE ARTIFICIAL LEAF



Presenter

Brianna Smith

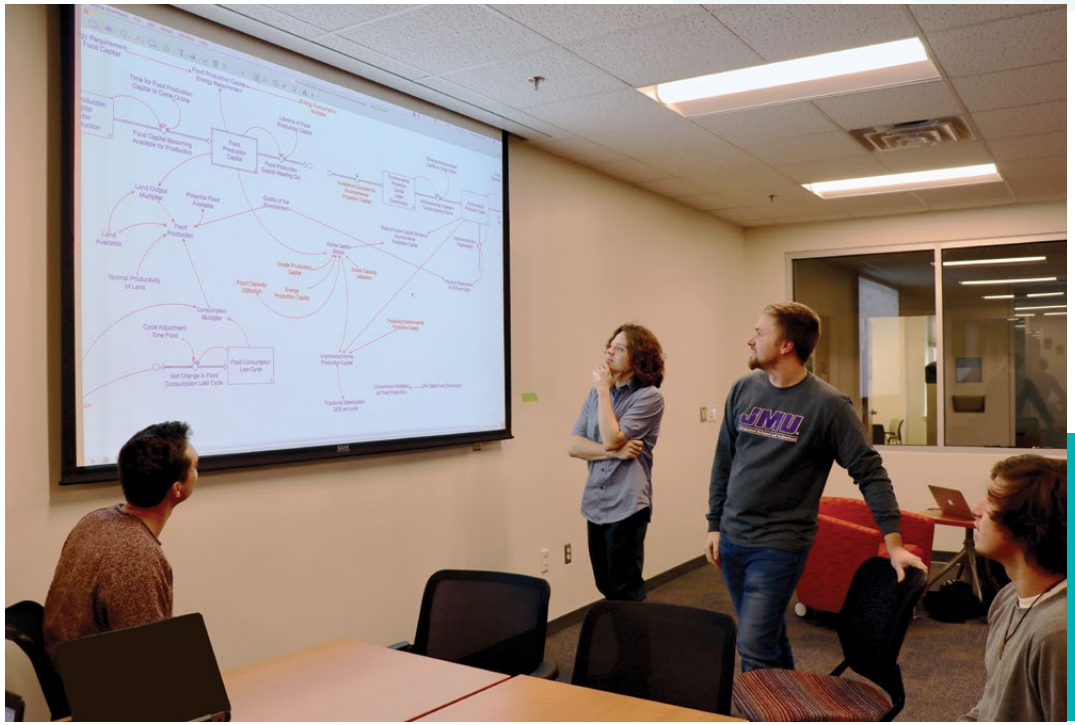
Advisor

David J. Lawrence

Brianna is inserting a photovoltaic cell sample into a surface profiler system. This system is being used to measure step height, which is a useful way to characterize material thickness.

Hydrogen is a promising fuel since the only byproduct of its combustion is pure water. Today, the majority of hydrogen is generated through unsustainable methane reforming processes; however, the renewable process of photoelectrochemical (PEC) water-splitting has become more popular in recent years as it can produce hydrogen from seawater and sunlight. Artificial leaves — devices that combine solar cells and water-splitting catalysts — are an example of promising PEC technologies. This project aims to fabricate artificial leaves with improved performance over those produced in previous capstones. Specifically, the bismuth vanadate ($BiVO_4$) photocatalyst layer will be made thicker in order to increase the surface area available for water-splitting, and a transparent antimony-doped tin oxide (SnO_2:Sb) scaffold will be added to the leaf in order to improve the transport of electrons through the structure.

STRATAGEM REMASTERED



Presenters

Sean Grier, Anton Foretich, Antoine Edelman, Joe Ziegler

Advisor

Rod MacDonald

Sponsors

Michael Bean, Forio

The team is modernizing the 1995 Stratagem model developed by Dennis Meadows. Stratagem is an educational tool that can be used by educators around the world to teach others about managing complex systems.

In 1985, Dennis Meadows, author of Limits to Growth, created the computer-aided board game Stratagem to promote systems dynamics concepts in a more understandable way. In the game, players are "ministers" of a developing nation and are responsible for allocating resources to grow their economy in an environmentally sustainable manner. Players gauge the repercussions of their decisions over 10 rounds and gain a general familiarity with feedback. At the end, the structure of the game's system is analyzed against the decisions made by the players, to learn about the capacity for human decision-making and to improve it. Permission has been granted to our team to recreate the game using modern applications such as Vensim and with support from Forio, which provides web-based hosting for the game and technical support for the development of the user interface.

STREAM STRESSOR ANALYSIS FOR THE NORTH FORK RIVANNA RIVER AND TRIBUTARIES

Presenters

Celeste Horton, Christopher Williamson

Advisor

Robert Brent

Sponsor

Virginia Department of Environmental Quality

The team is using a YSI multi-parameter probe to record long-term water quality data. The data will be used to look at diurnal shifts in 5 parameters: pH, turbidity, temperature, conductivity, and dissolved oxygen.

According to the Virginia Department of Environmental Quality (VDEQ), there are over 15,000 miles of impaired waters throughout the state. Our project aims to determine the pollutants or stressors that are causing impairment in 8 specific streams in the North Fork Rivanna River watershed. Water quality data were collected to continuously monitor 5 specific parameters: pH, conductivity, temperature, dissolved oxygen, and turbidity. These data, together with historic data collected by VDEQ, were analyzed using a modified Causal Analysis/Diagnosis Decision Information System (CADDIS) approach, designed by the Environmental Protection Agency (EPA) to guide stressor identification in impaired waters. Using this data analysis approach, we discovered that the most probable stressors throughout the watershed were sediment and nutrient pollution. The VDEQ will use these findings to develop a cleanup plan to restore these waters.

SUSTAINABLE LIVING DESIGN: BUILDING AND EVALUATING A TINY HOUSE

Presenters

Thomas Harton, Justin Starnes

Advisor

Jonathan Miles

The team is working to build a sustainable tiny home, equipped with renewable energy sources making it operational completely off-grid.

Tiny houses are becoming increasingly common and popular among various demographics. They are gaining traction around the world and enabling people to live more sustainably. The goal of this project was to design and build a tiny house that is energy-efficient, affordable, livable, and completely operational off the grid. The project required designing various energy systems that manage heat transfer and power generation. While building the tiny house, we aimed to document and demonstrate the steps involved in building a sustainable tiny house and consider the potential future economic and coding/infrastructure challenges associated with tiny houses. A major outcome of our project is to demonstrate how one can live within one's means in an affordable and comfortable manner.

SYSTEMS DESIGN OF LOWER LIMB EXOSKELETON TO INCREASE RUNNING SPEED

Presenters

Zachary Deutal, Tristen Spencer

Advisors

Hao Zhang, Roshna Wunderlich

The team is modifying their exoskeleton design on Solidworks and improving the prototype for testing.

