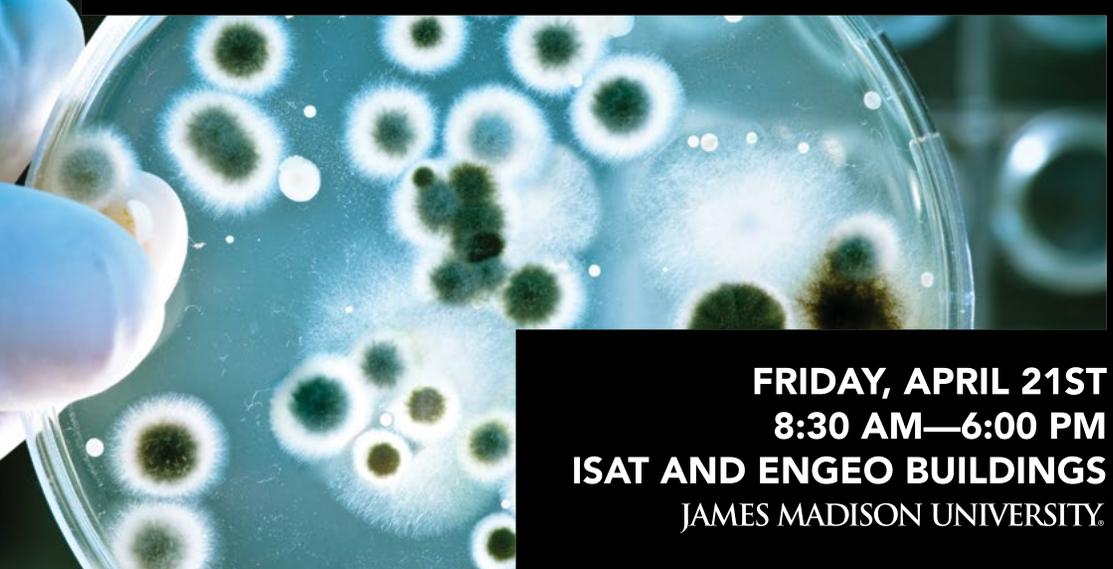


21st

**ANNUA
SENIOR CAPSTONE
PROJECT
SYMPOSIUM**

DEPARTMENT OF INTEGRATED
SCIENCE AND TECHNOLOGY



**FRIDAY, APRIL 21ST
8:30 AM—6:00 PM
ISAT AND ENGeo BUILDINGS
JAMES MADISON UNIVERSITY.**

ADDRESSING MEANINGFUL PROBLEMS OF SOCIETAL IMPORTANCE

As part of the ISAT experience, students in the Intelligence Analysis, Integrated Science and Technology, and Geographic Science degree programs dedicate countless hours to their capstone projects.

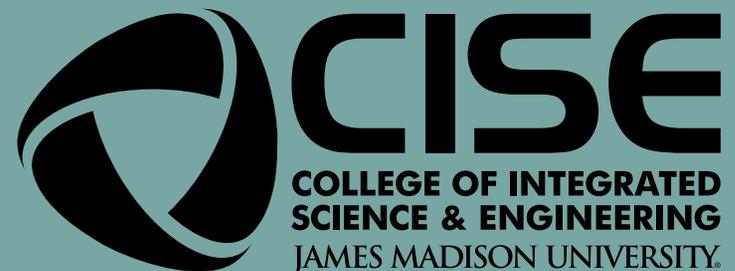
Working individually or in teams, students work on a problem with a real-world component, sometimes teaming with a local industry or governmental sponsor. Project ideas can come from the students themselves, from faculty advisors, or sponsors. This gives students the opportunity to use the knowledge and skills they have learned in ISAT to address a real-world problem, and receive valuable hands-on experience.

The projects represented in the following pages embody the intellectual and topic diversity within the ISAT Department, which emphasizes academically rigorous thinking applied to address meaningful problems of societal importance. Ranging in scale from the global to the local, from the highly technical to the humanistic, and everything in between, our students' capstone projects are the culmination of their undergraduate degrees.

Although only a fraction of their hard work is reflected here, I hope you will agree with me that these projects represent an impressive range of work.

Dr. Jeffrey Tang

Interim Head, Department of Integrated Science and Technology



INTEGRATED SCIENCE AND TECHNOLOGY

ADVISED BY DR. KARIM ALTAI

- 12. Evaluating Percutaneous Heart Valve
(Also advised by Dr. Olga Pierrakos)
- 14. An Experimental Study on Drag Reduction of Aftermarket Additions on an SUV
- 16. Solar Tracking Blinds

ADVISED BY DR. CHRISTOPHER BACHMANN

- 18. Giving Virginia Solar Supporters a Voice by Connecting Constituents to Local Representatives through a Streamlined Email Service
- 20. Optimizing Global Threat Detection and Prevention (Also advised by Dr. Timothy Walton)
- 22. A Holistic Approach to Harvesting Algae for Biofuels
- 24. Integrating Drones into Fire/Rescue
- 26. High Throughput Algae Quantification using Quantitative Polymerase Chain Reaction for a Novel Biofuel Harvesting System (Also advised by Dr. Louie Wurch)

ADVISED BY DR. MORGAN BENTON

- 28. Dialoggr: An Application using Quantified Self to help Type 1 Diabetics Manage their Chronic Condition
- 30. JMScoop: A Progressive Ride Sharing Application for JMU Students

- 32. Madison Conservation Corps: Software Development for Home Energy Audit

ADVISED BY DR. THOMAS BENZING

- 34. Native and Invasive Aquatic: Plant Species in Virginia Trout Streams
- 36. Stream Quality Analysis and Monitoring of the Proposed Interstate Pipeline through George Washington National Forest

ADVISED BY DR. ROBERT BRENT

- 38. Gauntlet Golf Course Environmental Impact Assessment and Reduction Plan
- 40. A GIS Analysis of Stormwater Facilities in Rockingham County: Policy and Geographical Distribution
- 42. Validation and Use of Handheld X-Ray Fluorescence Spectrometry for Measuring Mercury in Soil

ADVISED BY DR. TONY CHEN

- 44. Energy Audit of a Commercial Building: JMU Bookstore
- 46. Experimental Refrigeration Replacement

ADVISED BY DR. SHANNON CONLEY

- 48. Environmental Sustainability of Music Festivals: An Integrative Approach to Reducing the Environmental Impact of Festivals (Also advised by Dr. Steven Frysinger)

- 50. Science Fiction for Science Policy: Science Fiction as an Ethical Learning Device for Students and Policy Makers

- 52. Student Perception of GMOs and their Prevalence on Campus (Also advised by Dr. Amanda Biesecker)

ADVISED BY DR. SAMY EL-TAWAB

- 54. A Cyber Physical System to LoCaTE: Localization of Health Center Patients & Staff through an IoT Environment

ADVISED BY DR. STEVEN FRYSSINGER

- 56. Floating Island Technology: Water Ecology Enhancement Techniques
- 58. Food Waste Study of James Madison University
- 60. Living Tiny Legally
- 62. Optimizing Crisis Shelters for Greater Economic, Ecological, and Social Value

ADVISED BY MR. PAUL GOODALL

- 64. Energy Audit of the Woodrow Wilson Presidential Library and Museum in Staunton, Virginia

ADVISED BY DR. CHRISTIE-JOY BRODRICK HARTMAN

- 66. Energy Poverty: SOS (Also advised by Dr. Maria Papadakis)

