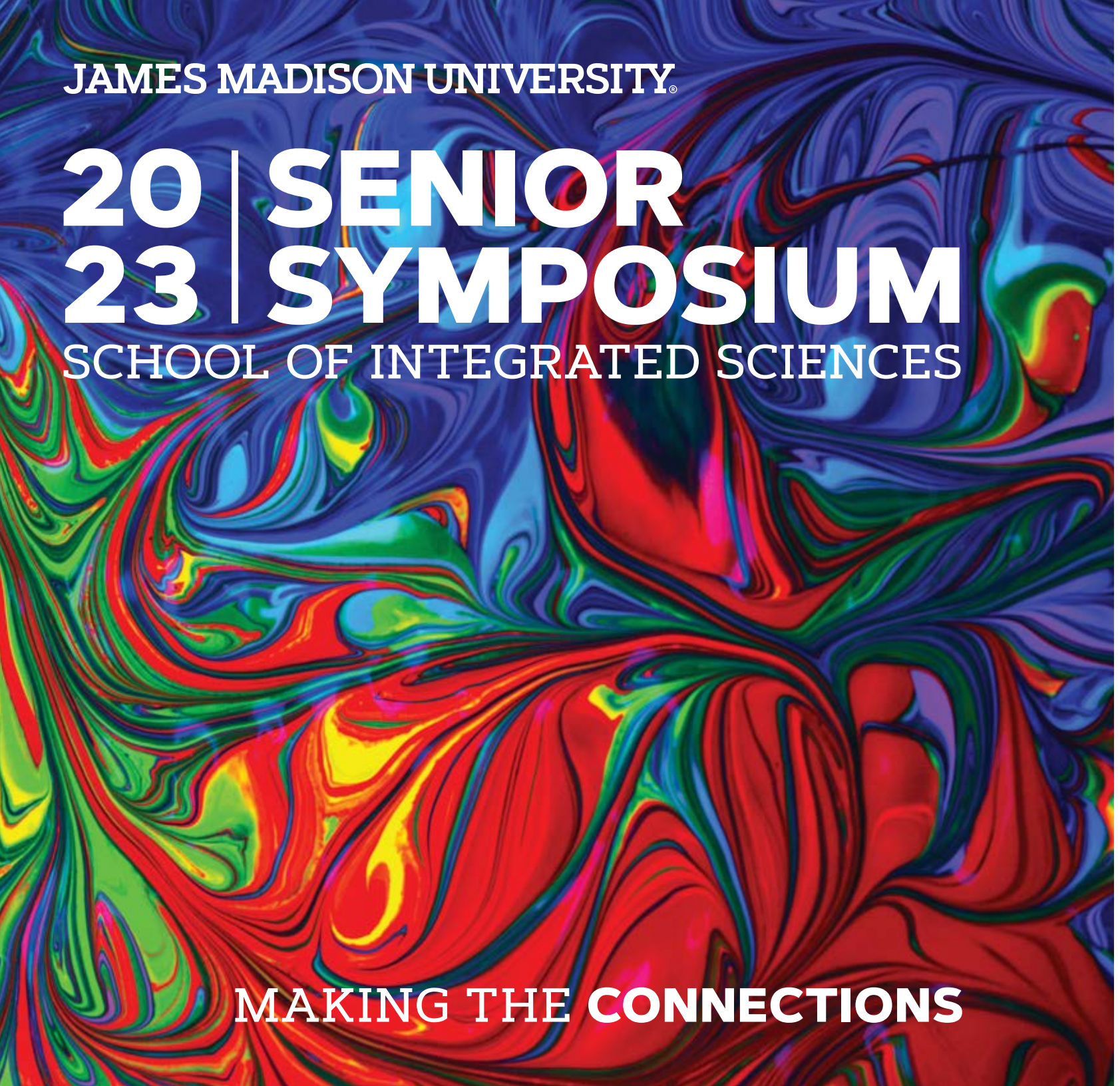


JAMES MADISON UNIVERSITY®

2023 SENIOR SYMPOSIUM

SCHOOL OF INTEGRATED SCIENCES

MAKING THE **CONNECTIONS**

Integrated Science and Technology

Intelligence Analysis

Geography

Throughout this book, you will discover an enormous breadth of scholarship accomplished by undergraduate students. Teams have worked many hours over to develop creative approaches to define, address, analyze and evaluate a wide range of complex and important problems. These projects showcase a skillset that is so needed in an increasingly specialized world—to include but not limited to the difficult integration of science, technology, systems thinking, and domain-specific methodologies to arrive at new insights and solutions. Capstones are inspired by student interests, commissioned by external sponsors, and guided by faculty advisers. Ideas are crafted into achievable projects through the development of stated goals, activities, timelines, and benchmarks. Along the way, undergraduates develop their independence and confidence as they work, struggle, explore, and succeed.

...and this is just the beginning for our School of Integrated Sciences Class of 2023!

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

CONTENTS

Integrated Science and Technology

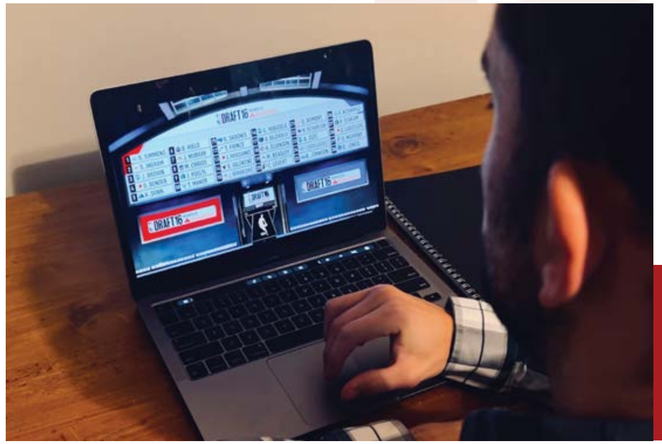
INTEGRATED SCIENCE AND TECHNOLOGY

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.

Diversity is the mix. Inclusion is making the mix work.

~ Andres Tapia

A QUANTITATIVE APPROACH TO THE 2016 NBA DRAFT



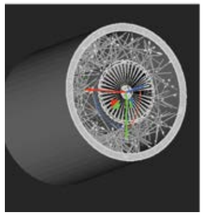
Student
Sam Lanning

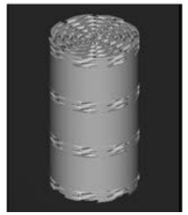
Advising
Robert Brent

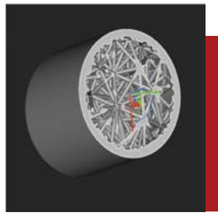
Sam is reviewing the results of the 2016 NBA draft.

Every year, the National Basketball Association (NBA) drafts promising college basketball players who aspire to become the next NBA superstar. However, not all of those selected will have successful careers because many factors go into the overall success of an NBA player. This project aims to use different metrics to make better predictions for an NBA draft prospect's success during their career. Using R-studio and RAPTOR statistical software, I compared college metrics to eventual NBA performance for players selected in the 2016 NBA draft - looking for metrics that were the most predictive of overall success. While unpredictable events, such as injury, can limit the effectiveness of statistical predictions, any improvements in the draft decision-making process can make the difference between multi-million-dollar losses or gains for franchises trying to choose the next NBA superstar.

BIOINSPIRED DESIGN OF MATERIAL ARCHITECTURE FOR ADDITIVE MANUFACTURING







Students
Connor Gavin, Darion Pleasant, Garrett Redden

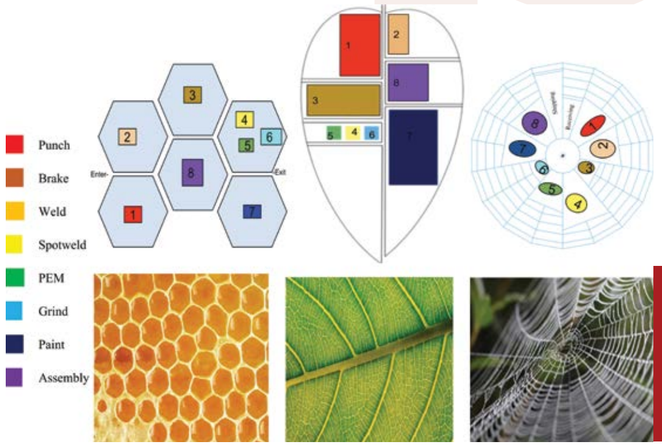
Advising
Hao Zhang

The team used three bioinspired concepts to design material structures for mechanical and sustainability performance improvement.