Approximately two soldiers are sent home every day because of lower limb injuries. However, these injuries can be minimized by using a lower limb exoskeleton suit. This project explores sustainable design of lower limb exoskeleton for solider. The objective of our research is to understand the ergonomics of the lower limb exoskeleton suit, design and construct a suit with lightweight materials and technology that support the weight a soldier must carry while increasing the speed and range of motion of the soldier. In this study, a design was created to increase the running speed for soldiers. Our results show that a spring system is able to increase ground reaction force during walking and running. The proposed exoskeleton design is able to increase human speed.

THE BIOCHAR IMPACTS ON SOIL NUTRIENT AND CARBON CONTENT IN THE ISAT MEADOW

Presenters

Jonathan Brittell, Grant Rabalais

Advisor

Wayne S. Teel

Jon and Grant are marking Hillside plots for the application of biochar.

Current studies estimate that biochar production and application at its peak is capable of offsetting 12% of current greenhouse gas emissions. The ISAT hillside meadow is a site for a long term study on soil carbon that has 8 sites amended with compost and 8 controls of equal size. We added four biochar plots along with controls. We identified and spread biochar composted with cattle manure on the plots in the spring of 2018. Our aim is to collect, analyze, and present data to affirm the projections of biochar's effectiveness. The full impact of biochar additions is often only revealed after a longer period than the duration of our study. Our data will establish a baseline for future studies and provide a snapshot of the current state of soils in the hillside meadow. Our scope of research included a biomass survey, soil nutrient content, organic carbon content, as well as soil testing done by Waypoint Laboratories.

THE IMPACT OF TREE CLEARING ON A TROUT STREAM CROSSED BY THE ATLANTIC COAST PIPELINE

Presenter
Jack Schrof

Advisor
Thomas R. Benzing

Sponsors
Jake Lemon, Trout Unlimited

Jack is gathering information on the damage caused by the tree felling that occurred due to the Atlantic Coast Pipeline.

The Atlantic Coast Pipeline is a large-scale interstate transport project to convey natural gas for a growing nation. During its construction, the pipeline has the potential to impact natural resources including trout streams. This study represents a continuation of measurements made on Hodges Draft, a trout stream in Augusta County. The purpose is to compare water quality during construction with 2 years of baseline conditions.

USING TENSORFLOW MACHINE LEARNING TO DEVELOP A SMALL AUTONOMOUS VEHICLE

Presenters

Benjamin Bland, Kashaun Finch

Advisor

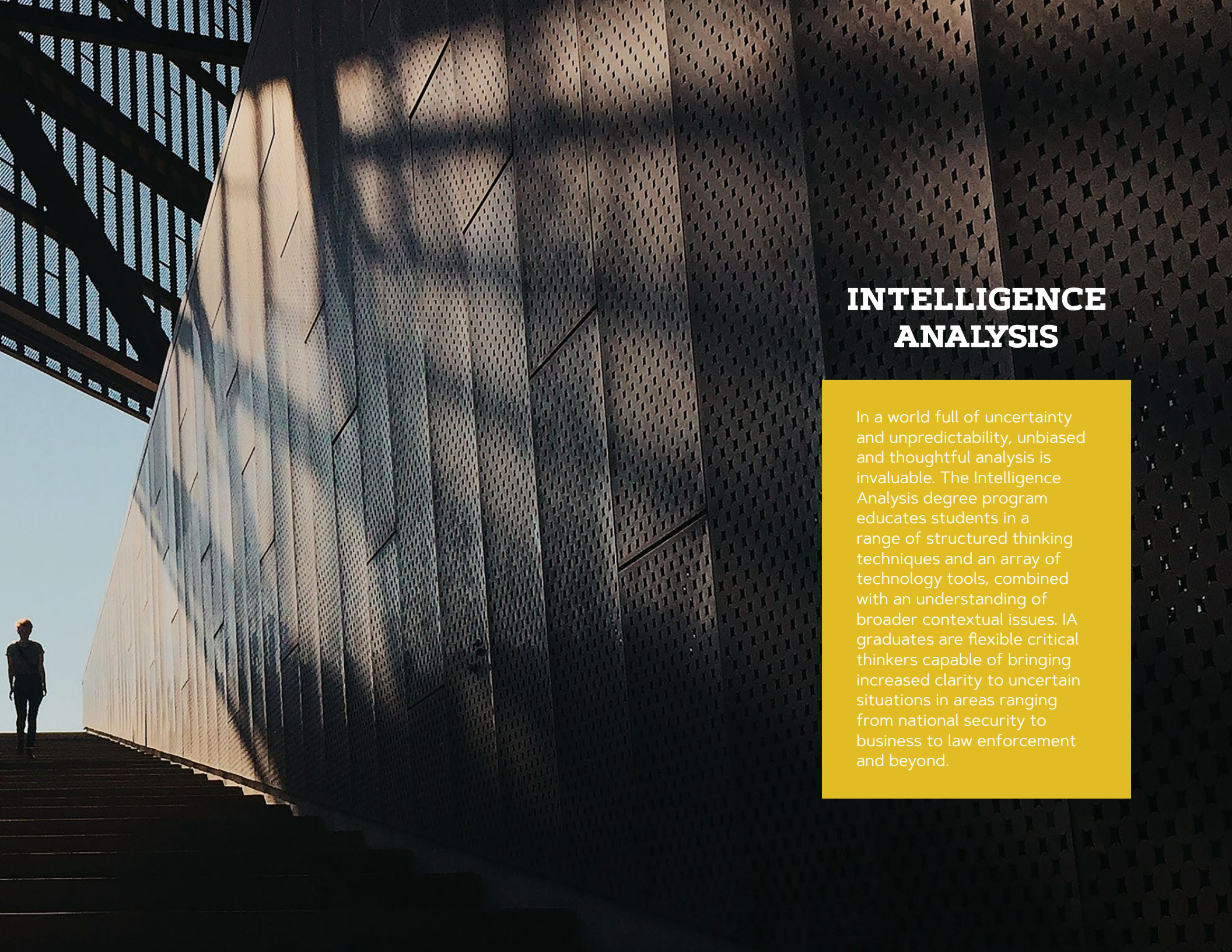
Anthony A. Teate

Sponsors

Ryan Luckay, Deloitte

Ben and Kashaun are assembling their robotic cars before embedding learning algorithms into the Raspberry Pi's that power the cars.