ADVISED BY DR. DAVID LAWRENCE

- 68. Photovoltaic Water Splitting for Sustainable Hydrogen Production

ADVISED BY DR. ROBERT MCKOWN

- 70. Analysis of Structural Stability of Human Prosecretory Mitogen Lacritin by Circular Dichroism
- 72. Topical Administration of Lacritin Peptide for the Treatment of Canine Keratoconjunctivitis Sicca

ADVISED BY DR. JONATHAN MILES

- 74. Establishing Distributed Wind Capacity in Virginia
- 76. Nondestructive Testing of Wind Turbine Blades using Thermal Imaging

ADVISED BY DR. CAROLE NASH

- 78. Geographic Information Systems as a Teaching Tool for Middle School Students: Land Use and Water Quality in the Chesapeake Bay Watershed
- 80. Streambank Restoration at the JMU Farm: Modeling and Best Practices for Streambank Restoration
- 82. Streambank Restoration at the JMU Farm: Landscape Design and Viewshed Protection
- 84. Streambank Restoration at the JMU Farm: Structure and Stability
- 86. Scientific Communication and the Web: A Case Study of the James Madison University Farm
- 88. Trash Separation and Recycling Facility: A Feasibility Study

ADVISED BY DR. NICOLE RADZIWILL

- 90. Improving Orographically Induced Snow Forecasts in Rockingham County
- 92. Investigation of Industrial Hemp for Commercial Production in Virginia (**Also advised by Dr. Mike Renfro**)
- 94. Latent Dirichlet Analysis (Topic Modeling) of Industrial Hemp in Product Descriptions, Academic Articles, and Legislative Communications
- 96. IoT Sensory Tube: Prototype to Production (**Also advised by Dr. Rebecca Simmons**)
- 98. Reducing the Costs and Environmental Impact of JMU On-Campus Salt Treatments Prior to Snowstorms
- 100. Weather Variability in the Shenandoah Valley: A Study to Support the Industrial Hemp Industry

ADVISED BY DR. EMIL SALIB

- 102. Access Control and VDI for a Private Cloud
- 104. Cyberphysical Systems: An Investigation of Security in the Internet of Things
- 106. Software-Defined Networking

ADVISED BY MR. MARK SHOWALTER

- 108. Open-Source Exoskeleton (**Also advised by Dr. Jonathan Spindel**)

ADVISED BY DR. STEPHANIE STOCKWELL

- 110. Development of a Comprehensive Strategic Guide for Young Adults with Acute Lymphoblastic Leukemia

ADVISED BY DR. ANTHONY TEATE

- 112. Hikr.db – Crowdsourcing of Hiking Trail Data through Mobile Applications
- 114. Home Energy Audit Application for Android Devices
- 116. Machine Learning and Object Recognition for Autonomous Vehicles

ADVISED BY DR. WAYNE TEEL

- 118. Using Ancient Practices to Fix Modern Problems: The Effect of Biochar on Einkorn Wheat and Soil Quality
- 120. Vermicomposting: The Responsible Alternative to Synthetic Fertilizer use in Agricultural, Urban, and Suburban Areas

ADVISED BY DR. LOUISE TEMPLE

- 122. The Construct of a Heterologous Vaccine Candidate against *B. avium* and *C. jejuni* Food Poisoning utilizing the *B. avium* Autotransporter, Baa1

INTELLIGENCE ANALYSIS

ADVISED BY DR. STEPHEN MARRIN

- 124. Evaluation of Current and Potential Cities for Refugee Relocation Communities in Virginia **(Also advised by Dr. Michael Deaton)**
- 126. Dynamics Driving Insurgency in North-West Pakistan **(Also advised by Dr. Michael Deaton and Dr. Timothy Walton)**
- 127. Social Engineering: Negative Impact on Capital One
- 128. Evaluating the Implications of a Defense and Security Sector Restructuring in Colombia **(Also advised by Dr. Noel Hendrickson and Dr. Tomás Regalado López)**
- 130. The Future of Criminal Analysis: Effectiveness and Accuracy of Predictive Policing **(Also advised by Dr. Noel Hendrickson, Dr. Michael Deaton and Dr. Benjamin Meade)**
- 132. A Policy and Futures Analysis of the North River Ranger District's Collaboration Strategy
- 134. Tipping Point: Radicalization and Digital Pattern of Life

- 135. Climate Change to Impact Coca Production in Colombia **(Also advised by Dr. Timothy Walton and Dr. Zachary Bortolot)**
- 136. Women in Terrorism: Sociological Factors that Influence Participation **(Also advised by Dr. Noel Hendrickson and Dr. Michael Deaton)**
- 138. Resource Scarcity and Radicalization in Indonesia **(Also advised by Dr. Timothy Walton)**
- 140. Troubled Water: Future Chinese Threats to Critical Water Infrastructure **(Also advised by Dr. Timothy Walton)**
- 142. U.S. Critical Infrastructure Cyber Security: Cascading Vulnerabilities in an Interconnected System

DR. QINGJIU TAO

- 143. An Evaluation of the Electric Vehicle Landscape
- 144. Chinese-Japanese Pacific Tensions
- 145. Value Drivers and Potential Threats for Internet of Things (IoT) Integration into the Aerospace and Defense (A&D) Industry
- 146. Futures Analysis of Cyber Security Products: Trends, Threats, and Recommendations into 2037
- 147. The Future of U.S. Smart City Water Infrastructure
- 148. Future Assessment of Point of Sale Transactions: Chip Readers vs. Near Field Communications

GEOGRAPHIC SCIENCE

DR. MACE BENTLEY

- 150. The Effect of Future Sea Level Rise on Storm Inundation of Major Hurricanes in Tampa Bay
- 152. An Observational Investigation of Long-lived Bow Echo Produced Meteotsunamis in Lake Erie
- 154. A Wintertime Lightning Climatology for the Contiguous United States

DR. AMY GOODALL

- 156. The Importance of Pollinator Diversity in School Garden Management
- 158. Improving Garden Design for Increased Use

DR. HELMUT KRAENZLE

- 160. Spatial Analysis of Crime in Harrisonburg: Burglary and Robbery

DR. HENRY WAY

- 162. Determining Development Levels of United States Counties Based on a Comparative and Spatial Analysis of Multivariate Criteria
- 164. A Spatial Analysis of Political Geography in Harrisonburg, VA

HONOR STUDENT PROFILES

Integrated Science and Technology BS



ANNIE DESMARAIS

Annie will be graduating in May 2017 with a Bachelor of Science in biotechnology with a minor in secondary education. Annie would like to thank Dr. Robert McKown, Dr. Kyle Seifert, Dr. Ronald Raab and her honors advisors for their support and guidance. She would also like to thank her friends and family for their continued support and encouragement throughout her time at JMU. After graduation she plans to obtain a Master of Teaching degree in secondary education and work to support STEM education at the high school level. Annie worked as part of a team on an ISAT research project titled “Analysis of Structural Stability of Human Prosecretory Mitogen Lacritin by Circular Dichroism.”



JOSEPH DODD

Joseph will be graduating in May 2017 with a Bachelor of Science in integrated science and technology (ISAT) with a dual concentration in biotechnology and telecommunications. Joseph would like to thank his professors for helping him discover what really interests him and challenges him. After graduation, Joseph will be working with Accenture Federal Services as a technology analyst. Joseph worked on the capstone project titled “OpenStack: Access Control and VDI in a Private Cloud” with his partner Tommy Shaffer in order to allow JMU students to have their own virtual desktop within a browser. In the project, he used many of the things he learned in his networking classes taught by his capstone advisor Dr. Emil Salib, whom he would like to thank for helping him develop and execute his project to the best of his ability.