Various material architecture systems have been developed to improve material mechanical properties such as lightweight and resilience. Many of these design ideas were inspired by observing nature systems. Traditional material architecture systems designed for additive manufacturing are usually simple repetitive structures (e.g. honeycomb), resulting in redundant use of material in a structure. The objective of this research is to investigate compressive mechanical properties of materials architecture systems (layered and core structures) developed with bioinspired concepts. The study analyzed peak load, strength-to-weight ratio, and resilience of these structures. The results are compared with common 3D infill patterns used in additive manufacturing processes. The result of this study will benefit material system design engineers with validated mechanical property results of bioinspired designs in the case study. In addition, it generates implications on the direction of bioinspired concepts that can be used in material architecture system design. This study contributes to the engineering management community by presenting a systems methodology of bioinspired design for material architecture systems development.

Integrated Science and Technology

BIOINSPIRED DESIGN FOR MANUFACTURING SYSTEMS SUSTAINABILITY



Student

Franklin Wallace

Advising

Hao Zhang

Franklin used three bioinspired concepts to design a manufacturing system layout and analyzed their sustainability performance.

Manufacturing systems design faces challenges of variability and uncertainty in the global market due to international competition, demand for a wide variety, and stringent sustainability regulations. Traditional manufacturing system design methods focus on optimizing and improving existing architecture (e.g., layout, sequence, decision-making), resulting in improved performances in separated aspects of system sustainability. While these methods usually generate local optimal solutions, high demand shifts and the general unpredictability facing manufacturing systems can result in a lack of necessary forecasting and future speculation that manufacturers need to predict. This research challenges traditional manufacturing system design with innovative bioinspired concepts to create bioinspired manufacturing system layout designs. The study will result in a systemic method to design sustainable manufacturing systems with bioinspired design concepts. Various bioinspired structures, such as the spiderweb and nautilus shell, and a baseline layout will be analyzed and compared. In the era of Industry 4.0, where manufacturing systems are evolving to be highly automated with smart controls, this research contributes to engineering management knowledge by providing a bioinspired system solution to manufacturing systems efficiency that offers greater adaptability and progression toward growth with lowered costs and energy consumption.

QUANTIFYING LOCAL FOOD WASTE AND IDENTIFYING SUSTAINABLE DISPOSAL ALTERNATIVES

Students

Hayden Abbott, Kyle Manuel, Tatum Lupa, Max Villescas

Advising

Jared Stoltzfus

JMU creates vast amounts of food waste from buffet-style dining halls, but regular waste audits help identify solutions.

Food waste is a critical sustainability problem due to the incredible volumes generated, associated greenhouse gas emissions, and economic costs. To understand the relevant regulations, we conducted a review of state and federal laws surrounding the management of food waste. We roughly quantified food waste volumes in Harrisonburg from restaurants, grocery stores, and JMU using industry publications, EPA data, and by conducting a food waste audit. While the vast majority of food waste in Harrisonburg is sent to the landfill, local alternative disposal options could include feeding to livestock, anaerobic digestion, and composting. By creating case studies of companies providing these services, we could determine which approach to propose for JMU, considering economic, environmental, and logistical issues.

JMU DUKESAT: A SPACE-BASED MESH NETWORK DEVELOPMENT EFFORT

Students

Ryan Buellesbach, Adam Fischer, Mufasa Hafeez, Alexa Houck, Jordan Johnson

Advising

Jonathan Spindel, Brian Cage

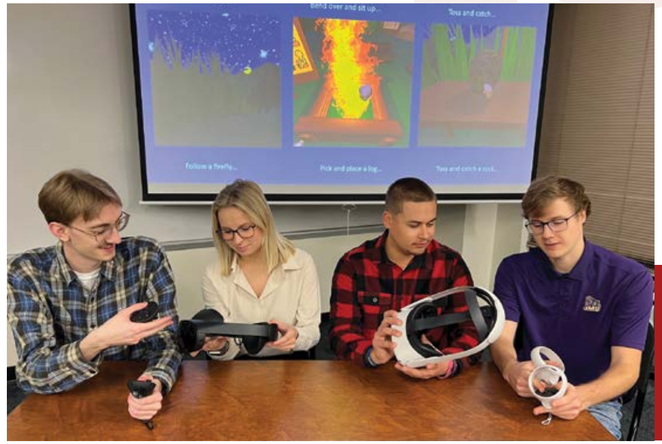
Sponsor

Madison Trust

Members of the DukeSAT development teams work together to launch two separate HiSAT mission payloads. These missions support developing and testing f prototype ground-to-air, air-to-air, and air-to-ground communications hardware in extreme conditions of low atmospheric temperature and pressure.

CubeSats are small-scale satellites that are generally single-purpose that can provide great flexibility for many low earth orbit (LEO) applications. LEO small satellites have become popular as they are significantly more cost-effective than large systems to produce and launch. Therefore, they can be designed for specific applications, usually directed toward some form of earth observation or single-purpose scientific mission. The JMU DukeSAT development effort aims to design, develop and test a wireless mesh network in space. Ultimately, this work focuses on serving as a proof-of-concept for implementing a wireless mesh network (MeshSAT) for other small satellites to access in LEO. Satellites connected to the MeshSAT network would then have access to more regular and reliable connections to ground networks, thereby increasing their utility for near real-time data transfer. As a stepping stone to space, a series of high-altitude balloon (HAB) launches have focused on testing program hardware at altitudes over 100,000 feet in low atmospheric pressure and sub-zero temperatures. These continuing experiments allow real-world testing of the program networking hardware and software at altitude and set the stage for exploring alternative forms of ground-to-space communications, expanding efforts to develop and test prototype systems, and providing data required to support anticipated space missions.

VIRTUAL REALITY GAME-BASED VESTIBULAR REHABILITATION THERAPY (VG-VRT)



Students

Karina Howard, Rober Look, Braeden O'Quinn, Lyle Rodgers

Advising

Jonathan Spindel

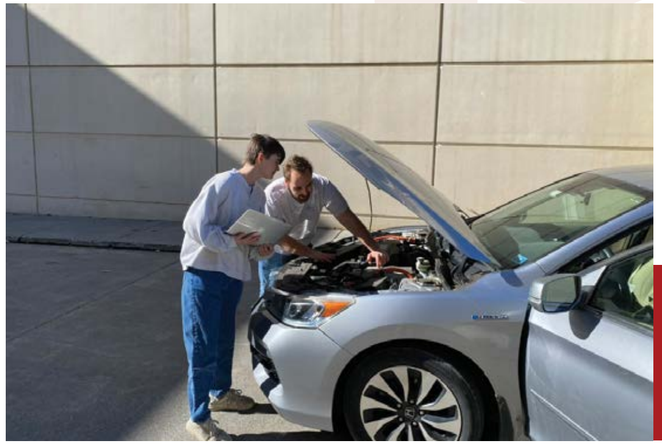
Sponsor

Madison Trust

The 2023 VG-VRT team evaluates the Oculus Quest 2 and Quest Pro VR systems as potential platforms for the continuing development of virtual reality game-based vestibular rehabilitation therapy games.

Vestibular rehabilitation therapy (VRT) is a set of simple exercises involving head, eye, and body movements used to treat patients with a wide range of vestibular and balance system disorders. While effective, successful application of VRT requires repetition multiple times daily and over a period of many months to achieve results. Many patients lose interest as the exercises are often perceived as monotonous, uninteresting, and provoke symptoms before results are achieved. In this study, the team is working to expand, develop and test the application of virtual reality (VR) to VRT. Video game-based VRT (VG-VRT) can help address many issues associated with traditional VRT by making the therapy process more fun and engaging, enhancing patient compliance and follow-through. The design of the VG-VRT system is to encourage movements similar to those in traditional VRT. Using the Oculus Quest 2 VR gaming system, we are developing, refining, and testing a gamified environment using Unity, a VR development platform. Key to this effort is making the game more versatile and providing feedback to the subject about their performance. In addition, a scoring system serves to reward subjects completing the exercises as a means to encourage compliance, enhance the entertainment aspects of the games, and make the experience more enjoyable. This continuing effort sets the stage for developing a full range of game environments that support collecting data essential to understanding the use and effectiveness of VG-VRT in improving results when compared to traditional VRT.

HORIZONTAL GAZE NYSTAGMUS IGNITION INTERLOCK SYSTEMS FOR CARS AND TRUCKS



Students

Charlie Thomas, Matthew Jenkins

Advising

Rod MacDonald, Ahmad Salman

The team is developing a device to reduce the incidence of drinking and driving and thus the number of fatal alcohol-related crashes.