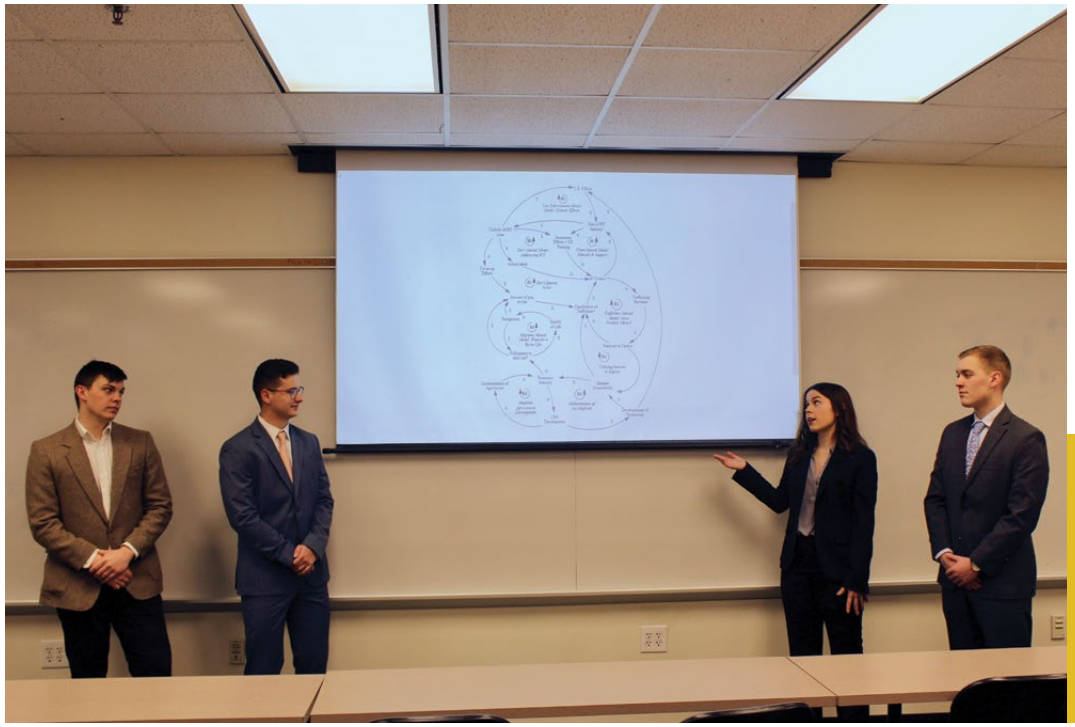
Autonomous features are slowly being introduced into recent car models. Our team is aiming to create our own autonomous robotic car using a Raspberry Pi, Python, the Google Vision API, and TensorFlow. The first stage of the project focused on allowing the car to recognize logos, and having it "speak" what it saw through a speaker. The second stage of the project focused on creating our own algorithm in TensorFlow and embedding the algorithm onto the Raspberry Pi, allowing it to recognize stop signs and turn lane arrows and navigate accordingly. The car will also be able to upload its algorithms to a cloud environment, where other cars with lower-scoring accuracy models will be able to download the more accurate model. This models how cars could be maintained in the future by downloading updates from the manufacturer.



INTELLIGENCE ANALYSIS

In a world full of uncertainty and unpredictability, unbiased and thoughtful analysis is invaluable. The Intelligence Analysis degree program educates students in a range of structured thinking techniques and an array of technology tools, combined with an understanding of broader contextual issues. IA graduates are flexible critical thinkers capable of bringing increased clarity to uncertain situations in areas ranging from national security to business to law enforcement and beyond.

ANALYZING HUMAN TRAFFICKING IN THE MAGHREB REGION OF AFRICA



Presenters

Hunter Brickhouse, Mary Elise, Gavin McCain, Ethan Brown

Advisor

Steve Marrin

Sponsor

Grace Farms Foundation

The team is explaining the Causal Loop Diagram they made to illustrate the underlying systems which play into the dynamics of human trafficking in the Maghreb region of Africa.

Human trafficking is a global issue that transcends sovereign boundaries and reduces individuals to numbers and labor. Our project analyzes how the current economic environment and migratory factors contribute to the future increase or decrease of human trafficking within the Maghreb region of Africa. This region covers Algeria, Morocco, Tunisia and Libya. Our analysis generates an increased understanding of the problem and the factors surrounding it, in efforts to better aid in informing decision makers about trafficking.

ASYMMETRIC WARFARE AND FUTURE CONFLICT

Presenters

Kayla Rogers, Brendan Zack, Olivia Viparina

Advisor

Noel Hendrickson

Sponsor

MITRE

The team applies futures analysis and cyber threat analysis methodologies to evaluate current and future geopolitical trends likely to result in global conflict.

In a world of increasing global conflict, asymmetric warfare provides US adversaries with a new arena to accomplish their nefarious objectives through nontraditional means. The U.S. Intelligence Community continues to recognize cyber operations as the most prominent threat associated with asymmetric warfare. Our assessment explores the future scenarios of conflict for China, Russia, and North Korea and how they might use offensive cyber strategies against the U.S. Government, allies or interests. Identifying and providing recommendations to mitigate future cyber threats from our most significant adversaries will help protect U.S. political, military, economic, social, infrastructural, and informational interests.

CHINA: DO THE UIGHURS REPRESENT A SERIOUS THREAT?

Presenters

Bridget Read, Ryan Walters

Advisor

Tim Walton

Sponsor

National Ground Intelligence Center

The team evaluated the Uighur people's security risk to China through both U.S. and Chinese perspectives.

The People's Republic of China (PRC) portrays Uighur fighters as a justification for counter terrorist actions, but are the central government's claims legitimate? The Chinese government has imposed heavy-handed countermeasures to prevent domestic-based separatist movements from spreading, at the cost of alienating members of the targeted populations and leaving them vulnerable to recruitment by Islamist extremist groups in the Middle East. Western media is often sympathetic to the Uighur population, leaving Western intelligence agencies and decision-makers with biased information. This project aims to evaluate the situation from a Chinese perspective through Red Teaming. In order to construct a better understanding for U.S. decision-makers on how Chinese decision-making works, each methodology utilized in during the analysis will be flipped and evaluated using Chinese reasoning.