ELIZA GAYLORD

Eliza will be graduating in May 2017 with a Bachelor of Science in biotechnology. Eliza would like to thank her mentors in both the biotechnology and integrated science and technology programs and her honors advisors for their support and guidance throughout her academic journey. After graduation she plans on pursuing a Ph.D. in bioengineering or biomedical sciences and building a career in the research and development processes at a biomedical company focused on therapeutic development. Eliza worked individually on her honor's senior thesis titled "The Topical Administration of Lacritin Peptide for the Treatment of Canine Keratoconjunctivitis Sicca."



NICK GENTILE

Nick will be graduating in May 2017 with a Bachelor of Science in integrated science and technology with sectors in environment, engineering & manufacturing, and biotechnology. After graduation, Nick will pursue a career in finance by working for a small financial services group in New Jersey.

His thesis aims to explore the agricultural, economic, and sociopolitical feasibility of growing industrial hemp on small and medium-sized farms in Virginia, and integrating production with a potential supply chain for three key products: 1) hemp fiber, 2) hempseed for livestock feed, and 3) hemp oil for biofuel. The goal of this project is to inform legislatures of the potential for industrial hemp to flourish as a commercial market that is not only economically beneficial, but environmentally sustainable as well.



BRANTLEY GILBERT

Brantley will be graduating in May 2017 with a Bachelor of Science in integrated science and technology with a concentration in information and knowledge management and a minor in computer science. Brantley would like to thank his professors in the ISAT department and the CS department for helping him discover his passion for computing and for exposing him to the various fields of information technology. After graduating Brantley will be working as a software developer at CarMax, Inc. in Richmond, Virginia. Brantley worked as part of a team on an ISAT capstone project titled "Software Development for Home Energy Audits: Reducing Energy Consumption in Harrisonburg Through Technology".

HONOR STUDENT PROFILES



KYLE HEESEN

Kyle is a senior in the ISAT program. His concentration is energy. Kyle studied abroad with Dr. Karim Altaïi in Costa Rica and found it to be an invigorating experience. The program helped him to gain experience in his interests of energy monitoring and savings. Kyle plans to complete his degree in May of 2017 and upon graduating, plans to work in technology consulting. Kyle is very grateful for the four years of experience at JMU and the ISAT department. He would like to thank all his professors to include his senior capstone advisor, Dr. Tony Chen. Dr. Chen has been a huge impact helping with his senior project as well as working in the classroom setting.



CHRISTIANA KATSOULOS

Christiana will be graduating in May 2017 with a Bachelor of Science in integrated science and technology with concentrations in both environment and sustainable manufacturing. After graduation, Christiana will be pursuing employment opportunities related to automotive or aerospace manufacturing.

Her thesis focuses on the improvement of SUV fuel efficiency through the addition of aftermarket aerodynamic features, which are intended to reduce drag on a typical SUV body shape. The SUV chosen for this study is the 2006 Range Rover Sport, as the body shape mimics the box-like figure of a typical SUV. Features to be tested and examined include fairings, wheel covers, side air dams, and full underbody coverage of the SUV.



RACHEL KORBA

Rachel Korba will be graduating in May 2017 with a Bachelor of Science in biotechnology. She is the president of JMU Fencing Club and is in Delta Gamma. Rachel will continue her education at Virginia Commonwealth University to earn her Master's in Clinical Laboratory Science with a concentration in microbiology. She aims to one day achieve a directorship position in a large clinical microbiology lab.

Rachel started working with Dr. Louise Temple on a dual vaccine platform combatting *Bordetella avium* and *Campylobacter jejuni* her freshman year. These species cause bordetellosis in turkeys and food poisoning in humans, respectively. The Shenandoah Valley poultry industry is economically affected which makes this project especially relevant to the JMU community.



PATRICK LANDESS

Patrick will be graduating in May 2017 with a Bachelor of Science in integrated science and technology with a concentration in energy. Patrick would like to thank his professors in the ISAT department and his honors advisors for their guidance in finding a project relevant to his passion and future career goals in renewable energy development. After graduation he plans to enter a career in wind or solar energy development. Patrick worked as part of a team on an ISAT capstone project titled, “Establishing a Distributed Wind Capacity in Virginia.” Patrick was a project lead for one of the project sites located on Tangier Island in the Chesapeake Bay. In an individual study, he studied the feasibility of distributed wind turbines located near airports, included as an appendix to the project.



SARAH MILLER

Sarah Lauren Miller will be graduating in May 2017 with a Bachelor of Science in integrated science and technology, with concentrations in international energy initiatives and environment. Sarah greatly appreciates and gives thanks to those who helped her along the way. Her capstone advisor Dr. Teel, honors advisor Jared Diener, all of the honors administration, and her ISAT professors have provided wonderful guidance to help her flourish academically. The Rodes family graciously allowed her to use part of their land for her senior project and offered advice. Her parents, family, and friends have provided unconditional support that helped her pursue her dreams. Her first research venture was advised by Dr. Tony Chen titled “In-Situ Measurements of R-Values of a Residential Building Using Thin Film Heat Flux Sensor and Heat Flux Plate.” This was presented at the National Conference for Undergraduate Research in 2016. Her senior capstone project was advised by Dr. Wayne Teel and is titled “Using Ancient Practices to Fix Modern Problems: The Effect of Biochar on Einkorn Wheat and Soil Quality.” A self-proclaimed life-long learner, she will continue to embrace unanswered questions and remain in awe of our natural world after graduation.



CASEY RAMIREZ CORTES

Casey will be graduating in May 2017 with a Bachelor of Science in chemistry and a minor in biology. After graduation, Casey will be attending The Ohio State University College of Optometry to pursue her Doctor of Optometry degree and continue research in the ocular field. Casey would like to thank her professors for the support and guidance they gave to complete her Honors Senior Thesis. Her thesis assesses the structural and thermal stability of the human tear glycoprotein, lacritin, using circular dichroism and Western blots. The alpha helical structure of lacritin was characterized with respect to ionic interactions between amino acids within the alpha helix in the presence of increasing temperature.

HONOR STUDENT PROFILES



JAMES ROLLIN

James will be graduating in May 2017 with a Bachelor of Science in integrated science and technology with double concentrations in environment and sustainable technology applications. James will begin his professional career with Accenture, working as a business technology analyst in their federal consulting division.

His project seeks to look in a local context, Harrisonburg, VA, and create a road map for those trying to live tiny legally. This originally looked at tiny homes on wheels and foundations. Unfortunately, efforts to make this a reality was greatly stymied by layers of red tape leading to foundations being the most viable option. The goal is to provide insight into navigating the legal barriers for tiny houses on wheels or foundations, understanding building and zoning codes, and how to incorporate green technologies into the design process.



KAITLIN TOMLINSON

Kaitlin Tomlinson will be graduating in May 2017 with a Bachelor of Science in integrated science and technology with a double concentration in energy and environment and a minor in biotechnology. She is involved in the JMU Triathlon Club and TAs for two labs: Environmental Issues in Science and Technology and Applied Calculus. Kaitlin is currently looking to start her career after graduation and hopes to later attend graduate school for biotechnology.

Kaitlin and her partner Rachel Stukenborg worked with advisors Dr. Papadakis and Dr. Hartman to create university-level teaching and learning resources about energy poverty. The lesson packages incorporated the spherical display system, Science On a Sphere.

Intelligence Analysis BS



KAYLA GRAVES

Kayla will be graduating in May 2017 with a Bachelor of Science in intelligence analysis and a Bachelor of Arts in modern foreign language Spanish. She is also minoring in Latin American and Caribbean studies. Kayla would like to thank her professors in the intelligence analysis program and her honors advisors for their guidance in developing a project relevant to both fields of study. After graduation she plans to continue her education in graduate school.

