JAMES MADISON UNIVERSITY®

2025 SENIOR SYMPOSIUM

SCHOOL OF INTEGRATED SCIENCES

MAKING THE CONNECTIONS

Integrated Science and Technology

Intelligence Analysis

Geography

Throughout this book, you will discover an extensive array of scholarly achievements by our undergraduate students. Teams have dedicated countless hours to developing innovative approaches for defining, addressing, analyzing, and evaluating a wide range of complex and significant problems.

These projects exemplify a skill set needed in an increasingly specialized world—encompassing the challenging integration of science, technology, systems thinking, and domain-specific methodologies to generate new insights and solutions.

Capstones are inspired by student interests, commissioned by external sponsors, and guided by faculty advisers. Ideas are transformed into achievable projects by establishing clear goals, activities, timelines, and benchmarks. Along the way, undergraduates develop their independence and confidence as they navigate challenges, explore possibilities, and ultimately succeed.

This is just the beginning for our School of Integrated Sciences Class of 2025!

Stephanie Stockwell, Ph.D.
Co-Director, School of Integrated Sciences
Academic Unit Head, Integrated Science and Technology

Henry Way, Ph.D.
Co-Director, School of Integrated Sciences
Academic Unit Head, Geography and Intelligence Analysis

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INTEGRATED SCIENCE AND TECHNOLOGY

INTELLIGENCE ANALYSIS

GEOGRAPHY

We integrate the **United Nation's Sustainable Development Goals (SDG's)** into our coursework and research. This connection adds real-world relevance and social impact, demonstrating how our efforts can contribute, even on a small scale, to important global goals.

Incorporating SDGs builds students' understanding of global citizenship and empathy as they learn about challenges faced worldwide and **gain perspective on how their fields can create positive change.** This prepares our graduates to incorporate social responsibility and sustainability into their future careers and furthers JMU's mission to develop engaged and enlightened citizens.

Integrated Science and Technology

The Integrated Science and Technology B.S. degree program teaches students to be holistic problem solvers. Systems thinking methodologies are used to define and find leverage points within complex problems. A broad and integrated STEM skillset—with focus areas in biotechnology, computation, energy, environment and sustainability, and manufacturing—is then applied. Training in responsible innovation and anticipatory governance helps to ensure that today's solutions don't become tomorrow's problems. This strategic integrated approach delivers graduates that are uniquely versatile, confident, innovative, and collaborative.

MODELING NUTRIENT ACCUMULATION WITHIN THE CHESAPEAKE BAY

Chesapeake Bay Crab

STUDENT

Ryan Bucciero

ADVISOR

Steven Frysinger

CONCENTRATION

Environment & Sustainability

This project aims to develop a model that simulates nutrient accumulation in the Chesapeake Bay using Stella Architect software. Nutrient pollution, primarily from agricultural runoff and wastewater, is a major environmental challenge for the Bay, contributing to harmful algal blooms, hypoxia (low oxygen levels), and the degradation of aquatic life. Understanding how nutrients accumulate and move through the Bay is critical for developing effective regulation and management strategies.

By creating a dynamic model, this project will track the flow of nutrients, such as nitrogen and phosphorus, from various sources into the Bay's ecosystem. The model will simulate interactions between land use, nutrient inputs, water flow, and the biological processes in the Bay. It will help identify key areas where nutrient levels are highest, predict how changes in land use or policy might affect nutrient concentrations, and assess the impact of different management strategies on water quality.

Ultimately, the goal is to provide decision-makers with a tool to make more informed choices about reducing nutrient pollution. By improving our understanding of nutrient dynamics, we can protect and restore the health of the Chesapeake Bay, ensuring its long-term sustainability for both the environment and the communities that depend on it.

ENHANCING SOLAR ROADWAY IMPLEMENTATION WITH ARCGIS

Sam is examining the use of solar roadways in a parking lot, an area with high potential ground insolation.

STUDENT

Sam Amrhein

ADVISOR

Steven Frysinger

CONCENTRATION

Environment & Sustainability

Solar panels have been used for energy generation for the past two centuries, utilizing large, flat areas of previously unused land. In the past two decades, some companies have considered the potential of solar energy generation from roadways. Rockingham County, Virginia, has approximately 908.8 miles of roadway, with an average road width of 12 feet. This provides roughly 2.07 square miles of roadway with potential for solar generation.

This project aims to identify which roadways in Rockingham County consistently generate the most energy and analyze the cost-benefit of solar panels in these areas. This will help determine the most optimal areas for solar roadways. The results from this capstone project will provide valuable insights to aid Virginia's Department of Energy in making informed decisions about the feasibility and efficiency of roadways as a source of solar energy generation.

LIFENET HEALTH'S MATRACELL AUTOMATION PROCESS

Tyler, Will, and Ryan are observing the Matracell process in clean rooms.

STUDENTS

William Dresden
Ryan Jones
Tyler Poole

ADVISORS

Chris Bachmann
Cheng Li

SPONSOR

LifeNet Health

CONCENTRATIONS

Applied Computing
Integrated Manufacturing

The Matracell decellularization process at LifeNet Health is vital for producing cardiac tissues used in life-saving procedures. However, the traditional method was labor-intensive, costly, and limited in scalability, creating challenges in meeting the growing demand for decellularized tissues. Our capstone project aimed to address these issues by designing and implementing an automated system.

The existing manual process increased production costs and introduced variability, limiting accessibility. To overcome these barriers, we developed a system integrating programmable control over pumps and valves and real-time monitoring via a software interface. These innovations ensured precise delivery of agents, optimized fluid dynamics, and improved process standardization while preserving tissue quality. The system's efficiency and scalability make decellularized tissues more affordable and accessible, benefiting patients requiring advanced cardiac repair solutions.

By automating the Matracell process, this project demonstrates the potential to significantly improve biomanufacturing efficiency and patient outcomes. Further refinements could expand its application to other tissue types, advancing regenerative medicine.

GEOPOLITICAL ANCHORS: UNDERSTANDING CHINA'S GLOBAL PORT INVESTMENTS

Students are exploring the potential for China's first Atlantic naval base in Nigeria.

STUDENTS

Brett Kaster

William Montgomery

Julio Perez-Solis

ADVISORS

Chris Bachmann

Phil Baxter

CONCENTRATIONS

Applied Computing

Industrial Manufacturing & Systems

The capstone project, developed through a strategic partnership between James Madison University, ARCgis, and the National Geospatial Intelligence Agency, addresses the increasing geopolitical tensions caused by China's expansion of its naval capabilities and strategic port investments across the globe. This initiative creates a sophisticated framework for monitoring and predicting the development of Chinese naval facilities and ports, enhancing situational awareness and decision-making for the U.S. military. Utilizing ARCgis's built-in feature analysis tools, the project analyzes potential spatial relationships between China's port investments, natural resources, and existing infrastructure within countries in the Belt and Road Initiative. This analysis aims to better understand the strategic motives behind the People's Liberation Army Navy's investments and plans.

Throughout the project, a comprehensive analysis of global economic factors related to the regions where China has invested is conducted. This includes assessing GDP, financial debts owed to China, the percentage of trade with China, oil reserves and production, major exports, and voting similarities in the United Nations between the host nations and China. By integrating this data, the project supports timely responses to potential threats posed by these investments, which are critical to maintaining international stability and protecting U.S. interests. The methodology not only tracks but also forecasts construction activities, ensuring that U.S. military strategists can anticipate and mitigate emerging threats effectively.

INVESTIGATING CHINESE RESEARCH BUOYS IN THE ARCTIC

Joe, Elizabeth, and Seth during a imagery gathering experiment using a DJI Mini 2SE Drone.

STUDENTS

Joe Burke

Seth Hollatz

Elizabeth Robertson

ADVISORS

Chris Bachmann

Phil Baxter

CONCENTRATIONS

Applied Computing

Environment & Sustainability

Industrial Manufacturing & Systems

As climate change accelerates the melting of Arctic ice, it opens new trade routes and access to untapped natural resources, significantly impacting global geopolitics and environmental sustainability.

Amidst these changes, China's expansion of its Belt and Road Initiative into the Arctic, highlighted by the deployment of environmental research buoys, raises dual-use concerns. These concerns stem from the potential for such technologies to be used for maritime surveillance, posing risks to international security and sovereignty.

This project aims to develop ways to locate unauthorized deployment of research buoys in the Arctic that might also be used to monitor U.S. naval activity in the region, to ensure the Arctic's transformation is navigated responsibly and in a manner that respects the interests and safety of the global community.

MICROBIAL ELECTROLYSIS FOR HYDROGEN IN ABANDONED OIL RESERVOIRS

Georgia is presenting at the 2024 IBE Conference.

STUDENT

Georgia Barefoot

ADVISOR

Cheng Li

CONCENTRATION

Energy

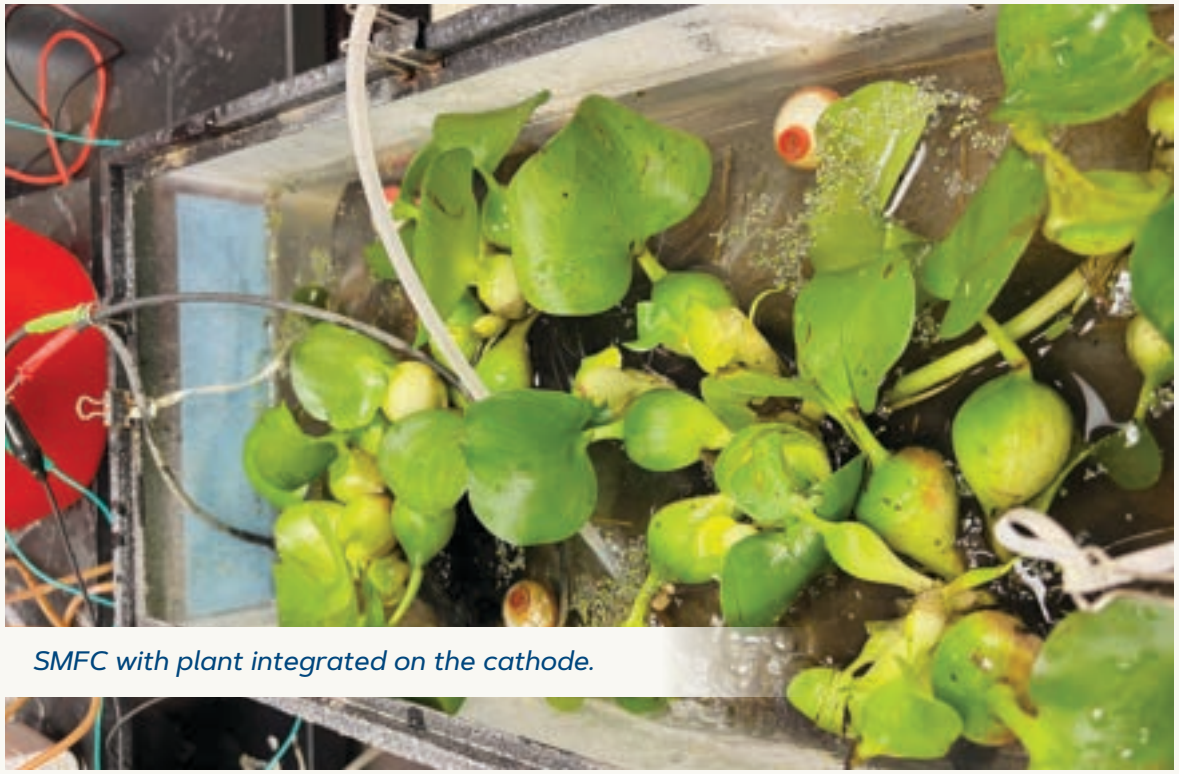
As the world transitions to cleaner energy sources, repurposing existing infrastructure for sustainable solutions is critical. This project explores the potential of abandoned oil reservoirs as sites for hydrogen production using microbial electrolysis cells (MECs)—a technology that harnesses microorganisms to break down residual petroleum and generate hydrogen gas.

Abandoned oil reservoirs are often seen as environmental liabilities, but they hold untapped energy potential. Traditional hydrogen production methods rely on fossil fuels or require significant energy input, limiting their sustainability. This research investigates how bioelectrochemical techniques can enhance hydrogen generation while also shedding light on the microbial communities responsible for breaking down hydrocarbons.