EVALUATING MOTIVATIONS OF DOMESTIC TERRORISM

Presenters

Britta Rollins, Mike Barton, Joseph Chavez, Timothy O'Shea, Logan Reynolds

Advisor

Steve Marrin

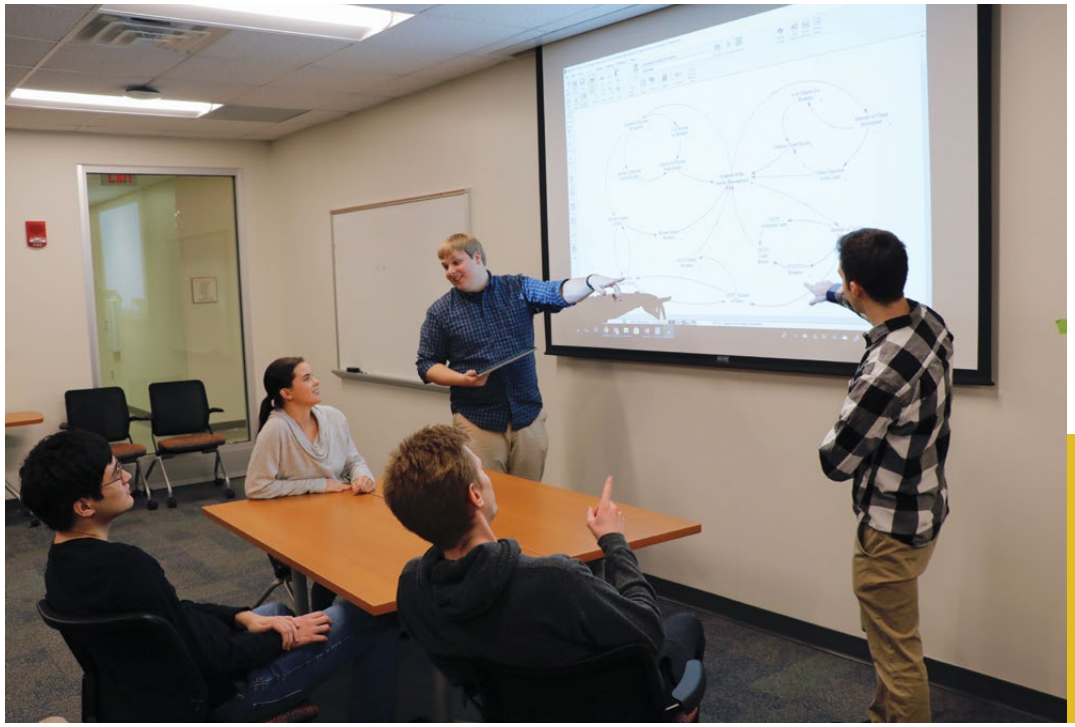
Sponsor

MITRE

The team uses a Structured Analytical Technique to evaluate and construct future scenarios to better understand the plausible shifts in the domestic terrorist threat environment.

When we think about terrorism, we often think about foreign threats; however, many acts of terrorism come from within the United States. This project focuses on the likely shifts in domestic terrorism motivations and tactics between now and 2025. This project uses standard analytical techniques to better understand the shifts in domestic threat environments and to postulate future trends of terrorism. It helps us better understand lone wolf and group terrorist trends and tactics, providing opportunities in improving counterterrorism and preemptive approaches for MITRE and their homeland security, defense, and intelligence clients.

EVOLVING SPHERES OF INFLUENCE AND RISKS FOR GLOBAL CONFLICT



Presenters

Hunter Pratt, Morgan Boswell, Colin Cahill, Christian Davis, Mark Mathies

Advisor

Steve Marrin

Sponsor

MITRE

The team is working to construct Causal Loop Diagrams explaining the dynamics between states in regions of the world.

This project assesses the likelihood of interstate military conflict by 2030 resulting from expanding and contracting Chinese and Russian spheres of influence. Through an in-depth examination of spheres of influence, the project produces a forecast of the potential for conflict between states. The project focused on Russia and China and determined the six regions where they appear to be looking to expand their spheres of influence, East Asia, Central Asia, the Middle East, the Arctic, Eastern Europe, and Africa, with each of these regions receiving scenarios that helped produce final forecasts at a regional and global level. The assessment focuses on how conflict can result from the interaction of spheres of influence as states compete over geography. This project will enable the sponsor, MITRE, to improve analysis through the assessment of spheres of influence, providing new insight into the drivers of interstate conflict.

HOW MIGHT AI IMPACT THE ROLE OF CI IN THE FEDERAL CONTRACTING INDUSTRY

Presenters

Andrew Ciampini, Alexa Dinunzio, Juliana Holloway

Advisor

Qingjiu Tao

Sponsor

Accenture

The team is collaborating and working together to develop methodologies that best represent the future impact of artificial intelligence.

The objective of our project is to determine a handful of potentially promising AI platforms that will assist Accenture's Competitive Intelligence team with their CI cycle process. Through research, we have identified various opportunities and implications and incorporated them into scenarios. We hope that after suggesting multiple different scenarios along with a scorecard matrix that rates each platform efficiency based on different categories, we can provide solid recommendations to the client along with how they will have to adjust their process accordingly in order to work the most efficiently with the platform they want to potentially integrate into their day to day work.

MAPPING WHITE SUPREMACY ACROSS THE INTERNET

Presenters

Emma Leonard, Ariel Kennedy, Lisa Colelli

Advisor

Kathleen Moore

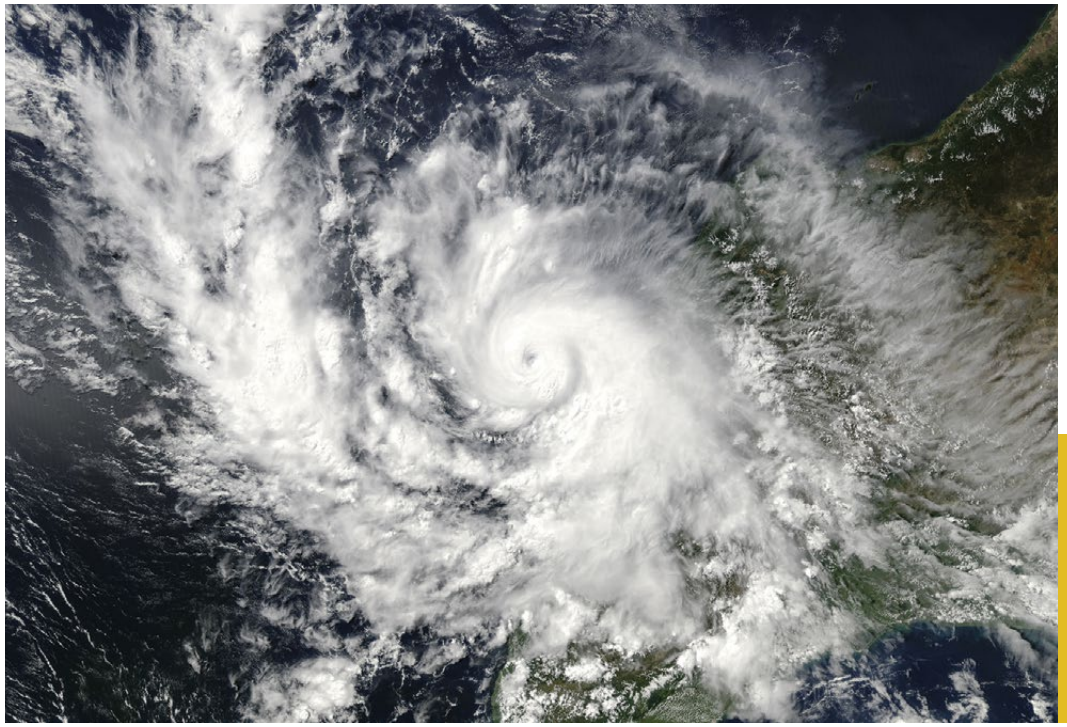
Sponsor

Undisclosed Name

The team is working to dissect and understand social network relationships within the White Supremacist movement on dark web forum sites.

The 2017, Unite the Right rally in Charlottesville, Virginia started a trend of Internet censorship that forced the white supremacist movement off private Surface Web sites and social media and onto the Dark Web. There is concern that through these actions, such groups are free to organize and coordinate, potentially violently, unhampered by law enforcement. This project analyzes the scope of Internet presence amongst actors in the white supremacist movement and where these communications take place. The results of this project will allow law enforcement to properly assess the threat of Dark Web with concern to the movement, while also proving a methodology for future investigations.

MONITORING NATIONAL DISASTER VIA REMOTE SENSING



Presenter
Nureli Musabay

Advisor
Xuebin Wei

Nureli is studying the risk of future storms by analyzing Hurricane Maria's Aftermath in Puerto Rico.