Drunk driving kills approximately 11,000 people in the United States each year. The fraction of traffic fatalities attributed to drinking and driving has remained constant for the last few decades. Behavioral solutions in the form of additional police enforcement, increased penalties for offenders, and social stigma for those arrested decreased the incidence of drinking and driving. Still, a technological solution is required to reduce further or eliminate this problem. This project has developed a device that passively tests a driver's sobriety level before the vehicle they are operating can go into gear. Using machine learning software in python paired with a raspberry pi, and an in-car camera, we developed an algorithm to test for horizontal gaze nystagmus in individuals. A device inside the vehicle will horizontally move a red dot across the driver's field of vision. As the driver's eye tracks the dot, a camera will track eye movement for jerk nystagmus. The algorithm developed will control for blinking, learn from previous tests, and identify acceptable jerk nystagmus for each driver. Data from the tests are encrypted to ensure the driver's privacy. Failed tests will prevent the vehicle from going into gear and being driven. The device is suitable for installation in all vehicles with an automatic transmission. The goal is to prevent an intoxicated person from operating a motor vehicle.

NATION-STATE STABILITY MODEL

Student

Corgan Jasper

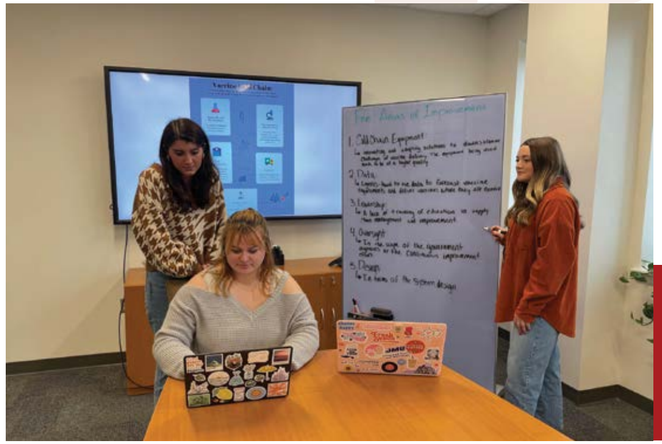
Advising

Rod MacDonald

Corgan is testing different policies in the Nation-State Stability Model.

The world is interconnected and highly complex. Internal conflict, civil war, and lawlessness in one country easily influence boarding states half a world away. These states are defined as providing decreased public services, economic stability, the ability to police its citizens, an inability to defend national borders, and eventually decreased legitimacy among its citizens. People within a state's borders fall into one of five categories: Active Support, Passive Support, Neutral, Passive Opposition, and Active Opposition. The purpose of the Nation-State Stability Model is to explain why states fail based on quantitative measures and policies. Constructed with the proper variable relationships, a computer model could be seeded with data of any scenario for a particular nation-state in space and time and run from that point to a conclusion where the state prevails or collapses in the face of one or two intrastate actors seeking its downfall or replacement. In the real world, the turmoil of nations represents lives and livelihoods with far-reaching material and social consequences. Either outcome is a product of relative resources and efficiency in the current model.

EVALUATING THE SUPPLY CHAIN OF THE COVID-19 VACCINE IN THE UNITED STATES



Students

Ava Carr, Meghan Gelerman, Abigail Robinson

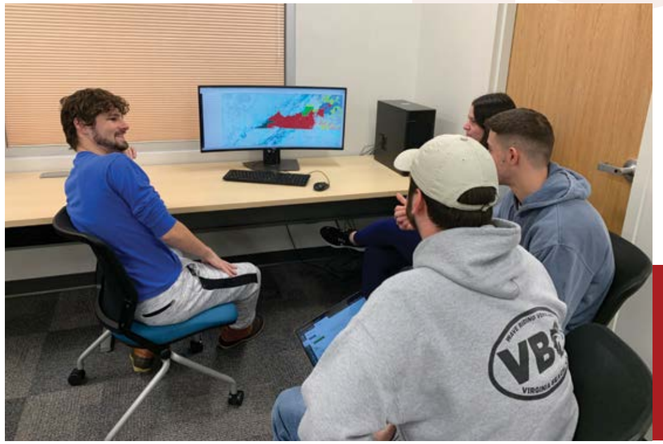
Advising

Amanda Sanson, Rebecca Simmons

Ava, Abby and Meghan examine the five areas of improvement for the COVID-19 vaccine supply chain across the United States.

Most COVID-19 vaccines are required to be stored in a deep freezer (-80°C to -15°C) during the transportation and distribution processes which created challenges in the supply chain. This project explored the complex issue of the COVID-19 vaccine supply chain across the United States and potential solutions that could be implemented in future vaccine supply chains. This project broadly covered three main goals: identifying and evaluating problems that exist within the vaccine supply chain throughout history, investigating how these problems came to exist and which ones are still impacting the current supply chain of the COVID-19 vaccine, and ultimately proposing potential solutions to specific problems through the implementation of existing technology by finding leverage points in the system. These goals were completed by exploring five main areas in need of improvement of the vaccine supply chain: leadership, oversight, design, data, and cold chain equipment.

PROSPECTING FOR UTILITY-SCALE WIND POWER OPPORTUNITIES IN THE VIRGINIA COALFIELDS



Students

Nathan Brent, Brody Callanan, Nick Finguerra, Chelsea Lang

Advising

Jonathan Miles

Nathan Brent, Nick Finguerra, Brody Callanan, and Chelsea Lang examining GIS data layers that are relevant to wind power development in the Virginia coalfields.

As Virginia transitions power production from fossil fuel-based to non-carbon-emitting sources, greater attention is being paid to the potential for utility-scale wind development on brownfield sites in regions of Virginia where coal production has served for many years as a major economic driver. Our project examines options for repurposing brownfields, particularly abandoned mine areas and other disturbed lands, to host utility-scale wind power projects. The primary benefits of this approach include the opportunity to continue using certain areas that are already compromised environmentally for energy production, and to provide local economies in these regions access to a new and thriving energy industry. The key elements of the project include (i) in-depth review of state and federal legislation that encourages coalfield energy development; (ii) development of mapping tools using ArcGIS to identify brownfield sites in Virginia and overlay them with data relevant to wind development including transmission and distribution, military training routes, bat hibernacula, etc.; and (iii) in-depth case study pertaining to a specific brownfield site located near Big Stone Gap, Virginia, that will involve additional mapping layers, prospecting, modeling, and community outreach. This site was selected based on an analysis of the wind resource it presents and its ongoing major reliance on coal. Through this project, we expect to better understand the potential benefits of advancing utility-scale wind development in the coalfield regions of Virginia and the economic benefits that will follow.

Integrated Science and Technology

APPLICATION OF REGENERATIVE FARMING PRACTICES ON A FORMER CONVENTIONAL FARM

Students
Blake Griscom, Alyssa Geary, Andy Logan, Liam Palmer, Cole Holland

Advising
Wayne Teel

Sponsor
Shenandoah Valley Organics

The capstone team is testing soil samples for their composition of sand, silt, and clay.

Across the world, conventional farming practices have degraded soils and uprooted ecosystems. Unless practices shift, the modern farming industry will collapse, thus severely impacting food security. This project aims to develop solutions to tackle this problem by addressing the main conventional farming issues. Our project uses regenerative farming techniques to determine whether they improve the soil conditions of a former conventional farm by using cover crops, crop rotation, and manure fertilizer. Another aspect of our project focuses on the application of biochar on farmland. Biochar rejuvenates soil and restores microbial life, and passively sequesters carbon dioxide from the atmosphere. Using biochar in poultry houses would reduce ammonia while simultaneously inoculating the biochar with nutrients. Research was conducted at a Shenandoah Valley Organics farm to identify the degraded soil metrics. We seek to document the transition of this farm to sustainable agriculture. The transformation process is designed to yield a mutually beneficial outcome for the farmer and the soil ecosystem. By examining soil and poultry litter on the Shenandoah Valley Organics farm, we gathered data on the conditions of a regenerative farming system. Applying the inoculated biochar in tandem with cover crops and minimal tilling would result in restoration of the natural soil. These practices aim to increase the health and productivity of the soil, restoring the soil while decreasing the farmers' reliance on external inputs, and increasing the resilience of the system.

BUILDING WITH FUNGI

Student
Kaylyn Berg

Advising
Wayne Teel

Kaylyn is checking on and watering her first fungal block in the lab.

Our current construction materials waste energy and heavily rely on fossil fuels in their production and manufacturing processes. In addition, these materials are non-compostable and often end up in landfills after use. Using compostable alternative materials can reduce or eliminate many environmental impact concerns in the construction sector. The production of manufactured mycelium into insulation materials could be an affordable and environmentally friendly replacement for current insulation materials. This project explores the process of growing myco-insulation in a lab setting. We plan to test the construction potential, study this material's unique properties, and have a solid insulation panel at the end.

THE FUTURE OF PLASTIC WASTE: A MULTI-DISCIPLINARY APPROACH

Students

Courtney Forberg, Zach Yelich

Advising

Stephanie Stockwell

Courtney and Zach working to conceptualize the plastic waste problem and analyze measures to "green" a life sciences lab.