By optimizing the conditions within MECs, this project aims to improve hydrogen yield and efficiency, turning abandoned reservoirs into renewable energy assets. The results could provide a scalable, low-carbon alternative for hydrogen production, utilizing existing infrastructure rather than building new facilities. If successful, this approach may reduce environmental hazards associated with abandoned wells while contributing to the clean energy transition.

This work not only addresses energy sustainability but also leverages biological processes to convert waste into fuel, paving the way for innovative solutions in hydrogen production and environmental remediation.

ENHANCING POULTRY WASTEWATER TREATMENT WITH SEDIMENT MICROBIAL FUEL CELLS



SMFC with plant integrated on the cathode.

STUDENT

Ben LaRocque

Christian Ward

ADVISOR

Cheng Li

CONCENTRATIONS

Energy

Environment & Sustainability

Poultry farms in the U.S. generate over 60 billion gallons of wastewater annually, containing organic matter, nutrients, and pathogens that can harm ecosystems and public health. Conventional treatment methods are energy-intensive and sometimes ineffective at fully addressing these pollutants. To tackle this challenge, our project explores the use of Sediment Microbial Fuel Cell (SMFC) systems as a dual-purpose solution to treat wastewater while generating renewable energy.

SMFCs harness naturally occurring microbes in sediment to break down contaminants, simultaneously producing electricity. This approach offers a sustainable, low-cost alternative to conventional methods, reducing pollution and greenhouse gas emissions. Beyond environmental benefits, we are exploring electricity generation from our SMFC to offset energy costs for poultry farms, improving economic sustainability.

Our research combines laboratory experiments and field trials to evaluate SMFC performance. In the lab, we'll simulate real-world wastewater conditions to assess factors like power output and pollutant removal efficiency. In the field, we'll collaborate with Virginia poultry farms to test SMFCs in operational environments, ensuring practical feasibility.

By integrating renewable energy generation with wastewater treatment, SMFCs present an innovative solution to the environmental and economic challenges of poultry farming and many other industries. Our findings aim to pave the way for scalable, sustainable practices that benefit ecosystems, public health, and farm operations.

CABLE BACTERIA IN JMU RETENTION PONDS: IMPACT ON MICROBIAL COMMUNITIES

Will is harvesting water samples.

STUDENT

Will Maier

ADVISOR

Cheng Li

CONCENTRATION

Environment & Sustainability

Cable bacteria are a unique type of filamentous bacteria that can transfer electrons over centimeter-scale distances in marine and freshwater sediments. These bacteria form extended chains, allowing them to transfer electrons from deep sediment layers (where sulfide is abundant) to the surface (where oxygen or nitrate is available), effectively linking different chemical zones. This electron transfer allows them to perform redox reactions that are typically spatially separated in sediments. During this process, they create pH variations along their length, generating highly alkaline (~9.0) and acidic (~6.0) conditions at the surface in the deeper layers. As key ecological engineers, cable bacteria significantly impact the biogeochemistry of their environment. They create electric fields and alter sediment chemistry, influencing essential processes like iron, sulfur, and carbon cycling. Their presence helps regulate nutrient availability, oxygen penetration, and the composition of microbial community structure, thus shaping the ecosystem's overall function and health.

The East Campus Retention Ponds are an integral part of JMU's East Campus Hillside Project, which promotes the focus on sustainability and environmental education. These retention ponds are designed as stormwater management systems that help filter pollutants, manage water quality, and reduce downstream flooding. Habitats for microbial communities are created from the ponds, contributing to the ecological health of the area. The ponds are surrounded by vegetation that supports biodiversity and enhances water filtration.

Sediment was collected from retention ponds in November 2023 to investigate the presence and functions of cable bacteria. Collected sediment samples were cultured for 4 to 8 weeks with the geochemical gradients of oxygen, sulfide, and protons investigated. Amplicon sequences of the 16S rRNA gene were also used to evaluate the phylogenetic diversity of the cable bacteria. Results confirmed the presence of cable bacteria and suggested their fundamental roles in the functions of retention ponds.

DETECTING MERCURY CONTAMINATION IN COSMETICS

Connor is analyzing cosmetic samples using the X-ray fluorescence spectrometer.

STUDENT

Connor Kasper

ADVISOR

Robert Brent

CONCENTRATION

Environment & Sustainability

Using cream-based cosmetics to lighten the skin is a practice performed around the world, particularly among dark-skinned populations. This practice has complex cultural and historical roots embedded in perceptions of status and beauty. Unfortunately, some cosmetic products used for skin lightening can contain high levels of mercury, which can be harmful to the body when used. This means that populations with cultural pressures for skin-lightening may be at higher risk for health complications due to mercury exposure.

This project explores the social-cultural factors that drive skin-lightening usage, uses a method of chemical analysis called X-ray fluorescence spectroscopy (XRF) to look for mercury in skin-lightening creams, and develops a risk assessment to help identify regions of the US that are likely to have a higher risk of mercury exposure from skin-lightening product usage. Our analysis did not detect mercury in a sampling of seventeen available skin-lightening products. However, other researchers have found mercury in many products from various countries, indicating the continuing potential for human health risks from mercury exposure.

DESIGN AND CONSTRUCTION OF A SONAR-EQUIPPED HYDRO-DRONE FOR LAKE BATHYMETRY

Miles is working on prepping the marine 12v battery for an in-lab test while Nathan checks over the connections.

STUDENTS

Nathanial Horner

Miles McIntyre

ADVISORS

Thomas Benzing

Robert Brent

SPONSOR

Earth Systems Management

CONCENTRATION

Environment & Sustainability

Most artificial ponds and lakes are built to retain water after heavy rainfall to prevent flooding. Over time, these bodies of water accumulate sediment and decrease in nominal volume. If left unchecked, these retention ponds can overflow and damage the environment, people, and property.

Our partners at Earth Systems Management have spent the last couple of years developing a sonar-equipped Hydro-Drone to create bathymetric maps in coastal waters. From their shared designs, we have built our own Hydro-Drone and applied this environmental technology to evaluate two small lakes, Lake Shenandoah and Newman Lake.

The drone is constructed on an off-the-shelf kayak platform and driven by two large rotors. Furthermore, the drone is controlled by a series of logic components such as a global positioning system, flight controller, and remote control. With this setup, the drone can be set on autonomous missions and simultaneously collect and store sonar data. With a comprehensive data set, we hope to contribute to how Lake Shenandoah is managed and submit these recommendations to the Virginia Department of Wildlife Resources. Additionally, our Newman Lake data and accompanying collection methods will be useful to JMU Facilities Management in their flood control efforts on campus.

INVESTIGATING MECHANICAL PROPERTIES OF RECYCLED PLASTICS

The capstone team is making test specimens with an injection molding machine and recycled plastics.

STUDENTS

Alex Davis
Ben Fernandez
Isidor Lacy
Daniel Lisco

ADVISOR

Hao Zhang

CONCENTRATIONS

Industrial Manufacturing & Systems
Tailored: Lean Manufacturing & Global Environmental Studies
Manufacturing Automation Manufacturing Systems & Environmental Sustainability

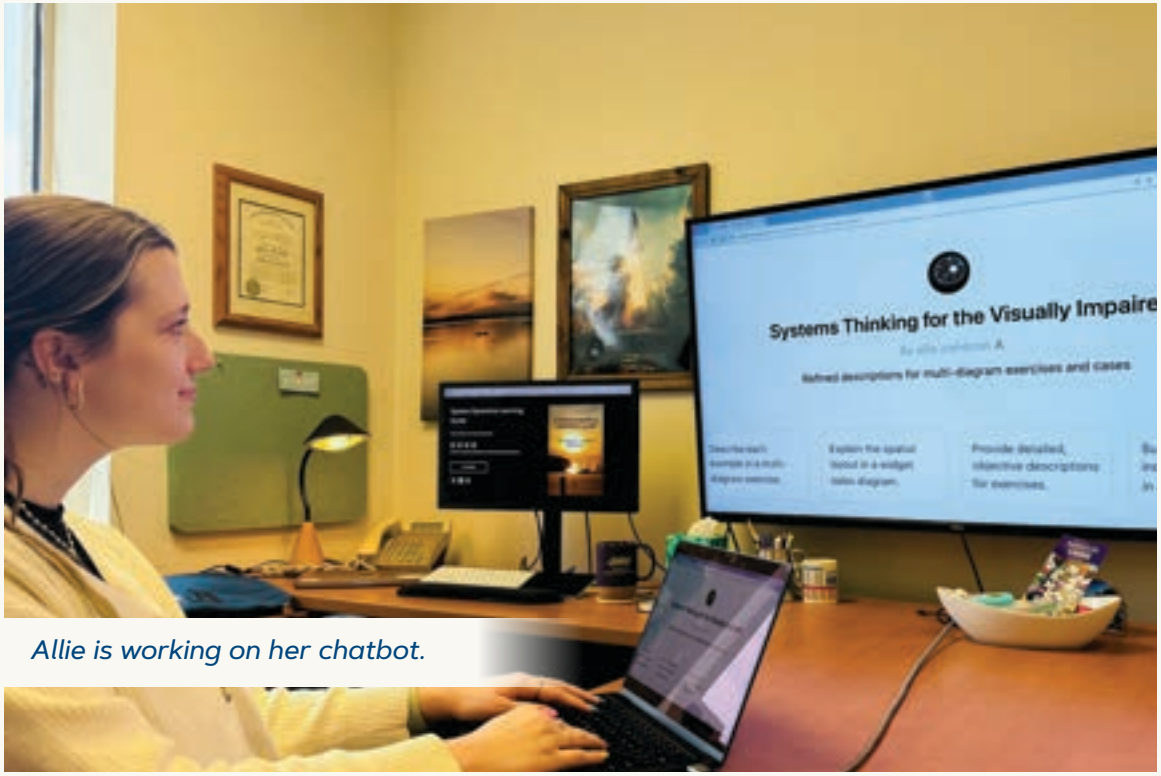
The widespread use of single-use plastics has intensified environmental pollution, making effective recycling solutions critical. This project investigates the mechanical properties of recycled polylactic acid (PLA), acrylonitrile butadiene styrene (ABS), and polyethylene terephthalate (PET) blended with bio-based fillers like rice flour, sawdust, and paper biomass. The goal is to enhance the structural integrity of recycled plastics and support the transition to a circular economy.

Recycled plastics often exhibit reduced tensile and compressive strength compared to virgin materials, limiting their usability. This study addresses these issues by optimizing polymer blends and evaluating their performance through standardized mechanical testing. Tensile and compression tests will assess strength, elasticity, and durability, helping identify viable formulations for engineering applications.

A key challenge in mechanical recycling is material degradation over multiple processing cycles. By integrating stabilizing additives and refining processing methods, this research aims to improve the quality and reliability of recycled polymers. The findings will be compiled into a comprehensive database to support future research and industry innovation.

Beyond technical advancements, this project promotes sustainability by reducing waste, conserving resources, and encouraging responsible plastic use. Its outcomes could help industries develop cost-effective recycling strategies, reducing dependence on virgin plastics. By tackling both technical and environmental barriers, this research contributes to more sustainable material solutions and improved waste management practices.

SYSTEMS THINKING FOR THE VISUALLY IMPAIRED USING GENERATIVE AI



Allie is working on her chatbot.

STUDENT

Allie Zombron

ADVISORS

Raafat Zain

Arwa Alnajashi (Univ. of London)

CONCENTRATION

Applied Computing

This project explores the responsible use of Generative Artificial Intelligence (GenAI) to enhance accessibility in Science, Technology, Engineering, and Mathematics (STEM) education for individuals with visual impairments. Specifically, it presents a proof-of-concept for generating descriptions of visual representations in Systems Thinking—a method that heavily relies on visual diagrams and models, often posing challenges for visually impaired users.