The island territory of Puerto Rico, with less than 4 million residents, faces an unprecedented and challenging reconstruction after the devastation left behind by Hurricane Maria. The research project aims to investigate an analytical and geospatial perspective on existing datasets to provide insight on areas that are at more risk by natural phenomenon's or potentially worsening socioeconomic conditions. Multidimensional critical thinking methodologies and geospatial tools are utilized to bridge gaps in knowledge by assuring a broad range of issues are covered. Applying these methods helps develop a more coherent discussion of topic and reduces assumptions and limitations of data.

MOTIVATIONS, ORIGINS, AUTHORITIES, AND FUTURE ROLES BEHIND CHINESE CYBER ADVERSARIES

Presenters

Rachel Miller, Myles Goggins, Melissa Toman

Advisors

Kathleen Moore, Tom Tao

Sponsor

SAIC

The team is constructing the charts necessary to assess the future threats of Chinese cyber adversaries using counterfactual reasoning tools.

Anthem, Amazon, Google, the U.S. Navy, Apple, and NASA. These are just a few of the many high-profile U.S. companies and organizations targeted by Chinese hacker groups in recent years. As hacking abilities continue to become more sophisticated, many organizations have begun taking proactive measures to safeguard their operations from future breaches. Working alongside the Science Application International Corporation (SAIC), our team's findings detail the motivations, origins, and tactics of significant Chinese cyber adversary groups through the use of case studies. In addition, methodologies such as Hypothesis Testing and Counterfactual Reasoning are utilized to provide insight into the current threats that Chinese hacker groups pose to the US, as well as forecast how they will evolve and influence future conflict.

NEW AGE TERRORISM: FORECASTING RECRUITMENT METHODS

Presenters

Aren Kiladjian, Paul Bernier, Zachary Bernier

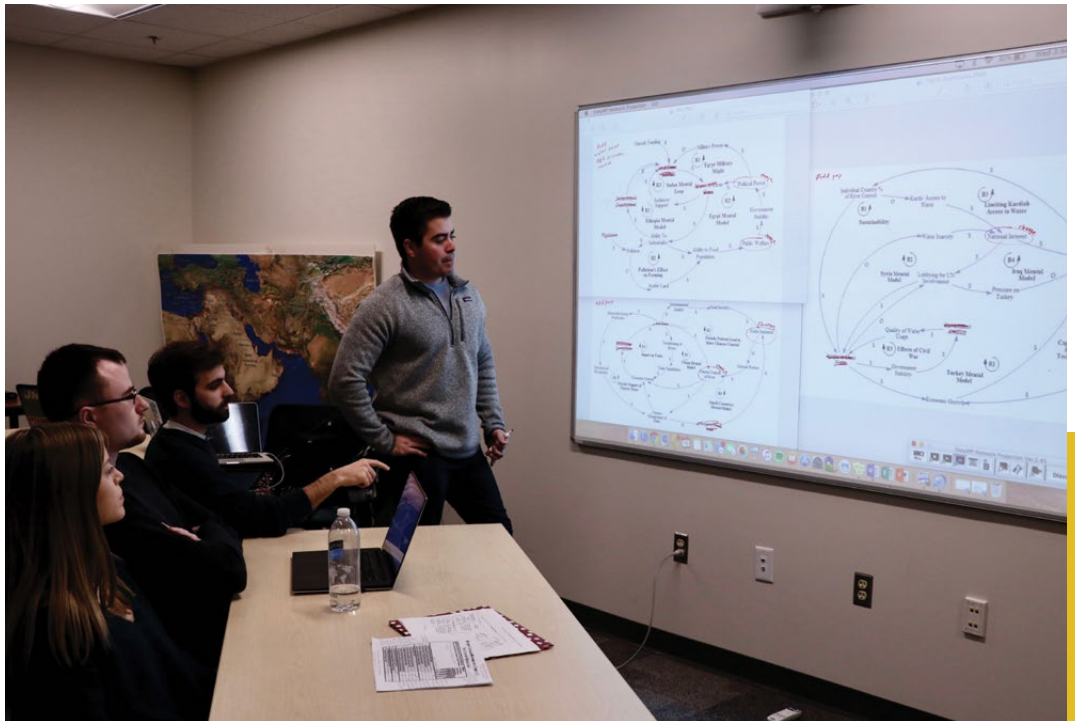
Advisor

Xuebin Wei, Kathleen Moore

The team is analyzing the terrorist recruitment cycle and how it applies to groups such as the Islamic State and al-Qaeda.

Few people associate terrorist organizations with social media propaganda. However, groups such as the Islamic State have increasingly made this their primary recruitment tool. While historically groups have relied on traditional methods of recruiting assets including kinship, monetary incentives, and intimidation, advances in technology have shifted techniques. An example is the recurrent video propaganda, social media posting, and individual targeting conducted by ISIS, which has attracted global attention. This research examines historical and current methods employed by terrorist groups to identify patterns, shifts in techniques, and the extent to which changes in the technological, political, and socio-economic environments could plausibly influence new-age terrorist recruitment. Our analysis identifies plausible future scenarios as well as social media and dark web usage to provide intelligence community members with an understanding of how organizations garner support, how this may change in the future, and what steps can be taken to prevent their growth.

RESOURCE WARS: EXAMING CURRENT AND POTENTIAL FUTURE WATER CONFLICTS



Presenters

Ian Campbell, John Saliba, Madison Sesemann, Adam Tett

Advisor

Tim Walton

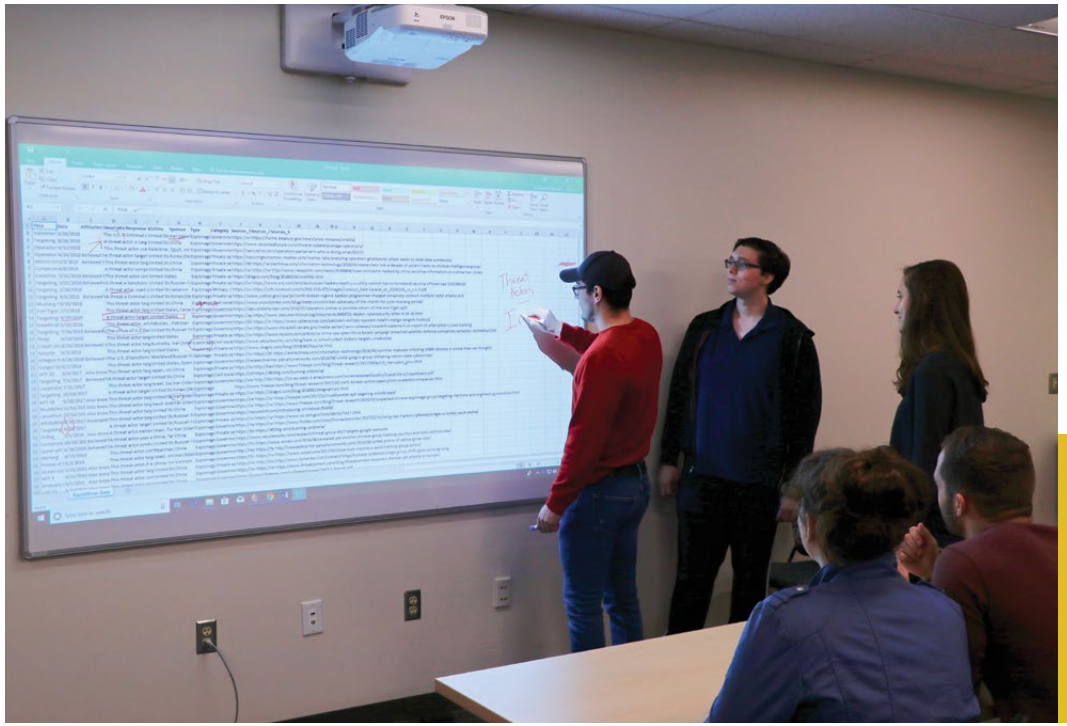
Sponsor

MITRE

The team compares three regional areas of water conflict using Causal Loop Diagrams.