Inspired by the bioremediation of PET plastic using engineered enzymes, we aimed to further explore the idea of and response to plastic waste over time. Recognizing that typical practices in life science laboratories are part of the plastic waste problem, we explored and implemented ways to make our laboratory—and others like it—more sustainable by making our laboratories greener. Two areas of focus were identified based on feasibility and impact to green our laboratories - plastic waste reduction and energy conservation. Using these focus areas, we established a green laboratory checklist to guide our laboratory and others like it to become more sustainable. In addition, we used methodologies such as scenario analysis and design fiction from the field of Science, Technology and Society (STS) to consider, imagine, and develop a greater understanding of the implications of plastic waste and how to implement a bioremediation-based solution in the future. In an event in collaboration with JMU's STS Futures Lab, these methods developed plausible scenarios within a specific domain and timeframe. In addition, they prompted reflection on visual media of the technology embedded in everyday life.

DEVELOPING A CHIMERIC PROTEIN FOR THE BIOREMEDIATION OF PET PLASTIC

Students

Archer Peacock, Rebecca Romero, Grace Taylor

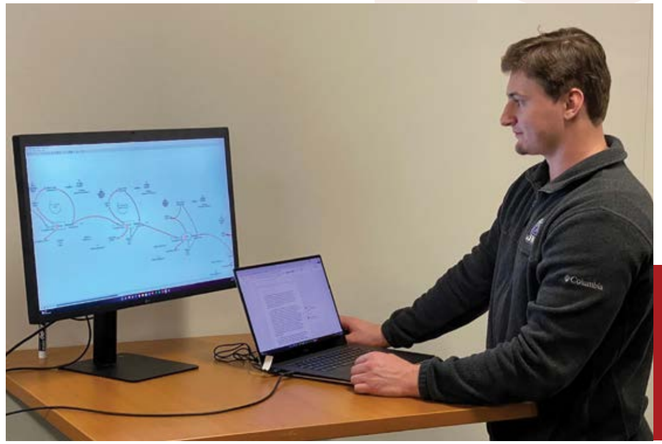
Advising

Stephanie Stockwell

The team is conducting downstream processing and quality analytic steps in the ISAT Biomanufacturing Lab.

Approximately 300 million tons of plastic waste is produced every year worldwide; only ~7-9% is recycled. The result is harmful plastic waste accumulation that negatively impacts ecosystems and communities around the world. Polyethylene terephthalate (PET) is one of the most abundant plastics due to its transparency and chemical strength. While naturally occurring PET-degrading bacterial enzymes have been identified (i.e., PETase and MHETase), their physiological requirements make them ill-suited for industrial use. We attempted to address this problem by bioengineering a chimeric PETase::MHETase protein that has higher tolerance to a greater range of temperatures and pHs for enhanced PET degradation. An engineered synthetic plasmid DNA construct was transformed into E. coli and expressed to produce the novel plastic-degrading protein. The biomanufactured protein product was purified by nickel column chromatography and quality-tested using standard assays. Finally, functional assays allowed us to measure PET plastic degradation.

SIMULATION MODELING APPROACH TO OPTIMIZING PRODUCTION SYSTEMS: ANTIBIOTIC FILLING LINE



Student
Jarad Pelczynski

Advising
Rod MacDonald

Jarad is developing an antibiotic production computer model in Stella Architect to understand and predict the impacts of production deviations.

Today, sophisticated industrial processes produce millions of lifesaving antibiotics - constituting an over 40-billion-dollar industry. Production deviations resulting in a halt of production costs the industry time, money, and potentially people's lives. Antibiotics have served as a foundational tool in the battle against many prevalent diseases; however, the processes, procedures, and challenges required to produce these lifesaving drugs remain complex. This project seeks to better illuminate the intricate world of antibiotic production through a system modeling approach focusing specifically on antibiotics' complicated industrial vial filling line. I modeled the filling process of the broad-spectrum beta-lactam antibiotic using Stella Architect to understand the causes of production deviations and better predict resulting impacts. I also developed a graphical process accurate system simulation to visually represent the complex systems that happen daily during antibiotic filling line production. The working systems model of antibiotic filling could aid engineers and technicians who struggle to address specific problems and deviations in the filling line. Finally, with a few variable tweaks, the Stella model can be expanded or customized to align with the operations of production lines in other manufacturing sectors such as electronics, automobiles, or food processing. Overall, the project's computer model accurately describes and predicts the outcomes of an antibiotic filling line while doubling as a generic process model that can be universally applied to other manufacturing and production sectors.

INVESTIGATING COMMUNITY-BASED SOLAR CHARGING SYSTEMS TO AUGMENT ELECTRIC VEHICLES WITH CLEAN, RENEWABLE ENERGY

Student
Joshua Crawford

Advising
Chris Bachmann

Sponsor
U.S. Department of Energy
Virginia Clean Cities

Josh Crawford believes electric vehicles can be a major force in reducing human carbon emissions, but only if they are charged with clean, renewable energy.

Carbon emissions from burning fossil fuels are a growing concern for the Earth's environmental health and human sustainability. Global climate change, rising sea levels, smog, and personal health problems are all negative impacts brought on by carbon pollution. The transportation sector accounts for approximately 1/3 of this pollution due to the petroleum fuels used to power vehicles' internal combustion engines. Electric Vehicles present a viable solution to reduce carbon-emissions from the Transportation sector IF they are charged by renewable energy generation systems. Solar charging stations can ensure that electric vehicle operation is completely renewable. Additionally, solar charging stations reduce stress on the electrical grid that would be caused by conventional plug-in charging. Despite these advantages, acquiring an EV and an accompanying solar charging system is cost prohibitive for most households. The Department of Energy recognizes this as a primary obstacle of widespread solar-powered electric vehicle adoption. Conducting research and implementing a public survey for EV/HEV vehicle owners, data has been collected to better understand consumer charging habits and Electric Vehicle popularity. My Capstone Project aims to investigate the potential for community-based solar charging systems to overcome these economic barriers and provide access to clean, renewable energy for all people.

ADVANCED TRACKING OF UNIDENTIFIED AERIAL PHENOMENA IN THE NEW DIGITAL AGE

Students
Bethany Biggi, Paris Beaver, Devon Embry

Advising
Chris Bachmann, Tim Walton

Devon Embry, Paris Beaver, and Bethany Biggi developed a novel system to extract meta-data from civilian UAP images and autocorrelate GPS coordinates with known aircraft flight paths.

On June 25, 2021, the Director of National Intelligence released a preliminary assessment of Unidentified Arial Phenomenon (UAP). In this report, the DNI confirmed that reports of UAP's from military personnel represent real physical objects of unknown origin that have been detected with multiple sensor systems including radar, infrared, electro-optical, weapon seekers, and direct visual observation. Furthermore, these craft exhibit highly unusual flight characteristics and do not belong to the United States. The report concludes that explaining the UAP will require resource investment into the collection and analysis across a broader swath of U.S. Government personnel. While the U.S. Military may have the most advanced sensing systems to provide accurate data on size, shape, speed, acceleration, and altitude, it is far more likely that civilians will be the ones to make observations of UAP, simply because there are far more civilians in the world than military personnel. Our goal with this project is to augment civilian reporting of UAP by developing a more modern system that will use the metadata stored in all digital imagery (cell phone photos/movies) to more accurately pin-point times and locations of occurrences. It will also auto-compare sightings to known commercial airline flights to quickly rule out human aircraft from unknown phenomena. Our dashboard will also include a map of UAP sightings that can be viewed over time, allowing spatial and temporal analysis of UAP activity.

ADVANCING ALGAE-BASED BIOFUELS BY INVESTIGATING A NEW RESILIENT ALGAE STRAIN, PICOCHLORUM RENOVO.

Student
Zack Woods

Advising
Chris Bachmann

Sponsor
National Renewable Energy Laboratory

Zack established a partnership with the National Renewable Energy Lab to further investigations into a novel species of algae (Picochlorum Renovo) that exhibits many characteristics necessary for advance biofuels.

Fossil fuels are a major driver of climate change, environmental degradation, and geopolitical conflicts. A major challenge hindering the phasing out of fossil fuels is the generation of renewable, sustainable, and economically viable replacements for liquid petroleum-derived fuels. Algae are a promising catalyst for renewable biofuel production because, unlike traditional crops, they can be grown on non-arable land using salt water and can accumulate large amounts of lipids that can be extracted and converted into drop-in replacements for gasoline, diesel, and jet fuels. However, the commercialization and broad deployment of algae biofuels face several challenges. Among these are identifying and developing robust, high biomass productivity, lipid accumulating algae strains and efficient, reliable, sustainable, and scalable cultivation, harvest, and lipid extraction methodologies.

Algae are typically grown autotrophically (using sunlight); however, some alga has shown the capacity to grow heterotrophically (without light). Heterotrophic algae cultivation offers many unique benefits, such as higher cell densities, lower land requirements, improved scalability, and the ability to utilize wastewater as a nutrient source. Algae grown heterotrophically are also often reported to have higher biomass productivities and accumulate larger lipid and triglyceride fractions, making heterotrophic algae cultivation a promising method for biofuel applications. Our project focused on determining if the microalga Picochlorum renovo, a resilient, high-productivity microalga recently developed and classified by researchers at the National Renewable Energy Laboratory (NREL), is capable of heterotrophic growth to aid in its deployment as a catalyst to produce biofuels economically at scale.