Kayla spent much of her time applying structured analytic techniques to evidence gathered in research on the Colombian peace process. Kayla worked as part of a team on an intelligence analysis capstone project titled “Evaluating the Implications of a Defense and Security Restructuring in Colombia.” In an individual study, she applied several theories from International Relations and Political Science to the Colombian peace process, included as an appendix to the project.

Geographic Science BS



LAUREN WHEELER

Lauren will be graduating in May 2017 with a Bachelor of Science in geographic science, concentrating in environmental conservation, sustainability, and development. She also minors in biology. Lauren would like to thank her professors and thesis advisors: Dr. Henry Way, Dr. Eric Pappas, and Dr. Helmut Kraenzle for their insight, instruction, support, and motivation both in class and on this project.

Lauren’s thesis project focuses on development within the United States. While the U.S. overall is highly developed, ranking number eight on the United Nations Human Development Index, there are regions within the country that are falling behind. Her project uses GIS to complete a spatial analysis of multiple development criteria—like health, education, and income—to determine the development status of U.S. counties. By doing this, she hopes to bring awareness to the development needs of areas within the United States while offering suggestions for development in a sustainable manner.

Lauren seeks to pursue her passion for sustainability and service post-graduation as a GIS consultant for a development agency. Long-term plans include starting a consulting firm of her own before receiving her Ph.D. and returning to academia as a professor.

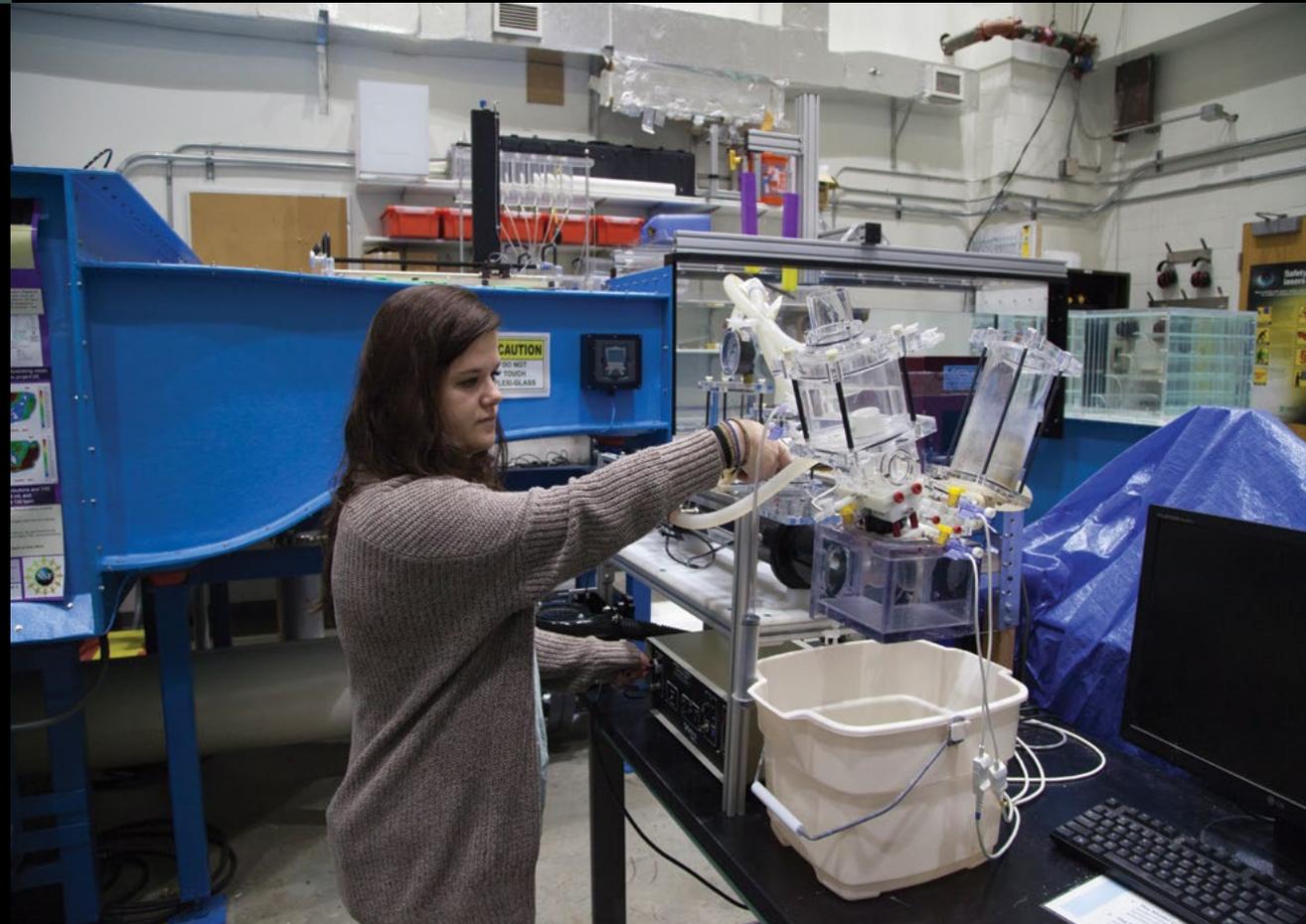
EVALUATING PERCUTANEOUS HEART VALVES

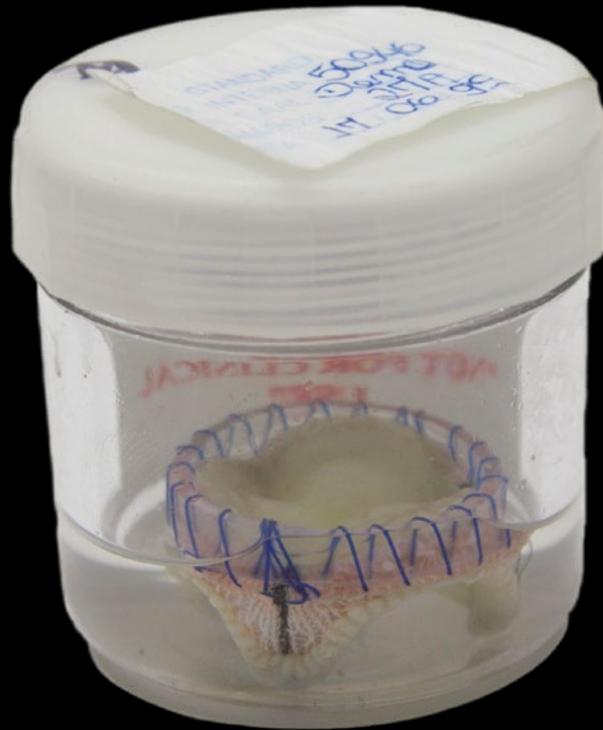
BS-ISAT
Energy and
Environment

Presenter
Julia Randolph

Advisors
Dr. Olga Pierrakos
Dr. Karim Altaii

Sponsor
Tom Maloney,
Edward Lifescience





Heart valve replacement in patients who suffer from valvular heart disease has substantially improved their life outcome. Despite the introduction of Transcatheter Aortic Valve Implantation (TAVI) in patients with conditions of oversizing and non-circular aortic annulus, percutaneous valves still do not compare to that of our natural heart valves. When evaluating these heart valves it is important to take into consideration the need for appropriate

performance metrics. The objective of this study is to evaluate the performance of the percutaneous valve, Sapien XT (Edwards Lifesciences), using the performance metric Vortex Ring Formation Number. To our knowledge, percutaneous valves have not been evaluated using this performance metric. A heart simulator will be used to research and collect data.