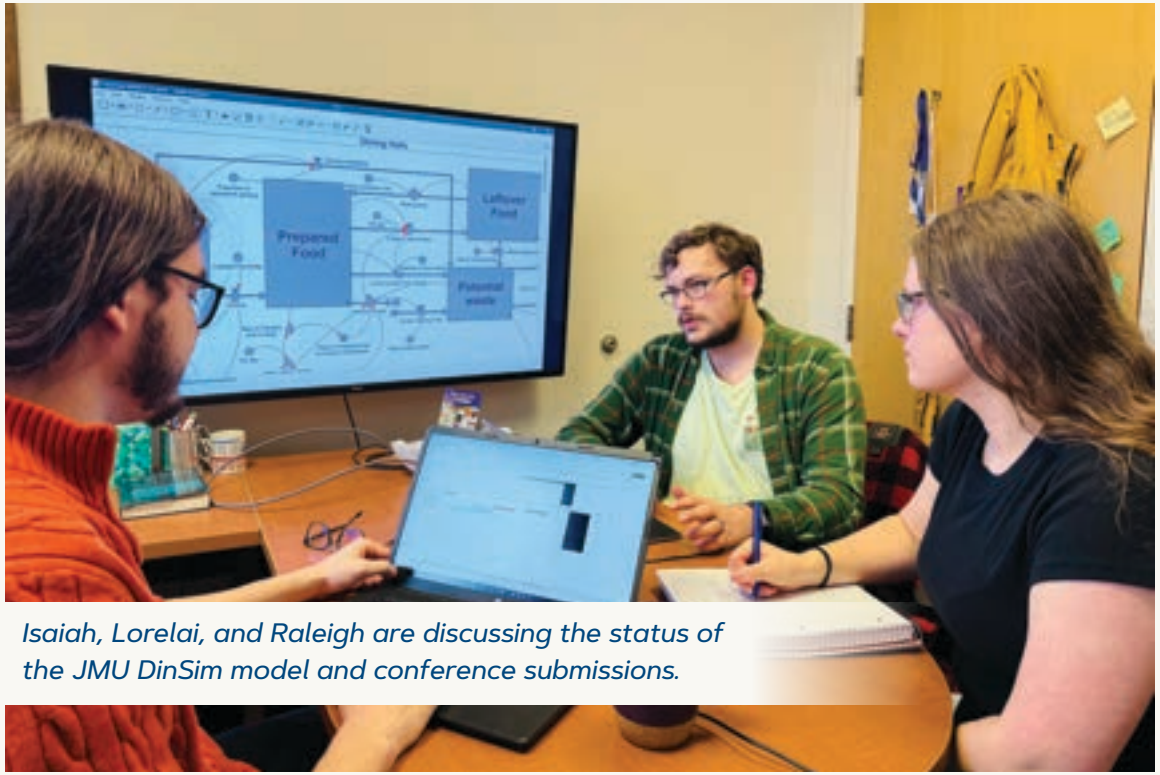
By aligning with Web Content Accessibility Guidelines (WCAG) 2.1 AA standards, as required under the Americans with Disabilities Act (ADA) for Title II entities, this project aims to improve access to dynamic system representations while promoting the ethical use of GenAI in education.

I have developed a ChatGPT chatbot, "Systems Thinking for the Visually Impaired," capable of recognizing and describing key Systems Thinking representations, including Behavior Over Time Graphs, Causal Loop Diagrams, and Stock and Flow simulation models. This innovation serves as a foundational step toward comprehensive accessibility in STEM learning.

Beyond benefiting individuals with visual impairments, this approach offers scalable accessibility solutions to enhance engagement and inclusivity across diverse disabilities and educational contexts.

The preliminary results of this project contribute to the System Dynamics Learning Guide and have been published in the paper, "Beyond Visual Limits: Systems Thinking for the Visually Impaired Using Generative AI," in the International Journal of Responsibility (DOI: 10.62365/2576-0955.1123).

THE LEFTOVERS PROJECT: FEEDING STUDENTS BY MITIGATING FOOD WASTE



Isaiah, Lorelai, and Raleigh are discussing the status of the JMU DinSim model and conference submissions.

STUDENTS

Isaiah Martinez

Lorelai Lamoureux

Raleigh Mann

ADVISOR

Raafat Zaini

CONCENTRATIONS

Applied Computing

Environment & Sustainability

Simulation Modeling

The Leftovers Capstone Project addresses sources of food waste in JMU Dining facilities. As determined by the 2019 JMU Student Support Hub survey, approximately 39% of the JMU student population experiences food insecurity. Food insecurity is a problem that many people face around the world, and solving this social issue is one of the United Nations' 17 Sustainable Development Goals.

Our project models the university's food production and dissemination system and how it contributes to food waste on campus. During the model construction, our team communicated with various stakeholders, including, but not limited to, JMU Dining Services, Aramark, the JMU Pantry, the Institute for Stewardship of the Natural World, the Community Engagement and Volunteer Center (CEVC), and the Basic Needs Advisory Board.

The resulting system dynamics model (JMU DinSim) simulates the current JMU food production and consumption structure to suggest potential strategies to repurpose perishable food to aid students in the JMU population who face food insecurity. Such a model would help stakeholders make better policy decisions regarding hunger prevention, mitigating waste, and expanding current student aid programs.

CLEARING THE WATERS: STREAM REMEDIATION UTILIZING BIOCHAR FILTRATION

The team is collecting water quality data and assessing biochar filter at Muddy Creek.

STUDENTS

Leah Sortore
Logan Markell
Lauren Knitter
Adam Boney

ADVISOR

Jennifer Coffman

SPONSORS

Jubilee Climate Farm
SWVA Biochar
VA Department of Forestry

CONCENTRATIONS

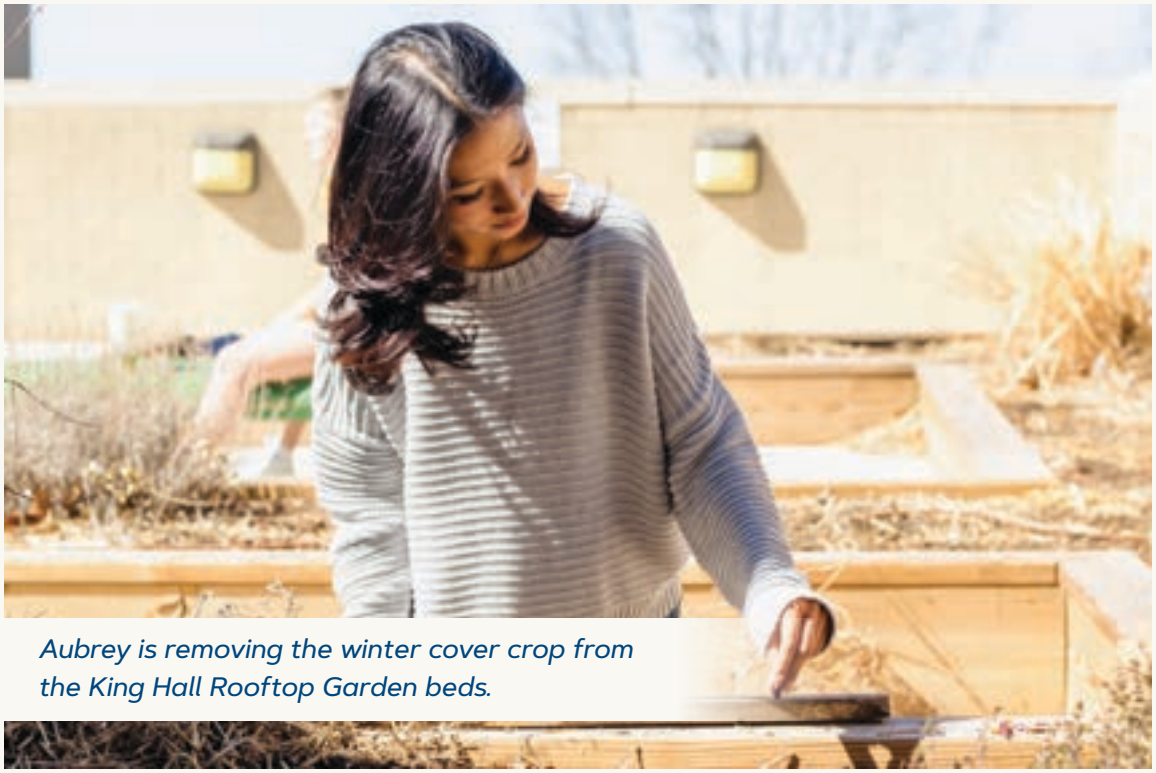
Energy
Environment & Sustainability

Muddy Creek, a tributary within the Chesapeake Bay watershed, runs through Jubilee Climate Farm in Mount Clinton, VA. Jubilee Climate Farm promotes regenerative agriculture with goals of improving the local ecosystem and empowering community members, including recent refugees and immigrants, by providing them with space to learn about and produce food sustainably.

Our research project focuses on the potential of biochar filters to improve water quality in a focal stretch of Muddy Creek, while also harvesting key nutrients from the creek to implement into the cropland. Muddy Creek is impacted by runoff from surrounding agricultural areas and has high nitrogen, phosphorus, and E. coli levels.

We have developed, deployed, and assessed the efficacy of biochar filters that prioritize using environmentally safe materials, including biodegradable burlap containment bags and sisal rope. We experimented with the ability of biochar to filter out pollutants from within the stream while simultaneously carrying out lab tests with controlled nutrient contents. While the functions of biochar as a filter in standing water and soil are more understood, the results from Muddy Creek will lead to a better understanding of its feasibility for use in more dynamic waterways and thus will inform implementation by other landowners.

ROOT TO RESILIENCE: A SUSTAINABILITY PLAN FOR KING HALL ROOFTOP GARDEN



Aubrey is removing the winter cover crop from the King Hall Rooftop Garden beds.

STUDENT

Aubrey Vu

ADVISORS

Carole Nash

Cindy Klevickis

CONCENTRATION

Tailored: Science & Technology Management

The King Hall Rooftop Garden supports food production, education, and community engagement initiatives. While it serves as a valuable space for community members to meet, study, and enjoy nature, its potential is tempered by unique challenges requiring holistic solutions. Limited shade and persistent wind make plant selection and care difficult, requiring gardening expertise. Additionally, funding limitations and intermittent volunteer support during the growing season place a heavy workload on the few who maintain the space.

Our capstone project provides a sustainable management plan to address these challenges. It highlights features of the garden that are important to users and enhances its role as an educational and community asset for JMU. The project integrates hands-on gardening, comparative studies of university and urban community gardens, and research into sustainable management models. It also incorporates insights from a survey of students who use the garden and administrator interviews. It provides baseline documentation for the garden, including soil nutrient content, bed positioning, and plant inventory.

Key features of the sustainable management plan include establishing an internship for garden oversight, implementing design improvements to the physical space to enhance educational and community outreach, and a review of funding sources. By integrating stakeholder input and comparative research, the plan provides practical, scalable solutions, ensuring the garden's continued contributions to the University.

ASSESSING A BIO-ENGINEERED SOLUTION FOR STREAMBANK EROSION AT THE JMU FARM

Patrick is preparing for the initial live stake planting at the JMU Farm.

STUDENT
Patrick DeHarde

ADVISOR
Carole Nash

SPONSOR
JMU Facilities Management

CONCENTRATION
Environment & Sustainability

Streambank erosion along the North River at the JMU Farm, where recreation and education are a focus, is accelerated by the removal of trees from the riparian buffer, combined with episodes of high river flow. This has undermined the streambank, resulting in the loss of biodiversity and increased sediment.

To address these problems, the project evaluates the effectiveness of the live-staking method, a form of bioengineering, for streambank stabilization. JMU, as an educational institution, can demonstrate best practices through this work. The live-staking method involves planting cut ends of various species of native trees into the streambank at an angle consistent with successful vegetation growth. Over the next few growing seasons, this should allow a root network to grow.

The project involved planting 355 live stakes of red osier dogwood, yellow twig dogwood, and bankers dwarf willow in March 2024 and monitoring their establishment and growth over a year. This monitoring program, which will be followed for several years, involves mapping the locations of the stakes and periodically assessing their health. In addition, drone photography provides a baseline for streambank conditions at the project's onset.

Preliminary results indicate that the overgrowth of bank vegetation, combined with record flow from Hurricane Helene, compromised the stakes in several locations, requiring the consideration of additional individual plantings and/or bundling of live stakes.