THE CREATIVE ANTICIPATORY ETHICAL REASONING (CAER) APP

Students
Zachary Shin, Danica Tran, Kaniya Whiting

Advising
Emily York

Sponsor
Morgan Benton

The team is brainstorming potential interface designs for one of the CAER App pages.

The Creative Anticipatory Ethical Reasoning (CAER) process was created as an approach to expand undergraduate STEM students' engagement with applying ethical reasoning to the analysis of technology. The CAER process utilizes scenario analysis, design fiction, and ethical frameworks to analyze the potential outcomes of emerging technologies. The CAER App was created to facilitate the process to support making CAER accessible, which can help promote responsible innovation and support STEM pedagogy. The development of the CAER application began in 2019 with previous Integrated Science and Technology (ISAT) students for their capstone project. The updated version of the CAER App allows for adaptability to different topics, technologies, and educational or consulting use cases. Making the application dynamic allows for facilitators to create topics and host sessions, users have the option to authenticate, and data protection and privacy practices can be administered. The focus of the application and CAER process can be expanded to various disciplines and settings outside of education, such as within the governance of technology, various engineering disciplines, and any area that involves technological innovation. Ethical dimensions are often treated as a secondary priority when it comes to the development of technology, which is a key aspect of the problem that is being addressed through the app. In addition, it reframes ethics as an intrinsically creative practice. The CAER application is portable, which allows for the application to be accessible and functional in various environments and on different devices.

SEDIMENT MANAGEMENT TOOL FOR IMPROVED STREAM HEALTH BELOW LAKE MERRIWEATHER

Students
Sean Wertheim, Jackson Barnett

Advising
Robert Brent

Sponsor
Virginia Department of Environmental Quality
Rockbridge County

Sean is calibrating the lake sediment monitoring equipment.

Many rivers around the world experience the common ecological stressor of excess sediment. Deposition and transport of excess sediment can originate from a variety of sources, including direct discharge, runoff from urban areas, or erosion from agricultural lands. Since 1996, the Virginia Department of Environmental Quality (VADEQ) has listed the Little Calfpasture River as not meeting water quality standards for aquatic life due to excess sediment. This sediment degrades environmental health by smothering aquatic life, decreasing oxygen, and disrupting food chains. Complex sediment transport processes play a huge role in determining instream sediment conditions for aquatic life, particularly in the Little Calfpasture River, where a dam and lake system interrupts the natural flow of sediment. To mitigate this problem, Jackson and Sean developed a remote monitoring system of probes upstream, at the dam site, and downstream to measure turbidity, pH, conductivity, dissolved oxygen, and lake level for over a year. In addition, on-site testing, cleaning, and calibration were performed monthly throughout data collection. Results from the monitoring will be used to develop a site-specific management plan for sediments that will improve environmental health in the Little Calfpasture River.

DETECTING DARK SHIPS IN THE SOUTH CHINA SEA

Students
Valerie Chenault, Charles MacCabe, Spencer Shilling, Mason Shockley

Advising
Timothy Walton, Philip Baxter

Sponsor
National Geospatial-Intelligence Agency

Thousands of ships traverse the South China Sea daily, with many turning their identification system off to participate in illegal activities like drug and human trafficking. This project explores machine learning capabilities to provide a solution to detecting dark ships. Using our combined knowledge of illegal fishing, applied computing, and remote sensing, we plan to investigate the behavior of dark ships in the interest of building a machine learning algorithm based on open-source data and imagery which pinpoints system outliers to be classified as dark ships.

FOODTRAC: AN APPLICATION FOR TRACKING AND MANAGING FOOD SUPPLIES

Student
Hiroki Miyabayashi

Advising
Steven Frysinger

Hiroki is using the Foodtrac App to track the foods in his fridge.

Food waste is a significant problem in the US because many tons of edible foods are thrown out due to poor food management. This project helps households better manage the food items bought by tracking them through the application to make it easier to organize what was bought and is needed. The application allows users to scan the barcode of food items and store the information so it can be easily tracked. Users can create shopping lists, recipes, plan meals, and be alerted when staple foods are getting low or perishable foods are nearing their expiration.

INFORMING THE MANAGEMENT OF LAKE SHENANDOAH THROUGH WATER QUALITY ANALYSIS

Student
Joe Dunnigan

Advising
Thomas Benzing

Sponsor
Virginia Department of Wildlife Resources

Joe is on Lake Shenandoah in his kayak using a handheld instrument for measuring water quality. Dissolved oxygen, conductivity, temperature, and acidity were monitored monthly at this location. Visual and photometric surveys of algae and aquatic plants were conducted seasonally.

Lake Shenandoah is located in Rockingham County near Harrisonburg and was created in 1957 by damming the confluence of two small streams, Congers Creek and Massanetta Springs. This public lake is managed for recreational uses including boating and fishing. For decades, Lake Shenandoah has struggled to meet its potential as a valuable resource for the community due to a long list of issues. Historically high sediment and nutrient loads have led to eutrophication in the lake, which causes large growths of aquatic plants to cover much of the lake's surface in the spring and summer months. A dam spillway failure in 2018 resulted in a lowering of the lake's water level by roughly 5 feet. While the lowered lake level impacted the fish community, it presented an opportunity to create wetlands to improve water quality. We aim to better understand the issues plaguing the lake through water testing and analysis of Lake Shenandoah and its tributaries. In turn, we pass this information to the managing agency, Virginia's Department of Wildlife Resources, to assist them in making more informed management decisions. Our analysis shows that the lake continues to suffer from eutrophication and could benefit from managing invasive species including Parrot's Feather, an emergent aquatic plant.

JUNIOR PROJECTS

The Capstone Project is the culmination of the ISAT Degree. Students begin their capstone work in their Junior year by identifying a Capstone Project in their area of interest and working with their faculty advisor to develop a comprehensive project proposal. These project proposals are presented in poster format during the student's Junior year and will be featured as presentations at next year's SIS Symposium.

Enhancing End-of-Life Care for the LGBTQ+ Community
Students: Taylor Manley, Josh Brewington, Tricia Wang, Abass Koroma
Advising: Shannon Conley, Kyle Metta
Sponsor: University of Virginia

Enhancing User Engagement with the Community Tool Box: A Data Science and NLP Driven Project
Students: Hani Malik, Carlos Crespo, Johnny Duenas
Advising: Kyle Metta

Life-cycle of an Electric Vehicle
Students: Ben Letteri
Advising: Rod MacDonald

A Quantitative Approach to the 2016 NBA Draft
Students: Samuel Lanning
Advising: Robert Brent
Sponsor: Tirdod Behbehani, Basketball Strategy and Analytics, Washington Wizards

Designing an Underwater Drone to Help Stop Illicit Activity in the South China Sea
Students: Willa Denton, Harrison Keller, Hannah Snell
Advising: Tim Walton, Philip Baxter
Sponsor: Zack Vandevander, National Geospatial Intelligence Agency

Controlling Ammonia in Poultry Houses using Biochar
Students: Ian Buswell
Advising: Wayne Teel

Construct a Self Sufficient Boat Powered by Solar Panels
Students: Ryan Masi
Advising: Steven Frysinger

The Fight Against Aging and What It Might Mean For The Future
Students: Evan Niehoff
Advising: Shannon Conley

Pre-Screening Cancer Detection Device for Underserved Communities
Students: Selina Matolak
Advising: Chris Bachmann

Small Scale Black Soldier Fly Production for Sustainable Food Waste Management
Students: Griffin Albrecht, John Stiles
Advising: Jared Stolfzfus

Design and Construction of a Wave Energy Converter for Nearshore Application
Students: Tristan Ripley, Griffin Hullinger, Erci Durham
Advising: Karim Altaii

Cleaner Alternative Fuels for Agricultural Equipment in the Shenandoah Valley
Students: Perry Evans, Ben Hite, Rex Nguyen, Ryan Visco
Advising: Chris Bachmann

Video Games for Vestibular Rehabilitation Therapy (VG-VRT)
Students: Tymaree Morton, Charlie Ruble, Isaiah Webber
Advising: Jonathan Spindel
Sponsor: Madison Trust

Building Energy Resilience through Microgrid Development in Tangier, Virginia
Students: Marco Chua, Ryan Carroll, Alex Fox, Peter Fyffe, Drew Lavoie, Nick Prentice, Malachi Walker
Advising: Jonathan Miles
Sponsor: Virginia Department of Emergency Management

Sustainability Assessment of Golf Ball Production
Students: Carson Peters
Advising: Rebecca Simmons