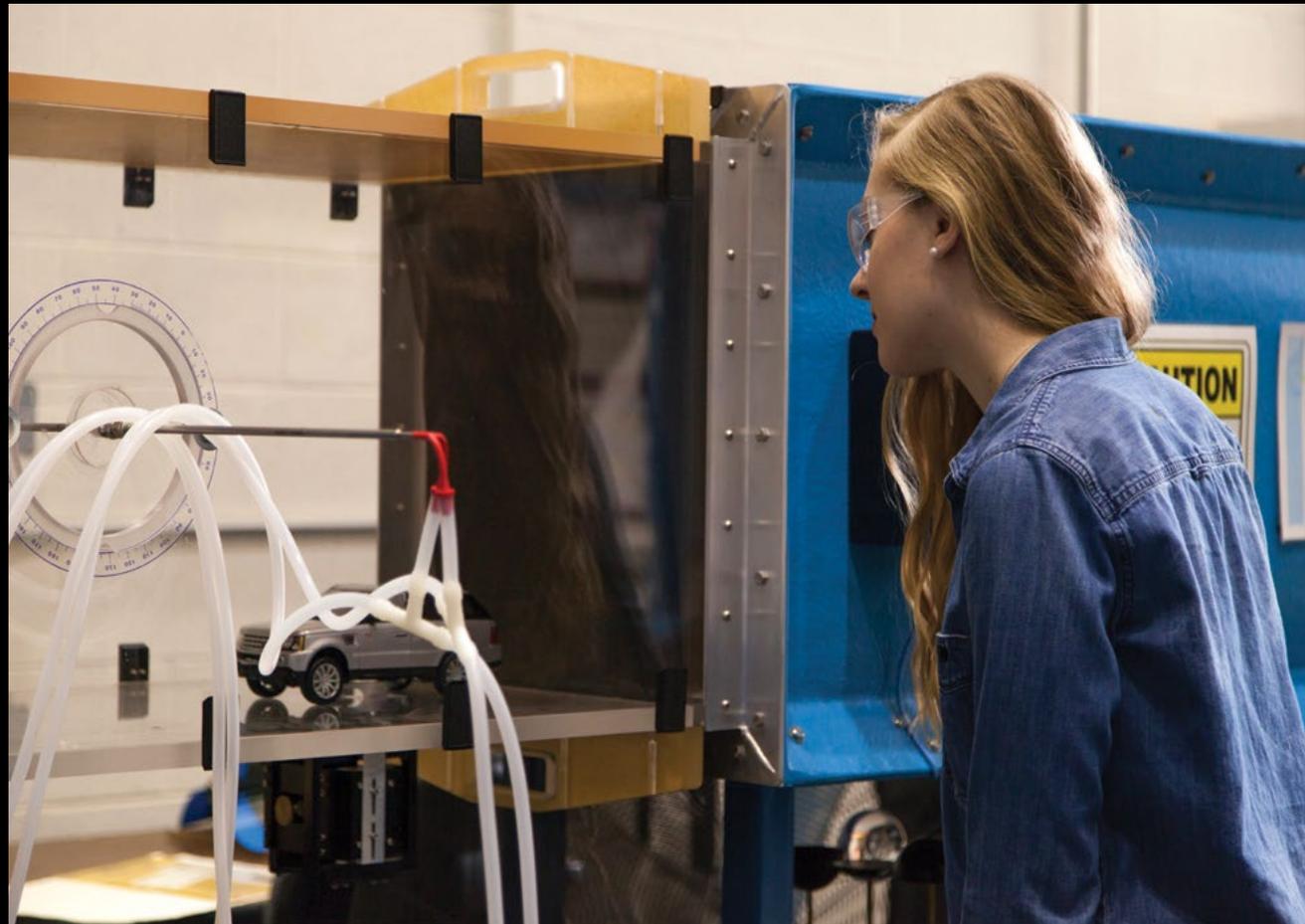
14 AN EXPERIMENTAL STUDY ON DRAG REDUCTION OF AFTERMARKET ADDITIONS ON AN SUV

BS-ISAT
Environment,
Production Systems

Presenter
Christiana Katsoulos

Advisor
Dr. Karim Altaii

Sponsors
Mark Showalter,
John Wild,
JMU Machine Shop



Christiana increasing the speed of the wind tunnel to verify the coefficient of drag of the model car in the test section, by recording pressure and drag voltage readings.



2006 Range Rover Sport toy car used in drag reduction testing.

SUV's main functionality includes hauling or off-roading and fuel efficiency isn't always the main consideration in the design process. Aerodynamic considerations are usually underutilized in the design of SUV's. The principles are typically used on race cars or sedans, and has recently been incorporated into the design of 18-wheeler trucks. SUV fuel efficiency can be improved with minor adjustments through the addition of aerodynamic features. The features used in this experimental testing include fairings attached to the back of the SUV, underside air dams, wheel covers, and/or full underside coverage

of the SUV. This project aims to test various aerodynamic features in order to identify which additions reduce drag and result in improved fuel efficiency. The 2006 Range Rover Sport is the SUV model used for drag reduction testing because of its common box-like shape. The testing process utilizes the wind tunnel located in the Advanced Thermal-Fluids Laboratory at James Madison University. A digital manometer with a pitot-static tube is used to measure pressure and a dynamometer is used to measure drag voltage. This data is used to analyze pressure and drag force calculations in order to obtain velocity and coefficient of drag results.