INTELLIGENT SECURITY: COMPUTER-VISION IN A ROBOTIC DOG

Max, Kyle, and Jeff are working with the artificial intelligence dog.

STUDENTS

Kyle Berkeley

Jeff Ekon

Max Langsam

ADVISOR

Anthony Teate

CONCENTRATION

Applied Computing

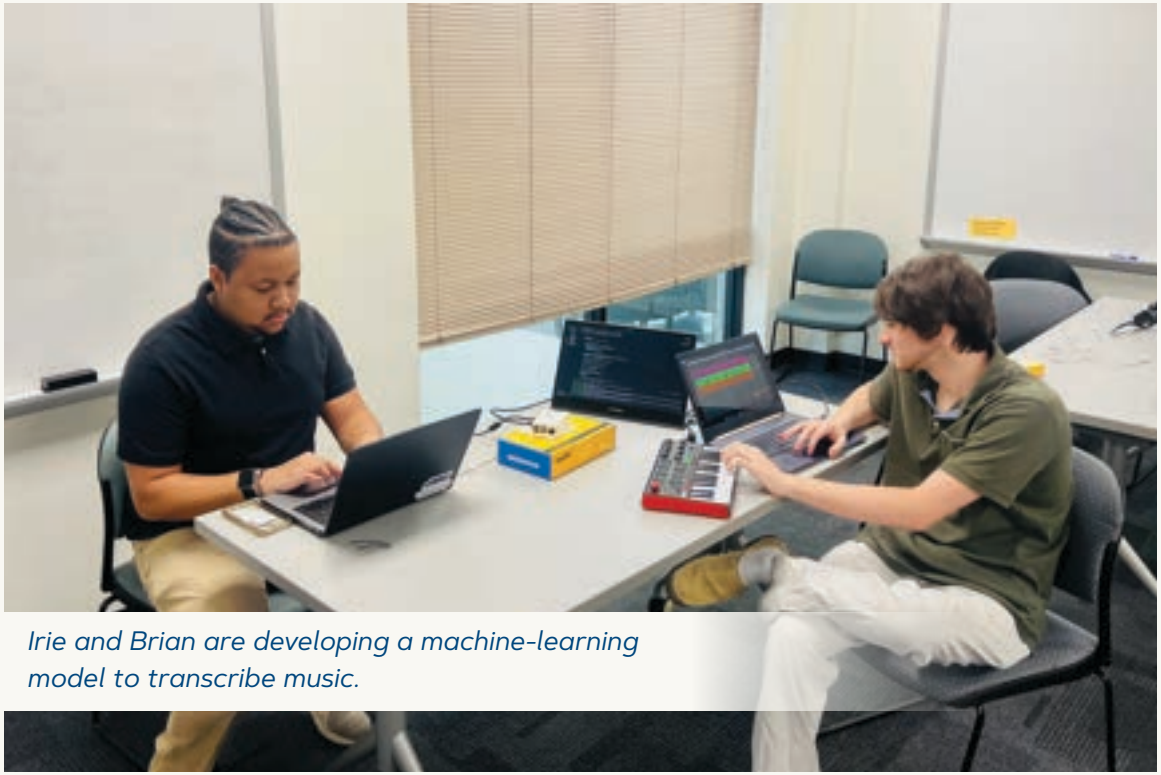
Security threats involving unauthorized weapons pose significant risks in public and private spaces. This project integrates computer vision and artificial intelligence (AI) with the Unitree Go2 Pro robotic dog to enhance security through automated object detection and autonomous patrol. Using a convolutional neural network (CNN), the system identifies and classifies weapons in real time, providing an additional layer of situational awareness.

The robotic dog is equipped with AI-driven image processing, enabling it to scan environments efficiently and detect potential security risks. Its autonomous patrol feature, supported by LiDAR-based mapping, allows it to navigate predefined routes and adapt to dynamic environments with high precision. This ensures continuous monitoring of critical areas, reducing the need for human intervention while maintaining an active security presence.

By patrolling venues such as airports, universities, and event spaces, the system can detect and track potential threats, sending real-time alerts to security personnel. When a weapon is identified, the robotic dog can transmit footage, trigger alarms, or integrate with existing security protocols for rapid response.

This solution enhances security by providing a mobile, AI-powered detection system that adapts to different environments. Its combination of autonomous patrol, LiDAR-assisted navigation, and real-time unauthorized weapons detection offers a scalable, proactive approach to modern security challenges.

DRUMECHO: REAL-TIME AUDIO-TO-NOTATION TRANSCRIPTION USING MACHINE LEARNING



Irie and Brian are developing a machine-learning model to transcribe music.

STUDENTS

Irie Clarke

Brian LaRosa

ADVISOR

Anthony Teate

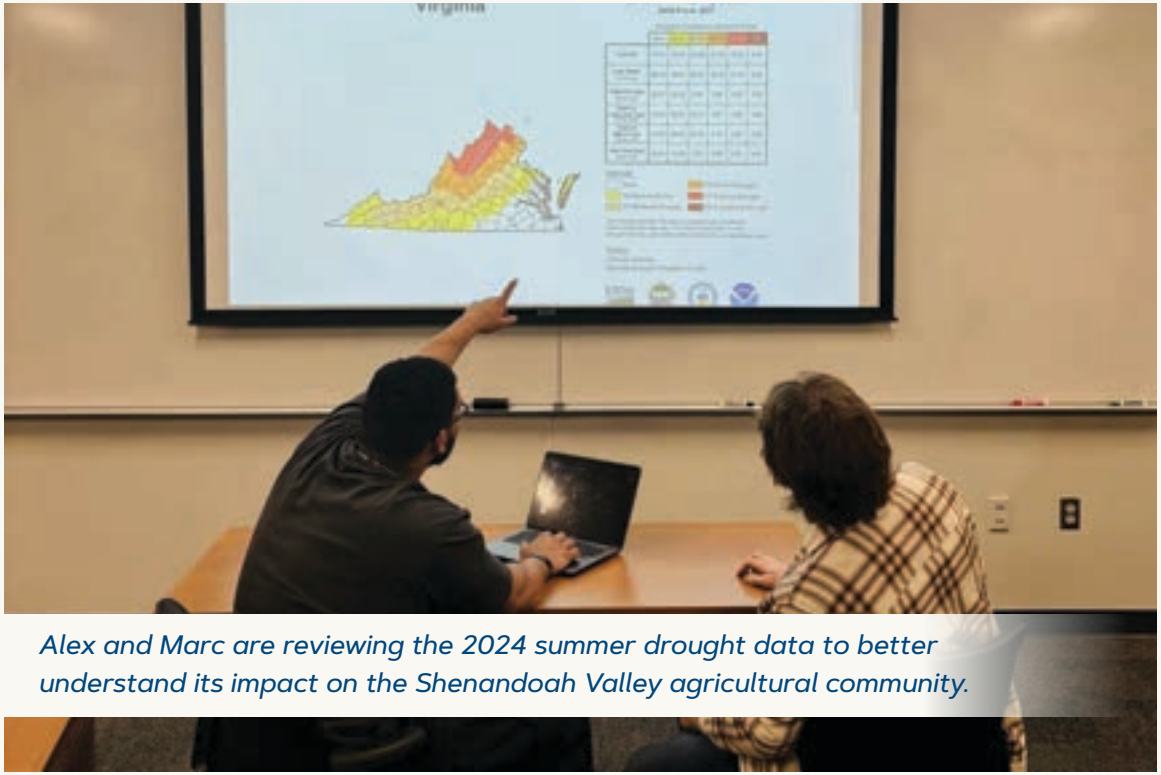
CONCENTRATION

Applied Computing

Music transcription traditionally requires skilled musicians to manually convert audio into written notation—a process that is time-consuming and labor-intensive. DrumEcho seeks to automate this process by developing a machine-learning model capable of transcribing analog musical audio into accurate sheet music in real-time. This innovation aims to assist musicians, educators, and students by simplifying the creation of precise musical scores.

Our project focuses on drums and clarinet, utilizing audio spectrograms and a hierarchical Convolutional Neural Network (CNN) for feature extraction. The trained model will be embedded into a Raspberry Pi 5, enabling real-time transcription of analog audio inputs. By addressing the complexities of pitch, dynamics, and articulation, DrumEcho aspires to make music notation more accessible and support musicological research.

AN ANALYSIS OF DROUGHT IN THE SHENANDOAH VALLEY



Alex and Marc are reviewing the 2024 summer drought data to better understand its impact on the Shenandoah Valley agricultural community.

STUDENTS

Alex Chizmadia

Marc Semelfort

ADVISOR

Tobias Gerken

CONCENTRATION

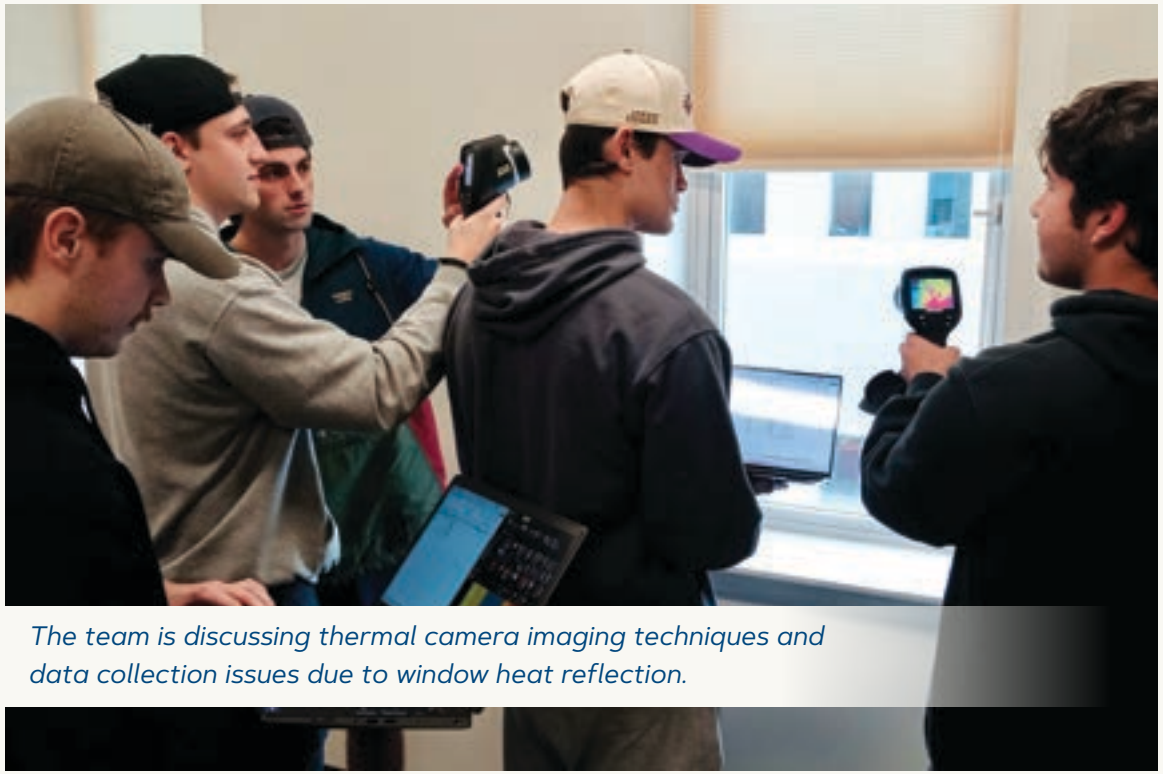
Environment & Sustainability

The Shenandoah Valley, located in Western Virginia, is a region with significant agricultural activity that is increasingly vulnerable to drought. In the summers of 2023 and 2024, the area experienced severe droughts, which had substantial agricultural and social impacts. This project aims to better understand how droughts affect the region by conducting stakeholder analysis through semi-structured, open-ended interviews with agricultural producers, water managers, and government officials. The goal is to explore how droughts are impacting the region, how different stakeholders are preparing for drought conditions, and whether any best management practices are being implemented.

By combining scientific data with insights from local stakeholders, the project will identify the types of information needed by agricultural producers, water managers, and government officials to minimize economic losses and improve resilience to drought. The findings will be presented through an informational dashboard that includes key details from the interviews, along with charts, graphs, and maps to help visualize and explain the drought's impacts.