Water is humans' most basic resource necessary for life, agriculture, and power. Depletion of water resources due to misuse, overconsumption, and degradation of the water, making it unusable for humans, often leads to conflict. Conflict over water resources is exponentially expanding, making it necessary to understand the factors that contribute to water conflict. Focusing specifically on three river basins, the Nile River in Northeastern Africa, the Tigris/Euphrates Rivers in the Middle East, & the Mekong River in Southeast Asia, causal factors were produced that demonstrate the similarities and differences that contribute to water conflict in these river basins. Understanding the similar factors can allow the United States government to predict possible new locations for water related conflict to break out. Additionally, this analysis provides possible security implications for the U.S. if or when conflict escalates or begins in these three specific river basins.

THE FUTURE EFFECTS OF CYBER OPERATIONS ON KINETIC WARFARE



Presenters

Chris Hernandez, Robert Tobias, Samuel Stine, Riley Flynn, Esther Alger

Advisor

Kathleen Moore

Sponsor

SAIC

The team is discussing major cyber threat actors while investigating different types of cyber operations utilized by state powers.

In today's environment, cyber technologies are quickly becoming a critical aspect of warfare for many global actors. With the rapid development of these cyber technologies and their emergence as a critical tool for global strategic influence, how could the cyber operations of U.S. adversaries likely influence U.S. military cyber and kinetic strategy by 2023? Cyber technologies and operations now occupy a significant portion of strategic concern among global actors, with that trend escalating every day. The United States government and military needs to navigate this complex and highly technical cyber realm more effectively to maintain their global influence. By understanding the technologies adversaries use and what they are used for, this project will provide insight into how the United States can integrate offensive and defensive cyber capabilities into their military tactics and strategies, better preparing them for a wide range of future conflicts.

THE FUTURE OF POLITICAL ISLAM IN INDONESIA

Presenters

Sandra Webb, Nate McBarron, Rachel Carlson

Advisor

Noel Hendrickson

Sponsor

National Ground Intelligence Center

The team pores over a map of Indonesia as they discuss the many causal factors impacting political Islam, represented in the complex system behind them.

As the country with the most Muslims in the world, Indonesia is an interesting example of the delicate balance between a highly religious population and a largely secular government. This project assesses, for the National Ground Intelligence Center, how influential political Islam may be in Indonesia's government by the year 2025. We explain the causal factors impacting present-day Indonesia, a strategic friend of the United States, and explore a set of plausible future developments. This analysis helps the United States better anticipate and prepare for potential instability in Indonesia and highlights Indonesia as a model for possible developments in similarly-structured countries.

THE IMPACT OF AN AGING POPULATION ON CHINA'S GOVERNANCE AND STABILITY

Presenters

Michaela Caudill, Alexa Fagan, Madison Chaplain, Rachel Wines

Advisor

Noel Hendrickson

Sponsor

MITRE

The team is determining which drivers are most uncertain to generate surprising and significant future scenarios for China.

While aging populations are a global trend, China's population is one of the most rapidly aging in the world. The number of people aged 60 and older in China is expected to jump from 17% of their population to over 30% by 2050. In such a short amount of time, these shifting demographics have the potential to cause economic and social instability. We explore how prepared China is to cope with the potential challenges and opportunities associated with this demographic change.

THE STATUS OF COMPETITIVE TECHNICAL INTELLIGENCE (CTI) IN THE USA

Presenters

Hailey Rogers, Galen McNaughton, Dean Hildner, Madeline Emerald

Advisor

Qingjiu Tao

Sponsor

Council of CI Fellows

The team is conducting an interview with a CTI practitioner to discover more information on competitive technical intelligence which they will then use to further their research into the field and compile the CTI survey.

Our project explores the status of Competitive Technical Intelligence (CTI) in the U.S. CTI enables companies to identify where technology can deliver competitive advantage in areas such as marketing and customer experience, product/service design, and R&D. This project focuses on developing a survey and using secondary data sources to determine a baseline of CTI practices in the U.S. The last survey of this magnitude was conducted in the 1990s and only covered the status of Competitive Intelligence, thus leaving a gap in information of what a CTI function fully encompasses. Without this information, it is difficult to understand how to build the most efficient and productive CTI team. Having a better understanding of this will help dictate what types of people should be hired into the field as well as what types of training they would receive.

WHICH EMERGING TECHNOLOGIES MAY DRIVE IT GROWTH IN THE FEDERAL LANDSCAPE?

Presenters

Brittany Hudson, Caitlin Bittmann, Chelsea Ward

Advisors

Tony Teate, Jeffrey Tang

Sponsor

Accenture

The team is working to determine the various emerging technologies that will impact the IT growth in the federal landscape.

Within the past 30 years, technological advancements, like laptops, have changed the daily practices within the federal landscape. Similar changes are expected to be seen in the future regarding emerging technologies. Actors within the federal landscape will need to address artificial intelligence, blockchain, and quantum computing or will risk falling behind competitors and adversaries like China. This project assesses how these emerging technologies may impact the federal landscape based on their individual opportunities and threats, projection of potential future scenarios and interplays between one another. These scenarios will help those within the federal landscape consider how to best prepare for or implement these technologies into their daily practices while the interplays will show how the technologies can be used to strengthen or undermine one another.

GEOGRAPHIC SCIENCE

As global connections and competition increasingly characterizes our way of life, understanding the importance of place and space has never been more critical. Geographic Science is a major that pushes students to see the connections between human societies and culture and the natural environment. It provides them with the tools to use and visualize data across spatial dimensions, and the knowledge to employ those tools carefully and appropriately. Our students blend all of these facets of geographic study together to better understand and address the problems facing the world today.