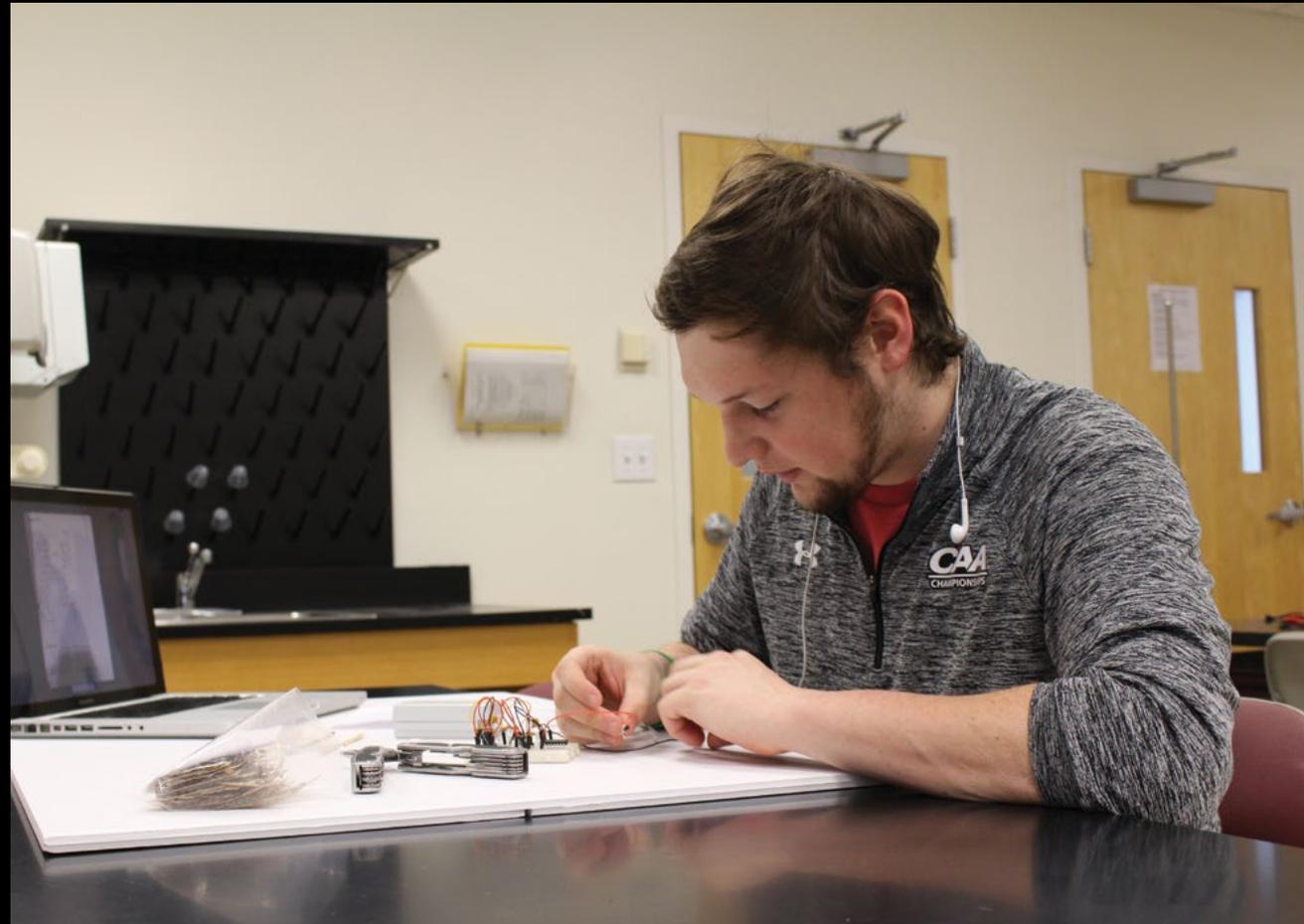
The drag coefficient of the car, compared with the various additional features, will provide evidence of a drag reduction. Final results show that the addition of the front and side air dams prove to have the most significant reduction in drag. With a 20% reduction in drag, fuel efficiency is improved, therefore, customers can benefit in the long run by having a more fuel-efficient vehicle, without sacrificing the spacious design of an SUV. Customers can gain this benefit by purchasing an aftermarket eco-package, that could be offered by car manufacturing companies.

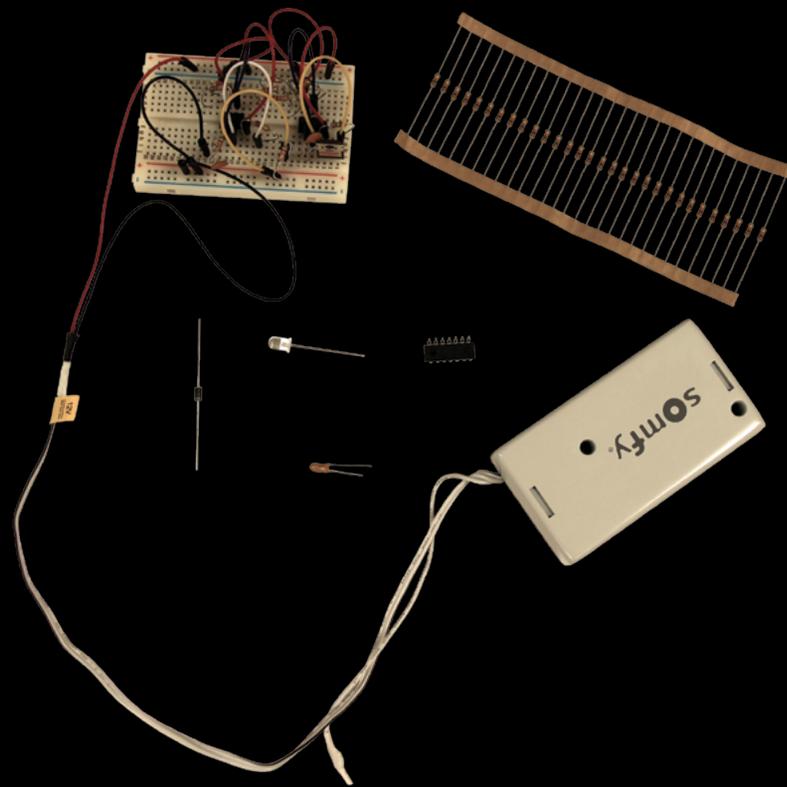
SOLAR TRACKING BLINDS

BS-ISAT
Energy

Presenter
Jonathan Pratt

Advisor
Dr. Karim Altaii





A house can potentially lose or gain between 25 and 60 percent of its heat during the winter and summer months. This consequentially increases energy consumption in order to make up for heat loss, but also lowers a house's overall energy efficiency. As energy consumption continues to increase in today's society, engineers are finding ways to decrease heat transfer to and from the surrounding environment. The goal of this project is to design and build a blinds system that tracks the sun as it moves across the sky with the intention to increase overall household efficiency. This system will track the sun in

order to absorb the maximum amount of direct energy intensive solar rays in the winter while keeping privacy. Alternatively, the product will track the sun during the summer months to reflect these highly intensive solar rays away from the house while letting in natural light. A sensing array, electronic control board, and a motor, are attached to the vertical blinds system in order to control the movement and position. It is my hope that this product will help reduce energy consumption in today's energy dependent society by beneficially impacting the overall energy efficiency of residential and commercial buildings.

GIVING VIRGINIA SOLAR SUPPORTERS A VOICE BY CONNECTING CONSTITUENTS TO LOCAL REPRESENTATIVES THROUGH A STREAMLINED EMAIL SERVICE

BS-ISAT
Energy

Presenter
Dustyn Vallies

Advisor
Dr. Christopher
Bachmann

Sponsor
Hampton Roads
Solar Group



Dustyn Vallies working along side the same technology that he is contacting Virginia politicians about.



The solar industry is on the rise and is creating jobs in the United States. There has been a 25% solar employment increase since 2015. This suggests that there are approximately 260,077 skilled solar workers starting the year in 2017. However, the U.S. is a large nation with unequal distribution of sunlight. Therefore, some states are leading the way in solar growth while others are not. This is rational. Yet, what is irrational, is a circumstance where two states have a similar solar resource and one state significantly outperforms the other. This irrational circumstance is our reality as Virginians. Virginia's neighbor North Carolina has created 6000 jobs and has installed enough solar to power 223,000 homes, while Virginia

employs 2000 and generates enough to power 2,100 homes. That is a 100-fold difference between the two states. Such a stark difference allows Virginia to be ranked 32nd and North Carolina ranked 3rd out of all 50 states for installed solar capacity. After considering the amount of solar businesses, insolation resource, and state policy, it is apparent that the main difference between the two states lies in policy. Thus, this senior capstone project intends to impact Virginia's state policy as a high leverage point that will support solar growth within the commonwealth. This has been accomplished by streamlining the way citizens contact their representatives. Previously, a citizen was burdened to: determine who represents them,

contact their local representative via phone or email, and become well versed enough to persuade a government official that their concern should influence their own decision making in regards to the Virginia's solar industry. This very daunting task has now been condensed into one click of a button. Since the completion of this project, a solar supporting Virginian can enter their name and zip code into a web application, and send a prewritten solar support email to their respective representative. Now 100+ clicks later, and 100+ solar supporters later, Virginia is now moving in a direction where policy makers are becoming more aware that their constituency supports solar.

20 OPTIMIZING GLOBAL THREAT DETECTION AND PREVENTION

BS-ISAT
Applied
Biotechnology

Presenter
William LeBlanc

Advisors
Dr. Christopher
Bachmann
Dr. Timothy Walton



Global Threat Detection and Prevention capstone student William LeBlanc doing research on Fenway Park blueprints to find locations of opportunity for security improvement.