Someone is Listening: Privacy in the Age of the Smart Home
Students: Amanda Davis, Aarushi Sharma
Advising: Tolu Odumoso, Emily York

The Role of Lithium In the Transition to Renewable Energy: Analyzing the Supply Chain
Students: Connor Devens, Elliott Rodgers
Advising: Rebecca Simmons, Rod MacDonald

Integrated Science and Technology

The ISAT Podcast: Exploring Topics in Science, Technology, and Society
Students: Jadon Moon
Advising: Raafat Zaini and Emily York)

Bioinspired Design for Material Architecture Systems Development
Students: Jack Wills, Stepheb Hwang
Advising: Hao Zhang

Cultivating the Fungal Jungle: Carbon Sequestration, Biodiversity Expansion, and Nutrient Exchange at Jubilee Climate Farm
Students: Bennett Raba, Sam McIntire, Stepan Toporkov, Peter Toporkov
Advising: Jennifer Coffman

Changing Recycling Behaviors of On-Campus Residents at JMU
Students: Braedon Miller, Stephen Afriyie
Advising: Dr. Jared Stoltzfus and Dr. Christie-Joy Hartman

Experimental High Altitude Communications Networking
Students: Ali Elhajj, Christian Chase, Oscar Hernandez, Reilly White
Advising: Jonathan Spindel

Design and Synthesis of Anti-Reflective Coatings for Solar Energy Applications
Students: Ian Lawson
Advising: David Lawrence

Invasive Species Management and Riparian Buffer Design on the Shenandoah River
Students: Annalise Henzler, Erin Early
Advising: Jared Stoltzfus
Sponsor: The Town of Shenandoah

Evaluating the Erodibility of Streams on JMU's Campus
Students: Kota Meltzer, Oliver Hite, Johnny Quinones, Rich McFadden
Advising: Robert Brent
Sponsor: Ali Sloop, JMU Facilities Management

Sustainable Design and Assessment of Strength and Thermal Properties for Hempcrete
Students: Henry Long, Bay Dewey, Shayan Shamloo
Advising: Jared Stoltzfus, Hao Zhang

Review Article on ADHD Manifestation, Diagnosis, and Treatment
Students: Alex Roy
Advising: Shannon Conley
Sponsor: Anne Henriksen

Creating a Riparian Buffer at James Madison University Farm: Environmental, Social, and Educational Benefits
Students: Reggie Wilcox
Advising: Carole Nash
Sponsor: Degesch America Inc

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.

Our ability to reach unity in diversity will be the beauty and the test of our civilization.

~ Mahatma Gandhi

THREAT OF MISINFORMATION: LOCAL LAW ENFORCEMENT RESPONSE TO ACTIVE SHOOTINGS

Students
Danielle Orth, Kendall Smith, Grace Dwinnell, Julian Osorio, Jordan Bernard

Advising
Stephen Marrin

Sponsor
Stephanie Bender, Deloitte

The team is brainstorming trends in case studies while utilizing the database created to provide insight into the relationship between misinformation and social media during active shooter situations.

Within the United States, the FBI has identified and reported a 52.5% increase in active shooter incidents since 2020, spreading across 30 states. Our project explores the role misinformation can play in local law enforcement's response to active shooter situations by analyzing over 50 active shooting case studies. Response time is an essential factor to law enforcement's ability to prevent injury, loss of life, and wasted resources. Using Oracle SQL, we created a relational database to comprehensively analyze the relationship between active shootings, local law enforcement's response, and misinformation. We used this database as a basis for subsequent analysis to understand why and how misinformation can affect local law enforcement's response to active shooter situations. In addition, the database aims to serve as a basic reference guide for local law enforcement entities to use in an emergency to quickly identify past patterns and techniques used by active shooters and more accurately respond to the current active shooter situations in a timely manner. In doing so, we aim to understand the relationships between these phenomena and answer the question: to what extent does misinformation impede local law enforcement's response to active shooter situations? What are the broader implications for local police chiefs and their local departments in the United States?

EVALUATING THE IMPACT OF CRITICAL MINERAL EXTRACTION ON KINETIC CONFLICT IN THE ANDES

Students
Variah Hauge, Dylan Marti, Laura Smith

Advising
Stephen Marrin

Sponsor
Larson Miller, MITRE

The team actively analyzing geospatial incident data and the location of indigenous groups across the Andes.

The United States Geological Survey (USGS) has designated a list of minerals as critical in the development of modern defense and renewable energy technologies. These critical minerals, such as lithium, beryllium, and cerium, have vulnerable supply chains characterized by import dependence, lack of diverse supply sources, and an absence of domestic production. As demand and foreign competition for critical minerals grow, countries that dominate extraction and production will have an industrial and economic advantage over import-dependent countries. Many South American countries, specifically those that comprise portions of the Andes Mountain Range (Argentina, Bolivia, Chile, Colombia, Ecuador, Peru, and Venezuela), have an abundance of these critical minerals and are experiencing significant investment growth in the extractive sector. However, increased extractive mining amplifies a variety of environmental, political, and socio-economic stressors, often resulting in the incitement of protests in opposition to mining operations. Our project explores the potential for discontent toward extractive operations to evolve into kinetic conflict and the risk that potential conflict poses to US national and economic security. With an awareness of how resource-based conflict can potentially disrupt mineral access, the US will be better positioned to mitigate this strategic security threat.

FORECASTING THE EVOLUTION OF ARCTIC COMPETITION BY 2030

Students
Lauryn Renda, Jacob Black, Sean Bagdon

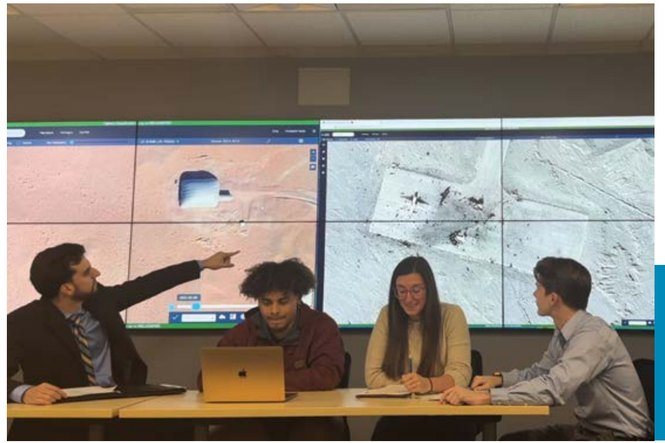
Advising
Stephen Marrin

Sponsor
The MITRE Corporation

A Russian icebreaker advances through the Arctic to help clear ice for improved shipping lane access.

Climate change is dramatically altering the physical composition of the Arctic, with the region warming twice as fast as any other region in the world. The rapid climatic changes to the Arctic are shifting its geography and influencing regional power dynamics. Our project explores the likelihood of increased Great Power Competition in the Arctic region by 2030 based on current climate change trends. Our analysis focuses on the role that Russia and China play in future power dynamics in the Arctic. We examined each actor through an economic, military, and political lens, characterizing their current activity to forecast future activity. Our project also considers the implications of a changing Arctic on US interests, so that the US can be better prepared for the future of the region. To accomplish these objectives, we used tools such as Structured Analytic Techniques and Geospatial Analysis to formulate our analysis. We have assessed that Great Power Competition is likely to increase in the Arctic based on growing Russian and Chinese military and economic investments amid rapid sea ice melting.

AN ANALYSIS OF CHINESE BALLISTIC MISSILE DEVELOPMENT



Students
Josie Carter, Christopher Saylor, Tristan Tryon, Elijah Tomlin

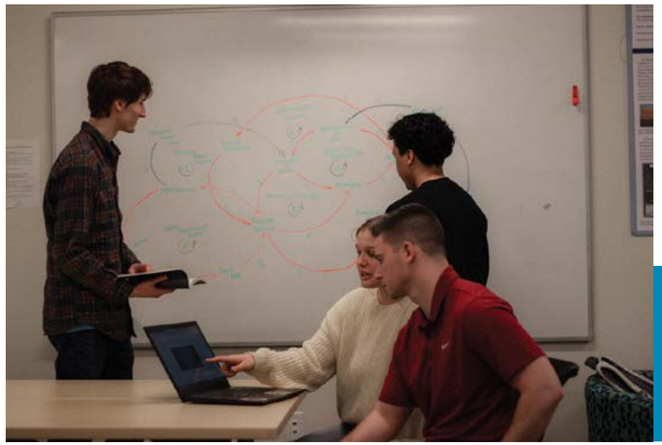
Advising
Stephen Marrin

Sponsor
National Geospatial-Intelligence Agency

The team is discussing its latest work on the methodology, including change detection analysis and causal loop diagramming.