The ultimate goal of this project is to provide a resource that can help agricultural producers, water managers, government officials, and the broader community better understand and respond to drought conditions. The dashboard will serve as an educational tool, helping stakeholders make informed decisions to improve preparedness and resilience in the face of future droughts.

RESIDENTIAL ENERGY AUDITING AND SOLAR PV FEASIBILITY ASSESSMENT



The team is discussing thermal camera imaging techniques and data collection issues due to window heat reflection.

STUDENTS

Jack Burris
Peter Hutchinson
Harrison McQuillan
Elijah Torres
Marcus Wear

ADVISOR

Maria Papadakis

CONCENTRATION

Applied Computing
Energy
Environment & Sustainability

Efficiency and conservation are key strategies for reducing energy consumption, CO_2 emissions, and costs, making them a 'win-win' for everyone. Rooftop solar photovoltaic (PV) systems also contribute to lower emissions and long-term savings, yet they remain underutilized in the U.S. residential sector. Our project explored potential energy-saving opportunities in homes and the feasibility of residential solar PV while identifying challenges that hinder major efficiency improvements and solar adoption.

We conducted energy audits and solar PV feasibility assessments for 10 volunteer homes. Each audit included a detailed analysis of utility bills, a home walkthrough, an evaluation of major energy systems (HVAC, hot water, appliances, etc.), client conservation habits, and thermal imaging of the home's structure. We used RETScreen Expert energy management software to conduct our solar PV analysis.

For each client, we provided a report summarizing our findings, including energy-saving opportunities, cost analyses for relevant improvements, and a breakdown of solar PV benefits and costs. These reports helped homeowners identify areas of energy waste and provided practical, affordable solutions to reduce energy costs.

AMERICA'S OFFSHORE WIND CHALLENGE: LESSONS LEARNED FROM CVOW

Matt and Ryan at JMU's Wind Training Facility.

STUDENTS

Ryan Endries

Matt Mesick

ADVISOR

Jonathan Miles

CONCENTRATION

Applied Computing

Industrial Manufacturing & Systems

The transition to renewable energy is vital for achieving the U.S. ambitious climate goal of reaching net-zero greenhouse gas emissions by 2050. The U.S. intends to deploy 30 gigawatts of offshore wind (OSW) energy by 2030; however, supply chain challenges have slowed progress. A lack of manufacturing infrastructure, specialized vessels, and skilled labor causes the industry to be heavily reliant on imported materials and labor from Europe and Asia, causing increased costs and delays while political and economic conditions fluctuate.

This project examines the U.S. offshore wind supply chain while considering the backdrop of Dominion Energy's Coastal Virginia Offshore Wind (CVOW) project, which is under construction. Upon completion in 2026, CVOW will be the largest offshore wind facility in the U.S., comprising 176 turbines with a capacity of 2.6 gigawatts. CVOW presents an opportunity to explore supply chain barriers, domestic manufacturing potential, and infrastructure needs for future projects.

Through analysis of CVOW's progress, successes, and challenges, this study offers insights into logistics, policy frameworks, and economic factors that impact offshore wind deployment. Our findings highlight structural barriers and offer strategies to enhance domestic supply chain resilience. Lessons learned from European OSW deployment and CVOW informed this work, which is intended to provide policymakers, industry leaders, and investors with knowledge that will advance a competitive U.S. offshore wind industry.

TACKLING THE PLASTIC WASTE CRISIS WITH ENGINEERED ENZYMES

Jake, Cat, and Casey are preparing bacterial cultures for enzyme expression and purification.

STUDENTS

Riley Alkhayat
Jake Obenhein
Casey Pence
Cat Kruse
Emma Espinoza

ADVISORS

Stephanie Stockwell
Louise Temple

CONCENTRATION

Applied Biotech
Environment & Sustainability

Every year, about 380 million tons of plastic are produced—the vast majority of which is used briefly and thrown away, lingering in the environment for centuries. While recycling is often promoted as a complete solution, the truth is that only ~9% of plastic waste is actually recycled. Plastics that escape our waste management systems degrade into microplastics and can be found almost everywhere—in our food, water, and bodies.

We conducted energy audits and solar PV feMicroplastics enter living organisms and have been linked to neurotoxicity, organ dysfunction, and DNA damage. One way to combat this problem is to advance plastic recycling technology. Our research project focuses on the optimization of a naturally occurring bacterial enzyme that can slowly break down PETase (polyethylene terephthalate) plastic into reusable monomers.

For this project, optimized variants of the PETase enzyme were bioengineered, biomanufactured, and tested for enhanced activity and stability. Through strategic enzyme optimization of this kind, PETase may be used to support a more sustainable circular plastic economy with fewer environmental and health impacts.

COMMUNITY ENERGY RESILIENCE AND THE IMPACT OF TRANSPORTATION

Jack is developing transportation assessment tools at JMU's wind training facility.

STUDENT

Jack Sellers

ADVISOR

Jonathan Miles

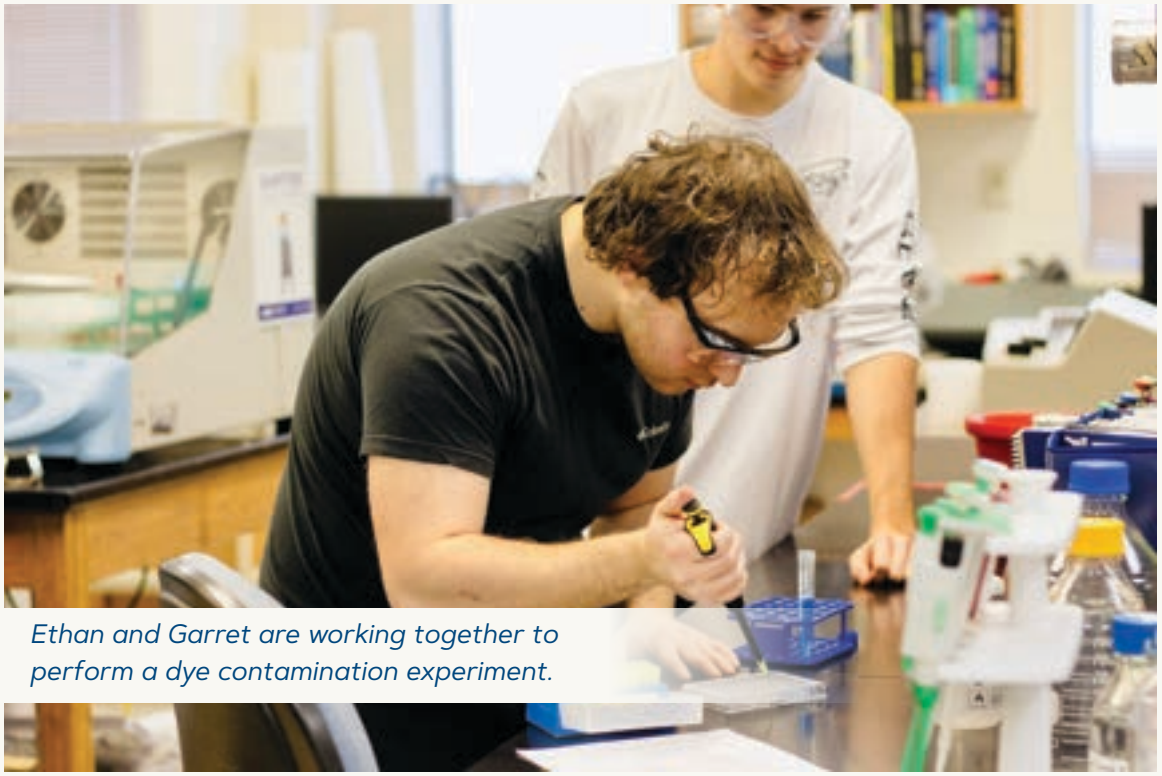
CONCENTRATION

Tailored: Environment Sustainability & Energy

This project is intended to enhance the Virginia Community Energy Resilience workbook and scoring tool that is under development at JMU's Center for the Advancement of Sustainable Energy with support from the U.S. Department of Energy. A tool that comprises a series of worksheets was developed for use by communities that wish to assess their transportation resilience. Mobility is critical in our modern world, and when it is lost for an extended period of time–especially among those who are disadvantaged and may experience food insecurity, be dependent on healthcare services, or experience other challenges–individuals and households become more vulnerable.

Disruptions of power services are anticipated to become more frequent and to persist over longer durations as weather patterns shift around the globe due to climate change. This tool will support communities that wish to assess and address their vulnerabilities to power disruptions and will assist them in identifying means to increase their transportation resilience and enhance their preparedness should critical infrastructures such as fuel distribution networks be compromised.

RETHINKING PLASTICS: SUSTAINABLE SOLUTIONS IN LIFE SCIENCE LABS



Ethan and Garret are working together to perform a dye contamination experiment.

STUDENT

Garret Ankeny

Ethan Tynan

ADVISOR

Stephanie Stockwell

CONCENTRATION

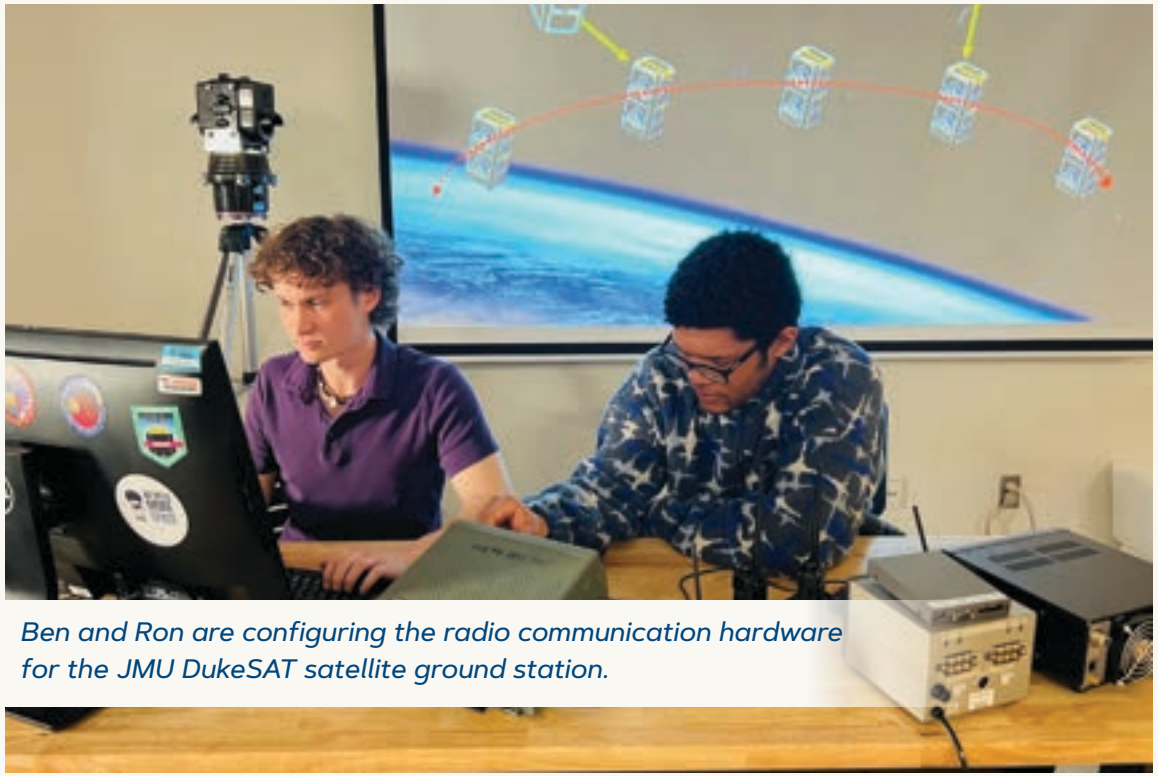
Applied Biotech

Life science laboratories consume 12 billion pounds of plastic annually, accounting for 2% of global plastic waste. A major contributor is the widespread reliance on single-use micropipette tips, chosen for their ease, purity, and cost-effectiveness. However, their disposal significantly impacts the environment and poses health risks.