A photo of Fenway Park in Boston, Massachusetts showing in detail the gates, stadium sections, and surrounding streets that all need to be taken into account when attempting to prevent any and all types of attacks.

For decades, one of the least detectable but most lethal weapons in the world has been the Improvised Explosive Device or IED. Rapid expansion of individual terrorist attacks in recent years has created the need for a system capable of detecting and preventing these attacks. The systems in place today are simply not capable of stopping a homemade and seemingly undetectable bomb. The Specific Aims of this project are: 1. To understand the capabilities of current threat detection technologies and identify the system's weaknesses as well as possible areas of potential improvement within all

aspects of threat detection using research and a variety of experienced military personnel and scientists, and 2. To identify and modify existing and emerging technology, regardless of its present purpose, to address the weaknesses and potential improvements addressed in Specific Aim 1. Techniques like ion mobility spectrometry have been used in the past to detect certain threatening materials. This capstone project takes technology like that as well as chemical sniffers, nuclear detectors, and even dogs and modifies how they are used to optimize the detection and prevention of a threat. Terrorist attacks around the world

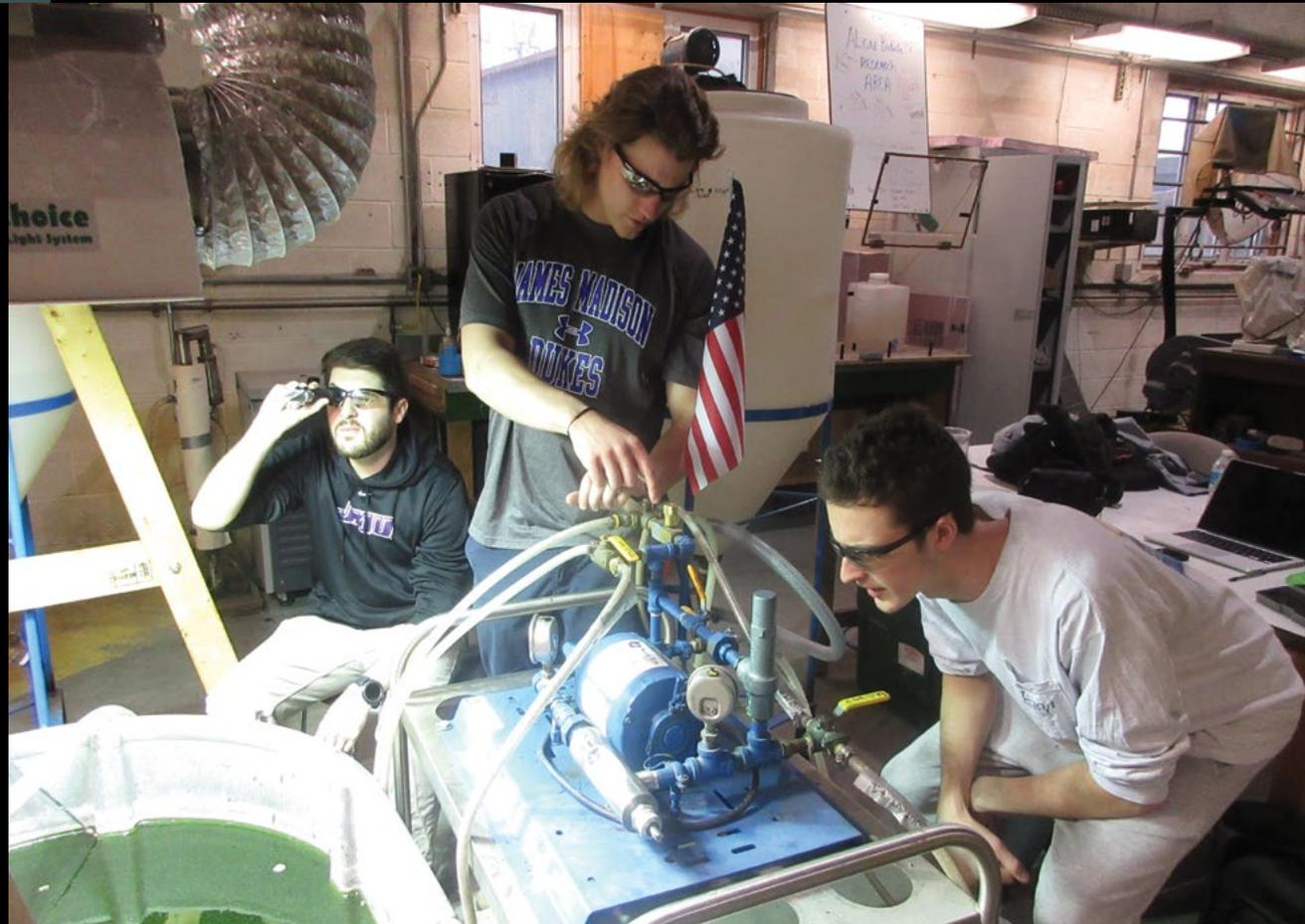
have been simplistic and repeatable. The goal of this project is to create a rapidly deployable system for mass crowds and eliminate that repeatability by making the initial attack more challenging than ever. This system will not be capable of stopping every threat that presents itself, however it will flag attackers who do commit these crimes as soon as they enter the target area, it will make their identification and capture significantly easier, and it will deter future attackers with the knowledge of the effectiveness of this system from ever attempting to carry out their plot.

A HOLISTIC APPROACH TO HARVESTING ALGAE FOR BIOFUELS

BS-ISAT
Applied
Biotechnology

Presenters
Pearson Justis
Kurt Lutter
Chris Tignor

Advisor
Dr. Christopher
Bachmann





This report evaluates the environmental, political, economic, and social implications that implementing algal biofuels would have on the United States. Implementation of this fuel source could lead to greater energy independence as a country as well as help alleviate some of the current environmental issues we are facing. In 2014, greenhouse gas emissions from transportation accounted for about 26% of the total U.S. greenhouse gas emissions, making it the second largest contributor of greenhouse gas emissions after the Electricity sector. Currently algal biofuel is not as economically viable as other fuel sources, however, it is better for the environment and

has byproducts that may be repurposed. While there are multiple ways to harvest algal oil and various strands to choose from, this project focuses on the emulsification and processing of the algae strand *Nannochloropsis*. Through the emulsification of n-Hexane and saltwater algae mix, oil can be extracted from the algae cells. Ultimately the goal of this project is to deliver high-quality oils from the algae with the least amount of energy input. Optimizing the amount of n-Hexane used during the harvesting process of algal oil may allow for algae biofuels to become an economically feasible fuel alternative in the future.

24 INTEGRATING DRONES INTO FIRE/RESCUE

BS-ISAT

Production
Systems

Presenters

John Parks
Christopher Butters

Advisor

Dr. Christopher
Bachmann



John and Chris working diligently to research the impacts of UAS in fire/rescue.



UAS (drones) such as this one pictured is what this capstone project hopes to help integrate into fire/rescue.