In 2021, the People's Republic of China (PRC) launched approximately 135 ballistic missiles for testing and training, which was more than the rest of the world combined. Our project explores recent and potential future developments in the ballistic missile capabilities of the People's Liberation Army Rocket Force (PLARF). We aim to predict the likelihood of significant improvements by 2025 and the implications for U.S. interests in the region. Using open-source intelligence and satellite imagery, we conducted geospatial analysis of missile silo fields under construction. We also utilized causal loop diagramming to better understand the systematic relationships between the many causal forces that influence the overall situation with the PRC. We then employed a form of futures analysis, the convergent scenario development in order to evaluate when and where a set of projected scenarios may plausibly occur.

FORECASTING CHINA'S DEVELOPMENT OF WEAPONIZED AUTONOMOUS DRONES



Students
Alyssa Getz, Matthew Summers, Matthew Luciano, Kyle Zeng

Advising
Stephen Marrin

Sponsor
U.S. Department of Defense

The group is collaborating to draw a Causal Loop Diagram. The diagram is a visualization of the Causal analysis method that the group used to assess the relationships between the actors, their goals, and strategies to achieve their goals.

In the past decade, China has become the leading exporter of weaponized aircraft delivering 282 combat drones to 17 countries, according to the Stockholm International Peace Research Institute. The use of Causal Analysis and Futures Exploration allows us to examine the current state of China's use of weaponized drones and possible future scenarios.

Our project forecasts the likelihood that China will develop and field weaponized autonomous drones by 2027.

EVALUATING COLOMBIA'S NEW APPROACH TO REDUCING COCAINE PRODUCTION AND TRAFFICKING

Students
Amber Lee, Cassidy Smith, Joshua Jurack, Ronan Whelan

Advising
Stephen Marrin

Sponsor
Federal Bureau of Investigation

Ronan, Amber, and Josh monitoring open-source intelligence after the second round of peace talks between Colombia and the ELN.

Our project explores the likelihood of Colombia's current national drug approach in reducing coca cultivation and cocaine trafficking by the year 2026. According to the DEA, the amount of cocaine from Colombia seized in the United States has increased since 2018. Utilizing ArcGIS online, we have portrayed coca cultivation and cocaine production rates to demonstrate the effectiveness of their current national drug approach. In doing so, we used Causal Loop Diagramming and Divergent Scenario Development, along with different indicators of change, to develop our analysis.

FORECASTING LIKELIHOOD OF EXTENDED DISRUPTION IN NIGERIAN ECONOMY

Students
Greg Gersony, Griffin Boag

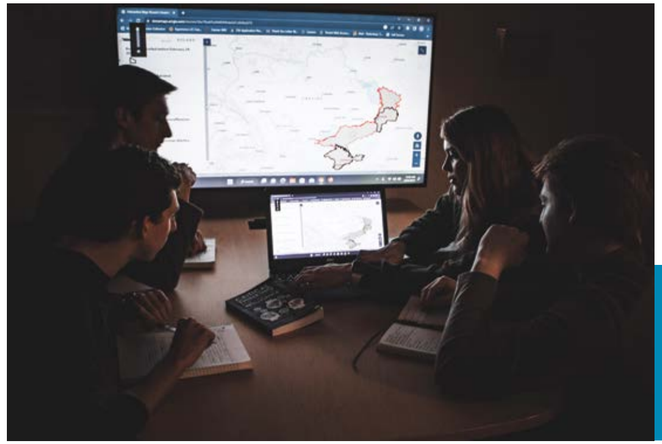
Advising
Stephen Marrin

Sponsor
Deloitte

The Group Discusses the Implications of a Causal Loop Diagram.

Amid the COVID-19 Pandemic and the Russo-Ukrainian War, shortages and supply chain disruptions disrupted global markets, rocking developing economies. Our project evaluates the likelihood of an extended disruption in economic activity in Nigeria's economy, taking account of a wide range of causal drivers among international market trends, government policies, inter-group conflicts, environmental trends, and domestic development efforts. In pursuing this question, the project utilizes key assumptions check, causal loop diagramming, convergent scenario development, and alternative futures analysis.

THE EVOLUTION OF RUSSIAN MILITARY CAPABILITIES THROUGH 2025



Students
David Brooks, Cameron Kerr, Kyle Peters, Theadora Robertson

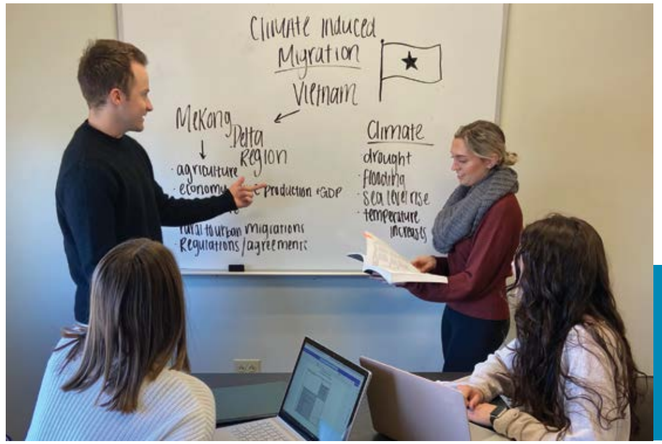
Advising
Stephen Marrin

Sponsor
The National Geospatial-Intelligence Agency (NGA)
US Army Special Operations Command (USASOC)

The team is examining a map of military forces' dispositions and military activity in Ukraine created by the Institute for the Study of War in order to evaluate Russian military capabilities.

Our evaluation of the military capabilities of The Russian Federation in Ukraine is in support of the mission of our sponsor, the National Geospatial-Intelligence Agency (NGA), and its role in protecting the security and advancing the interests of the United States. Our project evaluates a projected evolution of Russian military capabilities through the year 2025 using analytic methodologies designed to forecast insightful, plausible future scenarios. Our group developed future scenarios based on the evolution of three driving factors shaping Russian military capabilities: nature of military forces organization, acquisition of military equipment, and the orientation of Russia's foreign policy. It then used these scenarios to develop a forecast of the most likely evolution of Russian military capabilities through 2025.

IMPLICATIONS OF CLIMATE-INDUCED MIGRATION IN THE MEKONG DELTA



Students

Alyssa Christenbury, Jackson DiSilvestre, Tayler Henriques, Paige Samia

Advising

Jeffrey Tang

Sponsor

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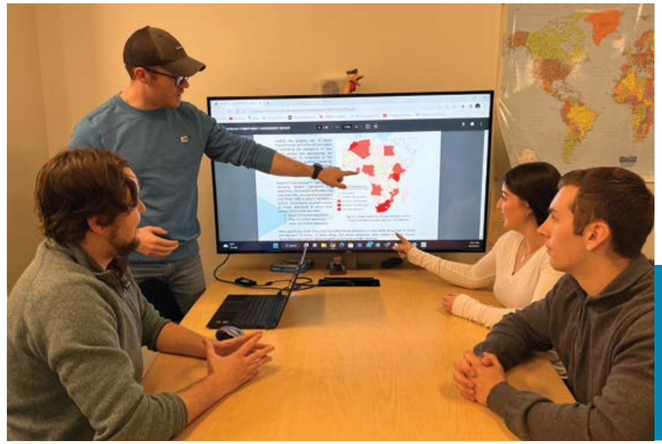
Team members discussing the impacts of climate-induced migration on the Mekong Delta region of Vietnam.

During the last ten years, approximately 1.7 million people have migrated from the Mekong Delta, which plays a key role in Vietnam's economic and agricultural growth. Climate change has caused severe flooding, ocean acidification, and salinity intrusion damaging agriculture and aquaculture. This has spurred migration from rural to urban areas. This migration pattern can lead to rapid city growth and cause issues with food and water scarcity. These effects have the potential to weaken trade relations with its partners including the United States. Our project assesses current climate-induced migration in the Mekong Delta region and the effects it has on Vietnam and its trade partners.

POTENTIAL CYBER-THREATS POSED BY WEST AFRICAN TERRORIST GROUPS



Students

Matthew Traver, Thomas Ferrell, Morgan Estep, Caleb Hackett

Advising

Jeffrey Tang

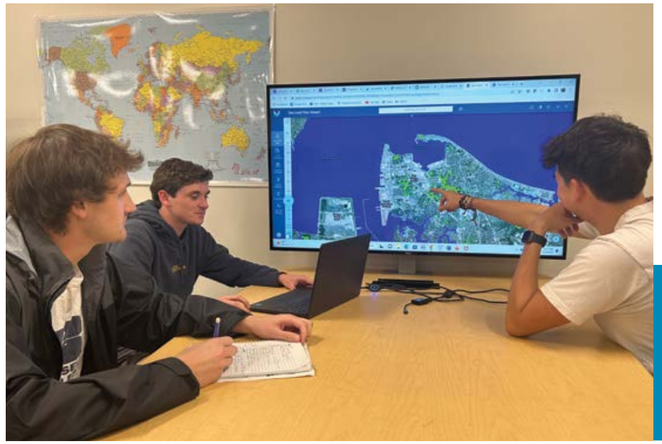
Sponsor

MITRE

Team members discussing the Western Sahel region of Africa.