BEE FRIENDLY: METHODS FOR INCREASING POLLINATOR AWARENESS AND CONSERVATION

Presenters

Anna E. Hellwege-Bales, Molly Rooney, Francesca Marie Ross, Olivia Faye Massie, Christopher R. Quin David A. Fish, Tristan Mariner, Willem G. Lensink

Advisor

Amy Goodall

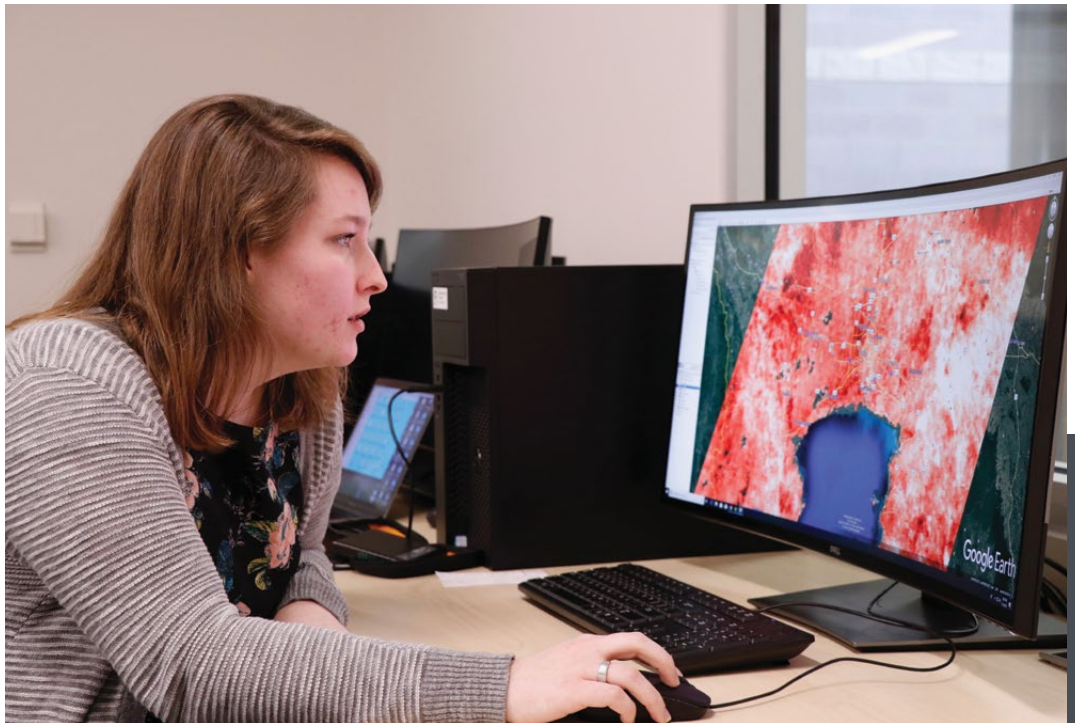
Sponsor

Harrisonburg City Public Schools

The team identifying plants and analyzing soil for a proposed habitat plan.

Pollinators are significantly tied to ecosystem function and resilience and are also critically important for human food supply. Pollinators have been in steep decline globally and are in need of conservation. The goal of this project is to devise methods to increase public interests in observing, monitoring, and conserving pollinators. Our work involves planning and managing public school vegetable gardens and native flower habitats, creating learning tools about garden species, and interacting with campus and city entities for public outreach which includes our development of a web-based, interactive map that depicts pollinator habitats. We also propose a citizen science that is designed to monitor pollinator species over time and will engage public school students in learning about pollinator diversity and data collection methods. Our presentation incudes interactive, hands-on activities.

IDENTIFYING POPULATIONS VULNERABLE TO URBAN HEAT IN BANGKOK, THAILAND



Presenter
Rebekah Everett

Advisor
Mace Bentley

Rebekah visualizes urban heat signatures using satellite imagery to identify loci of intense heat caused by city expansion.

With the consistent growth of cities worldwide, scholarship regarding the ecological, social, and health-related impacts of urban development has grown considerably. Of particular concern are the impacts of the urban heat island (UHI) effect caused by land use change associated with city growth. In this project, satellite and GIS data are used to characterize the urban heat island in Bangkok, Thailand and to demonstrate its change over an 18-year period, with the goal of identifying vulnerable urban populations throughout the metropolitan area. Using these digital and demographic data, the socio-spatial trends in uneven heating are constructed in the context of a tropical megacity to elucidate the connection between indicators of vulnerability and areas of significant warming over the past two decades.

USING GIS TO EVALUATE EQUITY IN CYCLING INFRASTRUCTURE IN VIRGINIA CITIES

Presenter
Hannah Cacner

Advisor
Henry Way

Hannah is analyzing maps from city transportation plans.

To help encourage higher rates of bicycling as a transportation choice, the broader development of cycling infrastructure in cities is critical; however, efforts to improve and implement such infrastructure have often effectively been spatially targeted at white, wealthier individuals, to whom cycling is often viewed as an amenity. Using GIS modeling, I will evaluate the "bikeability" of several cities in Virginia that have recently made significant steps to enhance their city's bicycle infrastructure. This model will evaluate not only the quality and safety measures of such infrastructure but also how high-quality bicycle infrastructure is distributed spatially with respect to race, ethnicity, age, and class of individuals. By creating such a model, I hope to be able to highlight parts of cities in which access to cycling as a means of transport could use improvement and where inequalities might exist.

BIOT

BIOTECHNOLOGY

Students in the Biotechnology degree program explore the growing realm of biotechnology and its applications. The program, which the School of Integrated Sciences jointly operates with the departments of Biology and Chemistry, allows students to take a deep dive into the field, including intensive laboratory experiences and opportunities for groundbreaking research. The projects listed in this book are those that are advised by faculty members in our School.

LEVELS OF HUMAN TEAR LACRITIN ISOFORMS IN HEALTHY ADULTS

Presenters

Brooke Justis, Casey Coburn

Advisor

Robert McKown

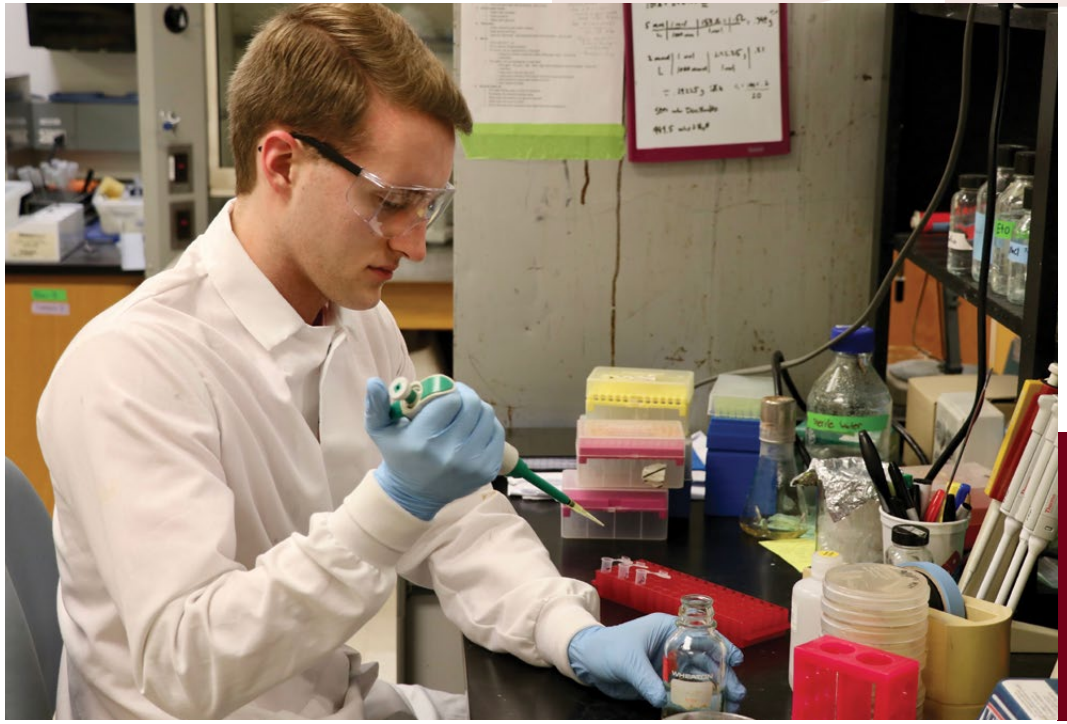
Sponsor

TearSolutions, Inc.