Our project challenges the dependence on single-use plastics by developing a safe and effective protocol for washing, sterilizing, and reusing micropipette tips. Through these methods, we aim to restore micropipette tips to a reusable state without compromising their laboratory integrity.

By establishing reliable Standard Operating Procedures (SOPs) and implementing strategies to integrate washed plastics into JMU courses and research projects, we can significantly reduce plastic waste in academic labs. By rethinking lab sustainability, this project could transform wasteful practices into sustainable solutions, contributing to the broader movement toward greener research.

JMU DUKESAT: SATELLITE GROUND STATION DEVELOPMENT AND TESTING



Ben and Ron are configuring the radio communication hardware for the JMU DukeSAT satellite ground station.

STUDENTS

Ben Rubin
Quron Anthony

ADVISORS

Jonathan Spindel
Bryan Cage
Stefano Colafranceschi

SPONSOR

Madison Trust
Northrop Grumman

CONCENTRATIONS

Applied Biotech
Applied Computing
Industrial Manufacturing & Systems

The JMU DukeSAT development effort is working on designing, developing, testing, and launching a constellation of small satellites (CubeSats) into low earth orbit (LEO) to test the implementation of a space-based mesh network. CubeSats are a cost-effective means of accessing space to collect data that support a wide range of missions from earth sensing to orbital space science. CubeSats, however, are constrained in their internal space and the energy available to run internal systems. Furthermore, each satellite requires a dedicated downlink and ground station to receive data and send control signals, and it is restricted to only communicating while above its assigned ground station. The ability to provide these satellites with access to a space-based local area mesh network connected to the ground would have a two-fold impact: First, each satellite would no longer need an onboard space-to-ground communication system, freeing up internal real estate and power. Second, access to this LEO mesh network would provide satellite users regular and consistent opportunities to access collected data and provide for better command and control.

The current capstone project work focuses on the construction of a JMU ground station to test space-to-ground communications, which is required to develop and test a proof-of-concept wireless mesh network for both high-altitude balloon (HAB) experiments and the continued development of a CubeSat constellation for testing in LEO.

IMPACTS OF SAND DAMS ON WATER AND SOIL QUALITY IN SEMI-ARID KENYA

Will is collecting data upstream of a sand dam in Machakos County, Kenya.

STUDENT

Will Sizemore

ADVISORS

Jennifer Coffman

Wayne Teel

SPONSOR

Utooni Development Organization (Kenya)

CONCENTRATION

Environment & Sustainability

Arid and semi-arid landscapes (ASALs) dominate over 80% of Kenya's territory and are home to around 35% of the human population, 90% of the wildlife, and 70% of livestock. Most of Kenya experiences two rainy seasons: short rains in November and December, and a longer rainy season from around March through May. However, the duration and intensity of these rainy seasons are becoming increasingly irregular. To mitigate water shortages, people in rural areas deploy various water storage methods for personal and community-wide use, with sand dams serving the latter. A sand dam is a reinforced concrete wall built across a seasonal riverbed to capture and store sand and water, thus producing an artificial aquifer for a community (UDO).

There are conflicting data on the long-term impacts of sand dams, particularly regarding salinization of water and soils, and subsequent effects on water quality and vegetation. This project analyzes salinity and E. coli levels at twenty-four different dam sites of different ages in Machakos and Makueni Counties, Kenya. Site observations and data collection in Kenya occurred during one week in 2023 and three weeks in 2024 while working with Utooni Development Organization (UDO), a local non-profit. Data were analyzed regarding age of dams, location and relationship to other dams, and land use. Results will assist UDO to better understand longitudinal impacts and, if needed, design remediation strategies.

THE CHARACTERIZATION OF HAZELNUT BIOCHAR FOR USE AS AN AGRICULTURAL SOIL AMENDMENT

Investigating the properties of hazelnut biochar.

STUDENT

Myles Patterson

ADVISORS

Wayne Teel

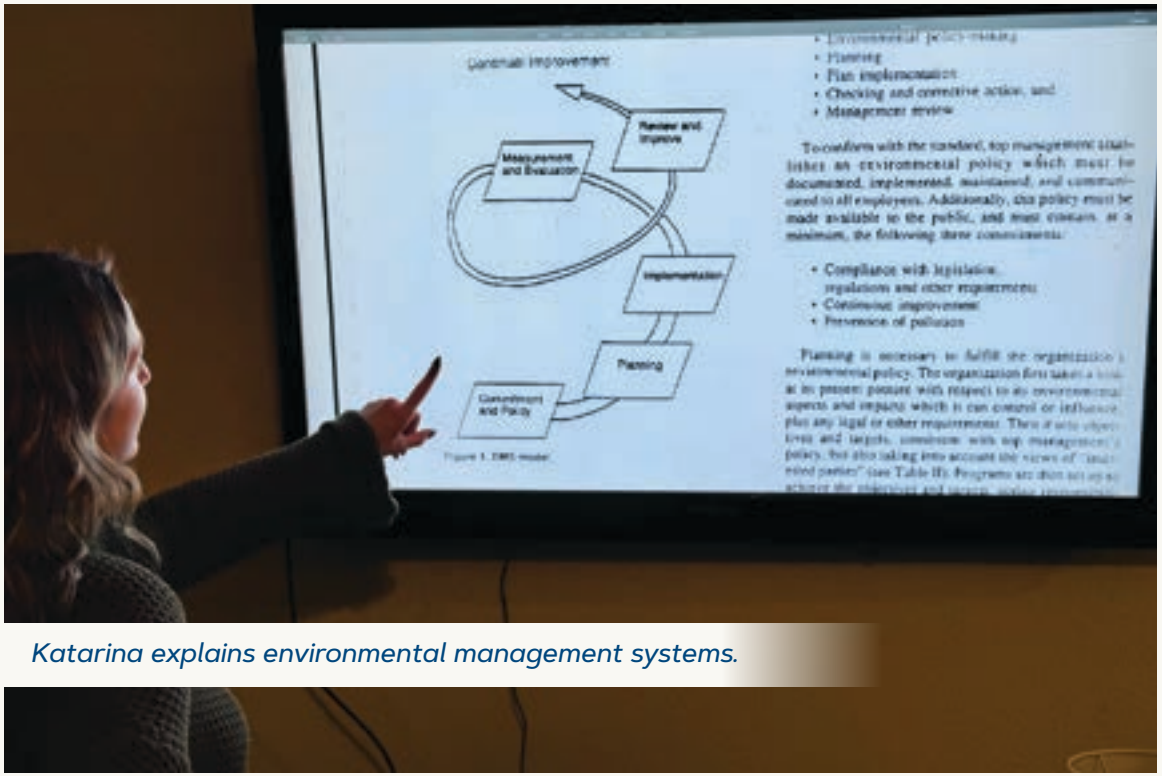
Jared Stoltzfus

CONCENTRATION

Environment & Sustainability

The process of creating biochar has a net effect of removing carbon dioxide from the atmosphere, which is necessary for climate change mitigation. This project investigates the other properties of hazelnut biochar that are beneficial to different soil types, as well as developing a specialized biochar to target specific environmental problems. The pH, residual carbon, nutrient content, ash content, and density of the biochar were collected to determine specialized qualities. Our hypothesis is that the hazelnut biochar will provide a specialized application in capturing greenhouse gases and filtering out toxins to address climate change and reduce environmental pollution from farms.

DEVELOPING AN ENVIRONMENTAL MANAGEMENT SYSTEM FOR JMU'S SUSTAINABILITY GOALS



Katarina explains environmental management systems.

STUDENT

Katarina Nickolaou

ADVISORS

Steven Frysinger

CONCENTRATION

Environment & Sustainability

JMU is committed to sustainability but faces challenges in managing its environmental impact across campus. To address this, our project develops an Environmental Management System (EMS) tailored to align JMU with the internationally recognized ISO 14001 standard. ISO 14001 provides a systematic framework for organizations to enhance environmental performance, ensure legal compliance, and promote continuous improvement.

Our project begins with a comprehensive environmental assessment of JMU's campus, identifying key areas of improvement, including waste management, energy efficiency, and resource conservation. Based on these findings, we propose actionable objectives and targets to reduce environmental impacts and improve sustainability practices. Additionally, the EMS framework integrates strategies for engaging stakeholders, monitoring progress, and maintaining compliance with environmental regulations.

By implementing this EMS, JMU will be positioned as a leader in higher education sustainability, reducing operational costs, conserving resources, and enhancing its reputation among students, faculty, and the broader community. This project offers JMU a clear and actionable roadmap to achieve ISO 14001 certification while fostering a culture of environmental stewardship across campus.

Intelligence Analysis

In a world of uncertainty and unpredictability, unbiased and thoughtful analysis is invaluable. The Intelligence Analysis B.S. 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 and critical thinkers capable of bringing increased clarity to uncertain situations in areas ranging from national security to business to law enforcement and beyond.

FORECASTING THE FUTURE OF ENERGETIC MATERIALS ON ASYMMETRIC WARFARE BY 2030

The group is analyzing the foundational elements of asymmetric warfare.

STUDENTS

Alex Temoshok

Molly Bauer

Sean Carley

John Ferreira

Izzy Jankowski

ADVISOR

John Robinson

SPONSOR

MITRE

Energetic Materials (EM) are chemical compounds that release large amounts of energy and power everything from construction tools to rocket propellants. Yet their evolving use in unconventional combat settings remains underexplored. This project investigates how EM could shape Asymmetric Warfare (AW), where non-traditional tactics increasingly challenge U.S. security.

We examined two case studies to clarify how EM might be applied to weapons systems widely used in AW, highlighting potential technological advancements and their impact on future conflicts. First, we employ Causal Loop Diagramming to identify key feedback loops–such as resource availability, tactical innovation, and strategic incentives–that drive EM proliferation. Next, we use structured Futures Analysis to envision multiple scenarios, considering how these materials could transform battlefield operations by 2030.

By analyzing foundational elements of AW alongside EM's rapid development, our research offers insights into emerging threats and possible countermeasures. The aim is to help U.S. defense planners anticipate shifting tactics, manage risks, and devise proactive strategies that address the expanding role of EM in conflict. Ultimately, this project underscores the importance of preparing for a new and evolving tactical environment.

IMPACT OF MIGRATION ON POLITICAL EXTREMISM IN FRENCH AND GERMAN ELECTIONS

Team members analyze migration data using data visualization tools.

STUDENTS

Lauren Ayres

Kylie King

Rachel Wall

Samantha Wootten

ADVISOR

Jennifer Davis

SPONSOR

Guidehouse

This project develops an analytic forecast of the impact of Middle Eastern migration on political extremism surrounding elections in France and Germany. The work aims to study the influence of the volume of Balkan Route migration on political extremism,migration policies, and social integration within the two countries. The political and societal stability of France and Germany is of significant concern to the United States considering the countries' military partnerships, unique relational dynamics with China and Russia, long-standing socioeconomic ties to the United States, and overall international influence.

The project utilizes counterfactual reasoning and data visualization software to analyze census, migration, and election data to provide a comprehensive final forecast. Both France and Germany are influential in internationalforums, so the United States must be prepared for shifting political environments, evolving priorities, and changing societal attitudes towards migration on a global scale.

FORECASTING THE THREAT OF UNMANNED AERIAL SYSTEMS ON U.S. GROUND FORCES

The group is analyzing various drone subtypes and their capabilities.

STUDENTS

Dawson Calvin

Matthew Snyder

Nathan Daly

Colin Lafley

John Lohr

ADVISOR

John Robinson

SPONSOR

MITRE

Small unmanned aerial systems (sUAS) are reshaping how militaries fight, as seen in the Russo-Ukrainian War. Both sides have used drones for reconnaissance, targeting, and kamikaze attacks, reducing the time and cost required to identify and destroy ground targets. Some analysts believe this signals a major transformation in the battlespace, while others argue that drones remain limited by vulnerabilities such as counter-drone defenses.

Our project examines whether these emerging drone capabilities present a significant challenge to U.S. ground forces over the next decade. We analyze real-world data from multiple conflicts, focusing on how sUAS strike tanks, infantry, and critical transport vehicles. By exploring technological advances, strategic implications, and practical constraints, we seek to distinguish hype from genuine transformation.