Cyber infrastructure in the Western Sahel region of Africa presents terrorist groups with opportunities to carry out a cyber threat campaign against the United States. Terrorist organizations have increased in size and capability in sub-Saharan Africa and are poised to seize control of developing infrastructure to induce chaos and strike terror into the lives of U.S. citizens through developing communications frameworks. We address the most salient U.S. vulnerabilities to potential cyber terrorism posed by threat actors operating out of the western Sahel region of Africa. Fueled by Chinese investment, this region is expanding in its industrial and cyber communications infrastructure. Our analysis uses future threat assessments to investigate the possibility of a wide-scale cyber-attack from West Africa that would disrupt the daily life for U.S. citizens.

THE RISING THREAT OF SEA LEVELS ON NAVAL INSTALLATION INFRASTRUCTURE



Students
Logan Haight, Lars Soholt, Sean Connolly

Advising
Jeffrey Tang

Sponsor
MITRE

Team members assessing the impact of potential sea-level rise at a naval installation.

Major installations of the U.S. Navy, including the largest naval station in the world, are facing roughly one hundred floods a year and some could be completely submerged by 2100. We examined the key threats to the physical, operational, and technical infrastructures of naval installations during the next several decades. The Navy is aware of the increasing threat of rising sea levels. Our analysis highlights the most urgent vulnerabilities to its installations by using visualization of coastal flooding data (both present and future), and future scenarios derived from driving factors of vulnerabilities.

FORECASTING THE CHINESE SEMICONDUCTOR INDUSTRY'S MANUFACTURING CAPABILITIES

Students
Aileen Towner, Hannah Taylor, Sean Reehl, Jonathan Dougherty

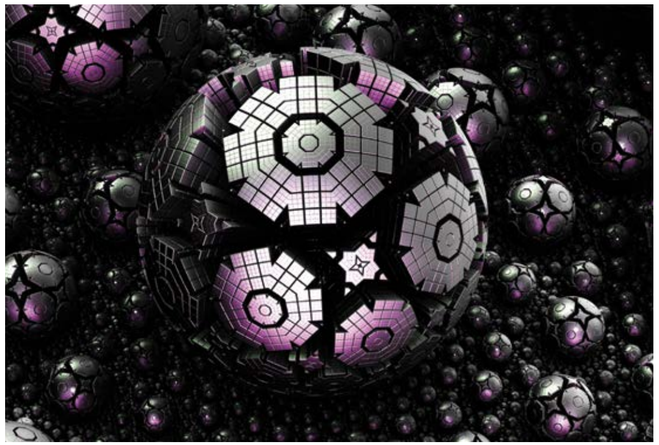
Advising
Stephen Marrin

Sponsor
US Department of Defense

Chinese semiconductor industry forecast group collaborating on methodology for their project.

The Chinese Semiconductor Industry is currently decades behind the United States in advanced logic semiconductor development, an issue that looms large amidst recent restrictions against the industry that impacts its manufacturing and production. Our project explores the Chinese Semiconductor Industry and forecasts China's semiconductor manufacturing capabilities within the next five to seven years. It aims to assist U.S. policymakers, specifically in the East Asia/Oceania region, by exploring the current semiconductor economy, identifying Chinese technology that may significantly impact the industry, and forecasting how this technology evolves within the next five to seven years. By using the analytic methods of indicator analysis, convergent and divergent scenario thinking, and ripple effect analysis, we forecast China's ability to produce smaller semiconductor node sizes in the short-term future. Our conclusion is that China is likely to rely on their domestic capabilities to reach the standard of semiconductor manufacturing required to compete on the global stage.

EMERGING CYBER THREATS TO U.S. SPACE INTERESTS



Students
James Randolph, Elizabeth Picha, Brooke Harmison, Lance Robinson

Advising
Jeffrey Tang

Sponsor
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Advancements have expanded the usefulness of space but have also rendered it increasingly "contested, congested, and competitive". U.S. reliance on satellites to maintain critical infrastructure has resulted in security vulnerabilities. Analysts have focused mostly on the threats posed by Russia and China. Our project assesses potential threat actors ranging from states to lone wolf actors. Using Structured Analytic Techniques, this project assesses the likelihood of new threat actors posing a significant threat to United States space interests.

GEOGRAPHY

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.

Diversity is the one true thing we all have in common. Celebrate it every day.

~ Winston Churchill

Thanks to our project sponsors

Anne Henriksen
Degesch America, Inc.
Deloitte
Federal Bureau of Investigation
JMU Facilities Management
Jubilee Climate Farm
Madison Trust
The MITRE Corporation
Morgan Benton
National Geospatial-Intelligence Agency
National Renewable Energy Laboratory
Town of Shenandoah
United States Army Special Operations Command
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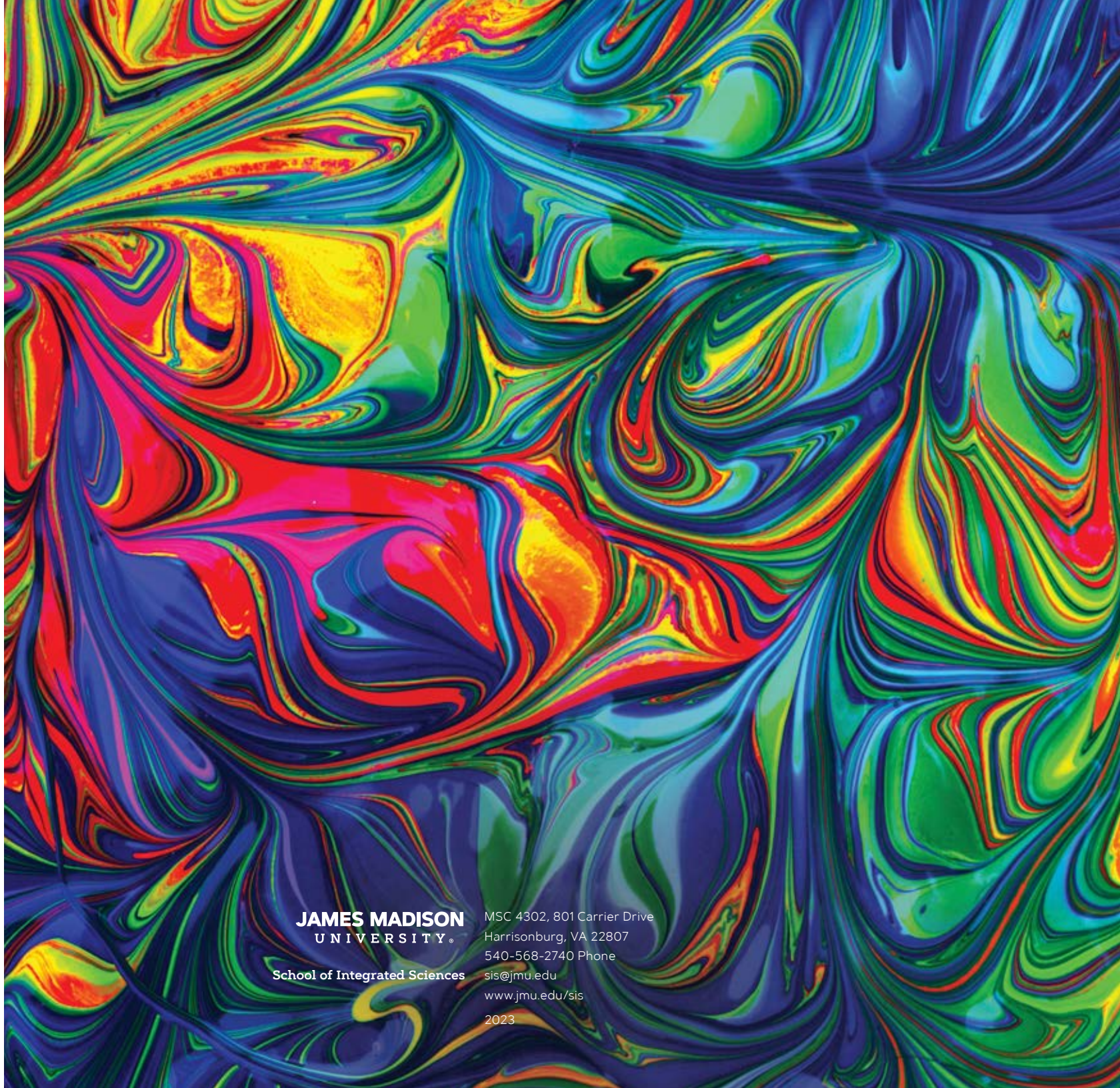

JAMES MADISON
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School of Integrated Sciences

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

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