Brooke and Casey are using a bicinchoninic acid assay (BCA) to determine the concentration of protein in normal human tear samples.

Lacritin is a tear glycoprotein reported to be decreased in patients with various forms of dry eye disease including Sjögren's Syndrome. By quantitating different forms of lacritin, we can provide a new diagnostic tool for dry eye. Human tear lacritin has been detected by Western blot analysis as an active lacritin monomer, an inactive cross-linked polymer, and a splice variant with unknown functions, termed lacritin-c. We report a multiplex Western blot assay for quantification of multiple lacritin forms in tear samples from healthy adults. Tear samples from twenty healthy adults were eluted and analyzed by multiplex Western blots in preparation for receipt of samples from the Phase II clinical trial of LacripepTM in Sjögren's Syndrome Dry Eye patients and healthy volunteers. Validation of this assay with tears from healthy adults provides a baseline for analysis of tear lacritin proteins from diseased individuals in future studies.

STRUCTURAL/FUNCTIONAL ANALYSIS OF FEGA AND FHUA IN BRADYRHIZOBIUM JAPONICUM



Presenter
Alexander Herd

Advisor
Stephanie Stockwell

Alex is preparing for a tri-parental mating that will hopefully produce mutant strains of Bradyrhizobium japonicum for genetic structure/function analyses.

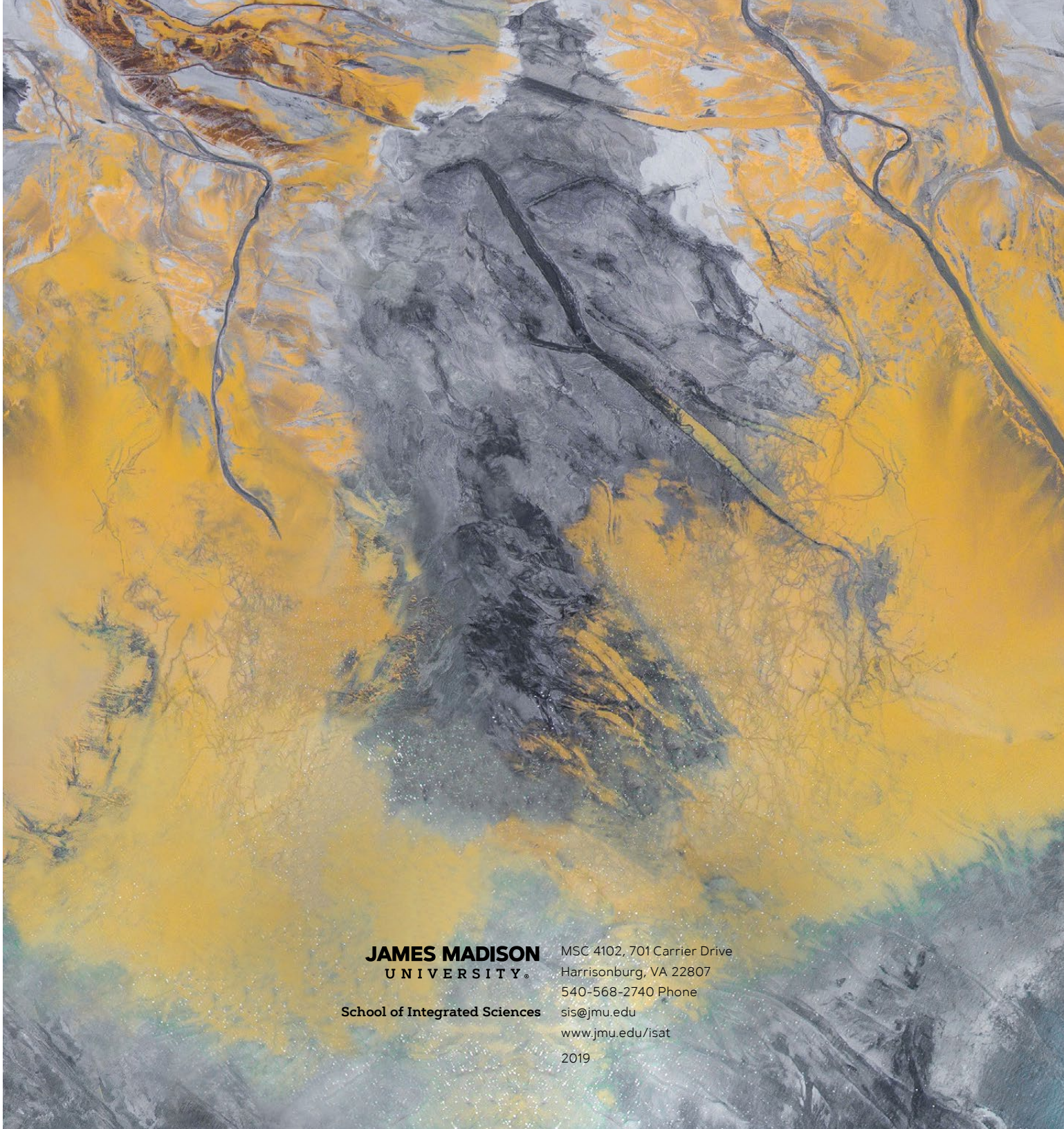
Bradyrhizobium japonicum is a Gram-negative soil bacterium commonly known for its agriculturally significant mutualistic relationship with soybean plants. This research project aims to compare two related B. japonicum proteins, FegA and FhuA, thought to be involved in a molecular signaling pathway between the bacteria and plants. The goal of the project is to investigate a possible link between structural domains within the protein and observed functions. Recombinant bacterial strains with altered FegA proteins were constructed, verified, and tested.

Thank you to all who have helped with the 23rd Annual Senior Symposium. Faculty, staff, and students contribute in many different ways toward this enormous event. Special thanks to the symposium committee: Fasha Strange, Rebecca Lipscomb, Whitney Sites, and Jessica Collins.

Also, thank you to Lynn Radocha, Alina Kondratenko, and Josh See for creating another outstanding symposium book. Each year the book gets better – and this year is no exception.

Finally, thank you to Lynda Chandler, Kathy Lubkowski, Jake Krug and all of our student volunteers. It takes a village to pull off this endeavor every year, and we could not have done this without your valuable contribution.

Linda Thomas, J.D., Ph.D.
Director, School of Integrated Sciences



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