To inform decision-makers, we propose scenarios on how drone warfare could evolve, including tactics to mitigate sUAS threats. Ultimately, our research helps clarify whether the rapid proliferation of inexpensive and disposable aerial assets will fundamentally alter future ground operations—and offers guidance on how U.S. forces can adapt.

THE RISING THREAT OF CHINA'S BIO-ENGINEERED WEAPONS TO U.S. NATIONAL SECURITY

The team analyzes the causal forces of Chinese genetically engineered weapons.

STUDENTS

John Fleetwood

Sydney Effer

Catie Reilly

Adam Scroggins

ADVISOR

Jennifer Davis

SPONSOR

MITRE

China's weaponization of biotechnology has caused concerns as a potential national security threat to the U.S. As a result of those concerns, the U.S. must utilize the National Security Commission on Emerging Biotechnology (NSCEB) to examine the critical intersections of emerging biotechnology for U.S. national defense activities. The team seeks to serve the Chief of Staff of the NSCEB by providing actionable insights into the research question, "What is the likelihood that China will develop and deploy genetically engineered weapons that will pose a significant threat to U.S. National Security in the next 5 years?"

China is looking to explore biotechnology as a new domain of warfare in an attempt to modernize their military. To pursue this objective, the People's Liberation Army (PLA) has used both offensive and defensive applications of CRISPR technologies. These applications of CRISPR technologies differ between the United States due to ethical differences between the countries. China has begun testing these gene editing methodologies with success for the future application of human enhancement and ethnic weapons for militarization.

Given China's continued advancements in genetic engineering and its drive to pursue biotechnology for military applications, the potential for genetically engineered weapons to emerge as a national security threat to the U.S. remains a significant concern. The PLA's investments in CRISPR-based technologies and ethical differences in research practices highlight an intent to leverage biotechnology for warfare. China's bioengineeringmeasures must be closely monitored to safeguard U.S. national security.

THE USE OF DISRUPTIVE EMERGING TECHNOLOGY IN INTERNATIONAL COUNTERTERRORISM

The team is working through various aspects of emerging technology issues.

STUDENTS

Lauren Edwards

Addison Surratt

Emily Babcock

Amelia Litowitz

Elisa Slater

ADVISOR

Jennifer Davis

The U.S. can enhance its national defense capabilities in reconnaissance and surveillance by incorporating aerial and ground unmanned systems and artificial intelligence into U.S. national security measures. This implementation will allow for more detail and accuracy in operations to identify and neutralize potential threats. We analyzed how integrating unmanned systems and cybersecurity measures into U.S. international counterterrorism policy enhances the ability to anticipate and respond to future terrorist attacks, ensuring a sustained competitive edge against evolving adversarial threats over the next 5 years.

It also provides an opportunity to counteract disruptive technologies introduced by international terrorist organizations by capitalizing on physical and digital domains. By understanding cybersecurity and unmanned system security measures, our research can support policy creation, address ethical concerns, and add protection and prevention measures to cyberspace, national security, and public safety to mitigate future terrorist attacks.

This research aims to address critical information gaps by analyzing methods of counterfactual reasoning, strategy assessment, and data visualization, actualized through the tools Tableau, Mapbox, Excel, and Gephi. Overall, our research methodologies address issues regarding AI and malicious code usage by terrorist organizations, the evolving use of unmanned systems in countering terrorism, and the effects of social engineering on the general public.

FORECASTING TALIBAN EFFORTS AGAINST TERRORIST ACTIVITY IN AFGHANISTAN

Students analyze data tracking terror groups in Afghanistan.

STUDENTS

Kylie Evans

Morgan Folsom

Connor Hicks

Casey Hughes

Grace Lane

ADVISOR

Jennifer Davis

SPONSOR

ManTech

This project will define the likelihood of Taliban senior leadership to provide opportunities for ISIS-K and Al-Qaeda to train, recruit, and carry out threats against United States (U.S.) interests in the Near East over the next five years. The Taliban's rise to power in Afghanistan following the U.S. withdrawal can provide opportunities for ISIS-K and Al-Qaeda to reestablish training camps, recruit members, and carry out threats against U.S. interests. The Taliban's authority has spiked insurgency and redeveloped a terrorist hub in Afghanistan which can provide a multitude of opportunities for alternative foreign state and non-state actors to undermine the authority of the U.S. and could increase the likelihood of threats against U.S. interests in the Near East.

As the Taliban consolidates control in Afghanistan, it's crucial to assess whether they are enabling or obstructing operations from Al-Qaeda and ISIS-K. By utilizing ArcGIS, we are able to highlight areas in Afghanistan that are being contested by one or more groups, note terrorist attacks aimed at competing organizations or attacks claimed by multiple, and track the activity of newly established and preexisting training camps. Causal Analysis allows us to map the events and factors that have led to Afghanistan's current terrorist landscape.

ARCTIC GOVERNANCE IN FLUX: ASSESSING PRC GREY ZONE ARCTIC INFLUENCE BY 2030

The team is examining resource distribution and maritime shipping routes in the Arctic Circle.

STUDENTS

Luke Blubaugh

Dylan Grimes

Daniel Leyde

Jacob Morse

Eric Suh

ADVISOR

John Robinson

SPONSOR

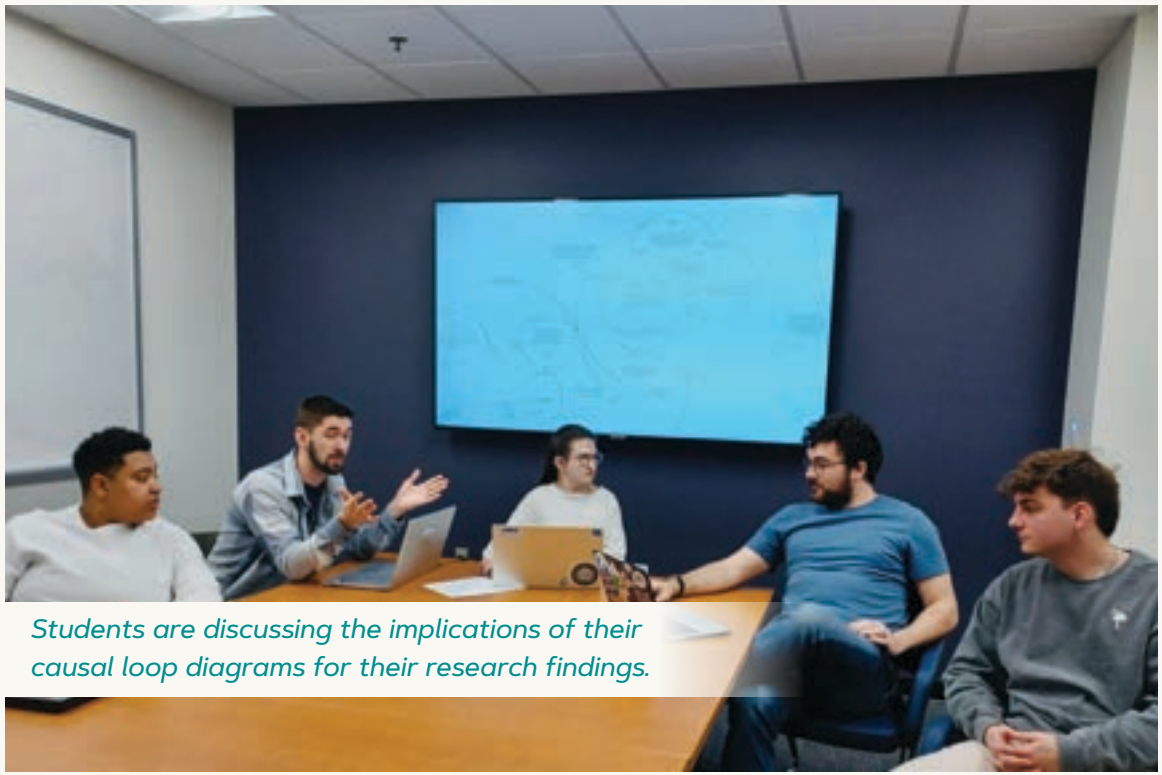
MITRE

China's expanding presence in the Arctic, fueled by economic investments and strategic partnerships, is reshaping regional governance and challenging the Arctic Council's consensus-based approach. This project forecasts how China's "grey zone" tactics—economic deals, infrastructure projects, resource access, and diplomatic maneuvering—may weaken the Council's authority by 2030.

We identified several key drivers that could trigger governance shifts, including China's growing bilateral economic agreements with Arctic states, evolving regional decision-making structures, and NATO's role in Arctic trade and security. Using Geographic Information Systems (GIS) to map China's investments, Causal Loop Diagrams (CLDs) to highlight interdependencies, and structured Futures Analysis to model multiple scenarios, our team offers a comprehensive view of how this grey zone governance in the region might evolve.

Our findings equip the U.S. Arctic Council Advisor with early indicators of potential challenges, enabling proactive policy responses and highlighting opportunities to preserve cooperative frameworks. As Beijing pursues strategic influence without overt militarization, these insights help safeguard regional stability. and uphold the Council's relevance amid intensifying geopolitical competition.

SHI'A TERROR GROUPS AND UNMANNED SYSTEMS EXPANSION IN THE NEXT THREE YEARS



Students are discussing the implications of their causal loop diagrams for their research findings.

STUDENTS

Hayden Knight

Delicia Lowe

Rudolph Mallamas

Margaret Miller

Alex Wingrove

ADVISOR

Jennifer Davis

The Russo-Ukrainian War has demonstrated the potential of unmanned weapon systems in battlefield settings through their cheap production, ease of use, and effectiveness in attacking military and infrastructure targets. As a result, this unintentionally sparked non-state actors' interest in further utilizing and integrating unmanned weapon system technologies.

The project focuses on Shi'a terror groups, including Hezbollah, the Houthi Rebels, and other proxy groups under the Iranian Axis of Resistance. In the Middle East, terror groups' current unmanned weapon system programs show promising and effective results against military targets and naval vessels. Given the state of geopolitics, it is highly likely that these Shi'a terror groups intend to expand and carry out operations. This will affect how United States forces can respond to the asymmetric use of unmanned weapon systems.

The project seeks to identify how unmanned systems could be used and advanced in different environments in the future. These answers will allow for strategies to be developed for the United States to properly prepare for the advancing Shi'a unmanned weapon system programs and their asymmetric tactics.

CONTINUED FENTANYL FLOW FROM INDIA LIKELY TO STRAIN U.S. ECONOMY BY 2030

The team is examining a map of international fentanyl trade.

STUDENTS

Téa Iverson

Keira Johnson

Gabi Schultz

Maddie Walden

ADVISOR

John Robinson

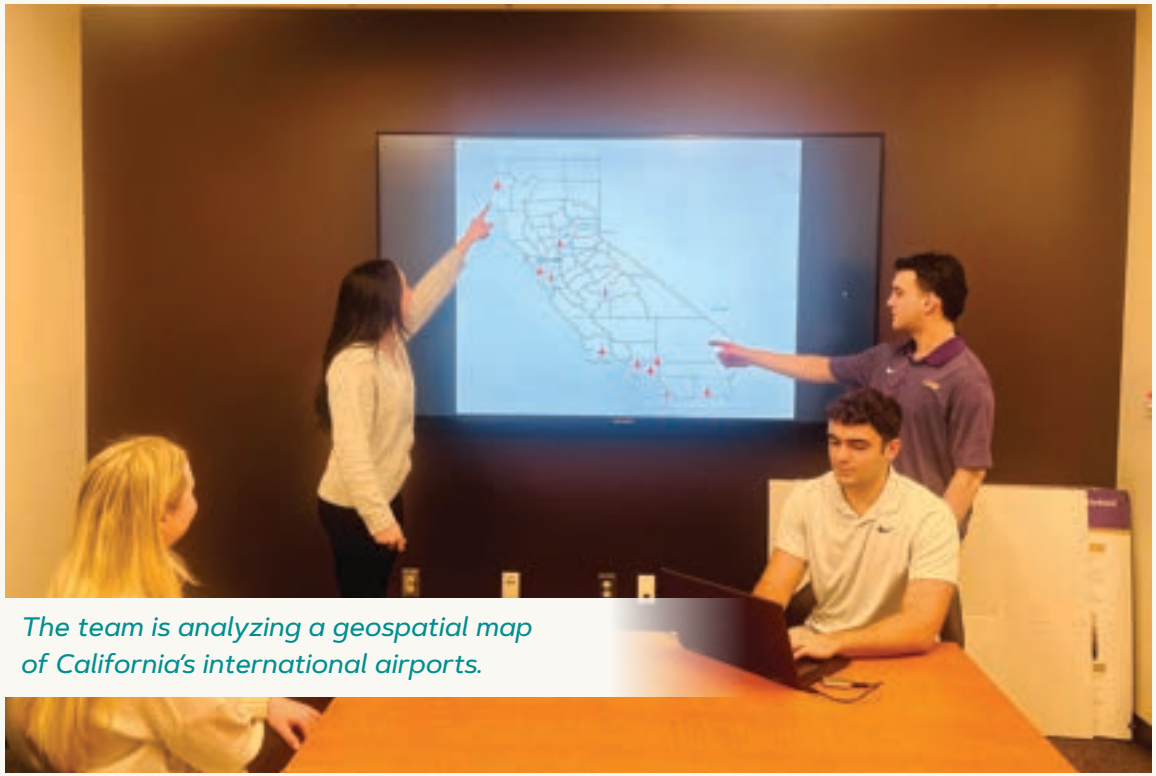
SPONSOR

Guidehouse

India is increasingly becoming a key supplier of fentanyl precursors, shifting global production away from China and amplifying U.S. concerns about illicit drug flows. Fentanyl, a synthetic opioid 50–100 times stronger than morphine, poses significant public health, security, and economic risks—especially since about 6% of Americans use illicit drugs daily. After Indian precursors reach Mexico or Canada, cartels finalize production and smuggle finished fentanyl into the United States, exacerbating an already severe opioid crisis.

Our project employs futures forecasting to examine how India's expanding precursor market might reshape the fentanyl trade over the next five years. We explore supply chain dynamics, regulatory factors, and cartel adaptations to provide policymakers, law enforcement, and public health stakeholders with early indicators of evolving threats. By assessing potential scenarios—from increased cross-border smuggling routes to international policy interventions—this study aims to offer actionable insights for mitigating the rising tide of fentanyl abuse.

ANALYZING THE POTENTIAL THREAT OF IRANIAN SLEEPER CELLS WITHIN THE UNITED STATES



The team is analyzing a geospatial map of California's international airports.

STUDENTS

Emily Patterson

Hayden Daly

Jayden Wyatt

Nico Martirossian

ADVISOR

Jennifer Davis

SPONSOR

ManTech

The increasing geopolitical tensions between Iran and the United States have heightened concerns regarding the potential activation of Iranian sleeper cells within US borders. The team selected California as the focus due to past sleeper cell plots in the region and its large Iranian population. This research, conducted with ManTech aims to assess the probability of an attack by Iranian sleeper cells on American soil within the next five years. The project will further spread awareness of how this is a growing concern for the U.S. This research will enhance national security preparedness by providing data-driven insights to aid in the detection, prevention, and mitigation of potential threats posed by Iranian sleeper cells.

Data related to demographics, networks, critical infrastructure, and finances help provide a better scope on how these sleeper cells may act in the future. The methods the team plans to use are network analysis, causal analysis, counterfactual reasoning, and GIS/data visualization. By leveraging intelligence reports, historical precedents, and geopolitical analysis, this study will provide actionable insights to support national security measures and policy development. These covert operatives are believed to remain dormant until activated for espionage, sabotage, or attacks.

This project delves into Iran's strategy and the extent to which these networks could pose a real danger. The goal of this research project is to gain an understanding of Iranian sleeper cells and the threat they pose within the U.S. as well as help gather information and data of this threat.

ENERGY UNDER SIEGE: THE THREAT OF TERRORISM IN WEST AFRICA

The group is examining energy infrastructure in Africa.

STUDENTS

Connor Dunn

Dylan Shelton

Evan Hoover

Finn Keena

Hayden Brown

ADVISOR

John Robinson

West Africa's expanding energy sector has attracted major global investments, yet extremist groups increasingly threaten this critical infrastructure. Our project evaluates the likelihood of Foreign Terrorist Organizations (FTOs) successfully striking West African energy facilities within the next three years, examining regional anti-West sentiments, operational trends, and geopolitical factors that heighten these risks. By analyzing past attacks and emerging patterns, we identify key vulnerabilities with implications for both regional stability and global energy markets.

Drawing on data from terrorism and energy databases, we focus on how potential disruptions could affect U.S. energy security and shape policy responses. Although ongoing political volatility and the shifting tactics of extremist groups complicate long-term forecasting, our findings offer actionable insights into ways to strengthen resilience and reduce exposure to high-impact attacks. By highlighting critical risk factors and possible scenarios, this research aims to guide decision-makers, energy stakeholders, and security planners in developing strategies to protect vital infrastructure and maintain regional stability.

TERRORIST THREATS ON U.S. INTERESTS FROM AFGHANISTAN TRAINING CAMPS

The team is studying a map of Afghanistan.

STUDENTS

Katie Fricke

Abby Zindler

Taylor Hankins

Victoria Jones

Jenks Britt

ADVISOR

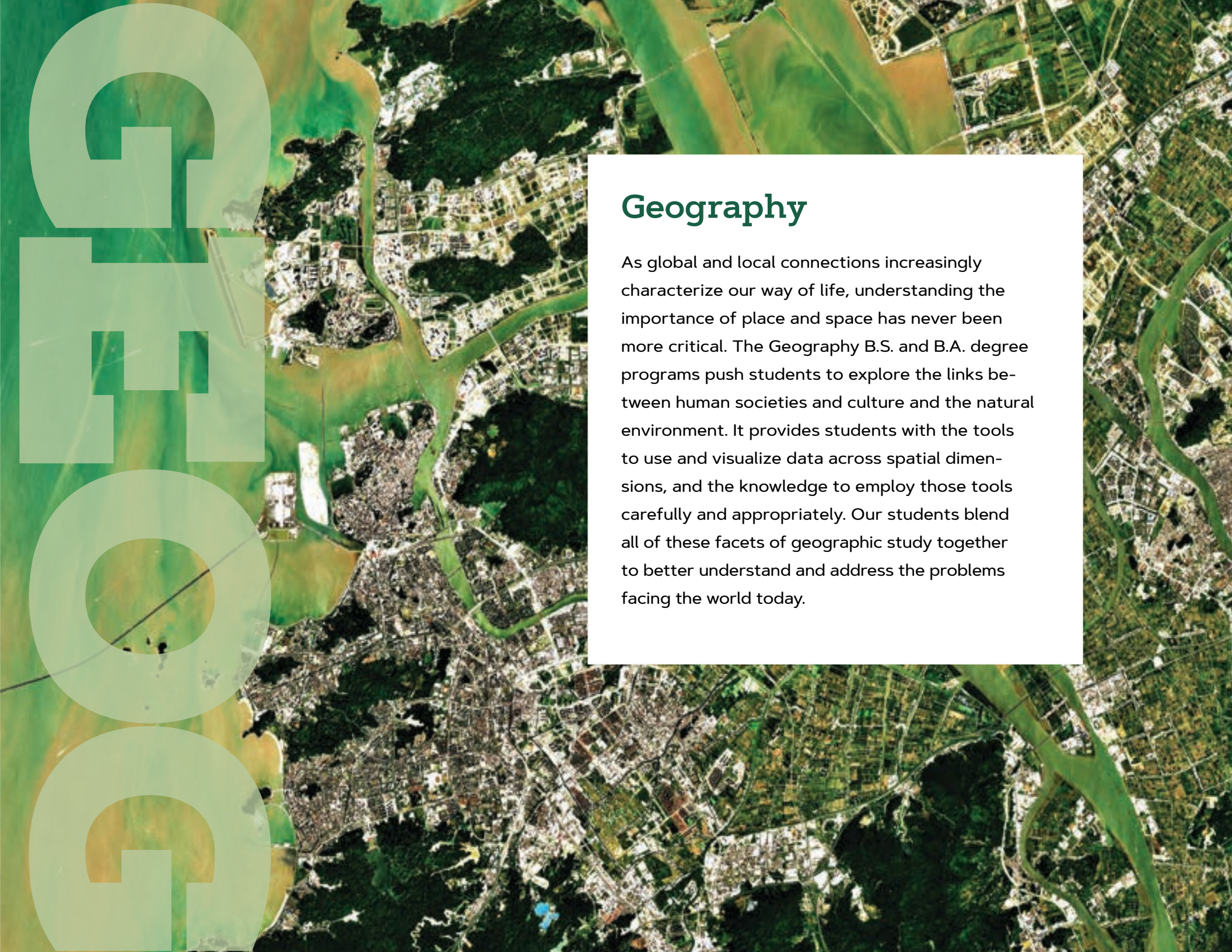
John Robinson

SPONSOR

ManTech

Afghan training camps led by al-Qaeda and the Taliban present an escalating threat to U.S. security. Our project examines how these camps, spread across at least 12 provinces, may facilitate a multi-city suicide bombing attack in the United States within three years, potentially causing mass casualties and societal uncertainty. We analyze why al-Qaeda and the Taliban are collaborating, focusing on advanced suicide-vest technology and specialized militant training.

Our findings aim to inform U.S. Central Command (USCENTCOM) about the camps' current capabilities and intentions, offering insights into the likelihood and potential impact of large-scale attacks on American soil. By understanding these alliances and emerging technologies, U.S. decision-makers can better anticipate threats, strategize counterterrorism measures, and strengthen homeland security. This paper provides actionable intelligence for near-term planning, shedding light on a growing jihadist network that might otherwise evade attention within Afghanistan's evolving landscape.



Geography

As global and local connections increasingly characterize our way of life, understanding the importance of place and space has never been more critical. The Geography B.S. and B.A. degree programs push students to explore the links between human societies and culture and the natural environment. It provides students 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.

UNDERSTANDING AND PERCEPTION OF DANGER IN REMOTELY SENSED IMAGES

Claire and Lucy are making final edits to the survey used in the study.

STUDENTS

Claire Hamilton

Lucy Reynolds

ADVISOR

Zachary Bortolot

Satellite imagery and aerial photography play a key role in research and decision-making, shaping the way humans live their everyday lives. The images captured by satellite and aerial sensors differ from those people commonly encounter.

Our research explored the relationship between image interpretation, perceived danger, and demographic factors, including experience with image analysis and the choice of color composites used in displaying satellite images. For example, our project examined how gender influences the perception of satellite imagery based on different color composites.

To investigate these relationships, we conducted an online survey with JMU students from the Intelligence Analysis and Geography programs. The survey began with demographic questions such as age, race, and education level. Participants were then shown an image for five seconds before answering questions related to their perception and interpretation of the image. The results were analyzed statistically to determine how demographic factors, image analysis experience, and color composite choices influence the perception of danger and the accuracy of image interpretation.

ASSESSING LAND CHANGE AND URBAN HEAT ISLANDS IN THE CITY OF HARRISONBURG

Alex is assessing the image and classification results with NASA colleagues.

STUDENT
Alex Temoshok

ADVISOR
Xiaojing Tang

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CONCENTRATION
Environment & Sustainability

This project aims to aid the City of Harrisonburg Public Works in using NASA Earth observation data to assess and manage tree canopy cover in Harrisonburg, Virginia. Harrisonburg has lost over 1,500 ash trees on public lands since the arrival of emerald ash borer in 2017. This is a concern because urban trees are widely accepted as one of the most effective long-term solutions to reducing the effects of urban heat islands. The City of Harrisonburg Public Works has attempted to mitigate this loss with new tree plantings. This project utilizes Landsat 8, Sentinel-2, and NAIP imagery to identify tree canopy and land surface temperature change in Harrisonburg from 2014 to 2024 to identify potential areas for future tree planting initiatives.

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JAMES MADISON
UNIVERSITY

School of Integrated Sciences

MSC 4302, 801 Carrier Drive
Harrisonburg, VA 22807
540-568-2740 Phone
sis@jmu.edu
www.jmu.edu/sis

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