Unmanned aerial vehicles, commonly known as drones, are quickly becoming a vital tool in the art of saving lives. UAV's have many capabilities that allow them to be useful in emergency response; UAV's can be equipped with specialized cameras, provide a bird eye's view of a scene, access areas unreachable by foot or vehicle, and search an area rapidly. However, the current federal regulatory structure provides hard to navigate barriers that inhibit the regular use of such devices. These barriers that are preventing firefighters and other first responders access include lack of funding,

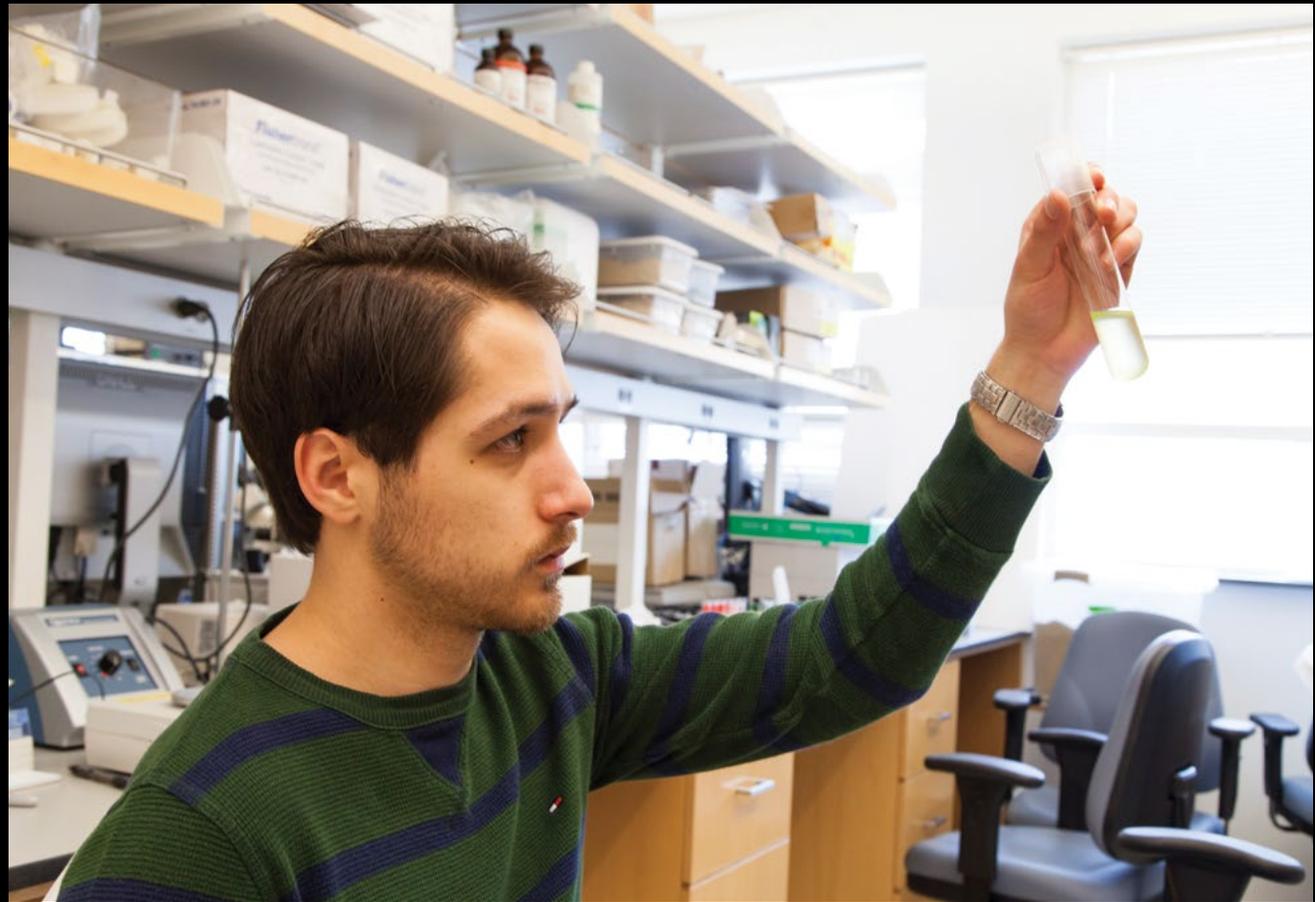
strict regulations on where the UAV can be flown, what type of training is necessary to fly the UAV. This project explores the existing technology, usage opportunities, regulations, training, and funding hurdles that a fire rescue agency may face, and offers information to combat them. The goal of this capstone is to spread critical information to public safety and first responders on how to gain access, funding opportunities, and current technology through a free educational conference hosted at James Madison University.

HIGH THROUGHPUT ALGAE QUANTIFICATION USING QUANTITATIVE POLYMERASE CHAIN REACTION FOR A NOVEL BIOFUEL HARVESTING SYSTEM

BS-ISAT
Applied
Biotechnology

Presenter
Dillon Flebbe

Advisors
Dr. Christopher
Bachmann
Dr. Louie Wurch





As concern over burning fossil fuels and its effect on the environment grows, so does the need for clean and renewable energy. Algae biofuels are a promising carbon-neutral source that could be adopted in place of liquid fossil fuels. The algae biofuel project at JMU is focused on the harvesting aspect of algae biofuel production, with the goal of improving energy return on investment and economic feasibility, which has yet to be proven. Analyzing energy return and economic feasibility requires the number of cells being processed to be known. Currently the project is using spectrophotometry and a

hemocytometer to obtain cell counts. However, these methods have inadequacies. Spectrophotometry is the quick and easy method, but the results vary based on the amount of chlorophyll present leading to inaccurate measurements. Currently counting cells with a hemocytometer is considered the best option because it is believed to give accurate counts, but it is extremely slow and relies on the operator to count the cells. Preliminary data indicates a large standard deviation (+/- 1.73 million cells/ml) associated with this method, likely due to human error. QPCR is a high throughput method of

quantifying based on replicating DNA and fluorescent dye binding to the newly created DNA products. While significantly more expensive due to specialized machinery and consumable reagents, because it is based on DNA the cell counts it produces are accurate. A qPCR protocol was developed for the *Nannochloropsis* algae and utilized as an alternative to the hemocytometer. Based on preliminary data, there appears to be room for improvement which qPCR can exploit. Using qPCR to quickly and accurately count cells can aid in the research of algae based biofuels and possibly lead to the fuels' implementation.

DIALOGGR: AN APPLICATION USING QUANTIFIED SELF TO HELP TYPE 1 DIABETICS MANAGE THEIR CHRONIC CONDITION

BS-ISAT

Information
and Knowledge
Management

Presenters

Rachel Berry
Erin Donovan
Ana Fitzpatrick

Advisor

Dr. Morgan Benton



Team members- Rachel, Ana, and Erin working on their code for their mobile application, Dialoggr.

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FOLDERS
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    splash.png
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Type 1 diabetes is a chronic disease that affects millions of people. Diabetes is characterized by the body's inability to produce insulin causing a medical dependency on artificial insulin. Diabetes is very difficult to control and requires constant self-monitoring. Diabetics have to learn how to serve as their own physicians, dieticians, and personal trainers, often beginning at a young age. Doctors attempt to calculate the amount of insulin needed for each patient based on handwritten records of blood glucose levels, carbohydrate

intake, and amount of exercise performed for the one week preceding an appointment. Although this medium is simplistic, it is not proactive. The data collected is not secure, easily accessible, or informative. The purpose of this project is to create a mobile application that will help diabetics manage their condition. The application will provide a quick and easy way for patients to input their blood glucose levels, carbohydrate intake, and sleep activity. The application will then serve as a way for diabetics to evaluate their own data and find relationships

between the aforementioned factors. The patient's doctors will then be able to use the comprehensive data to better treat and advise the patient. Future study and development will allow this application to be used as a big data collection system that could allow researchers to identify relationships and trends, ultimately resulting in better treatment options and a more manageable lifestyle for diabetics around the world.

JMSCOOP: A PROGRESSIVE RIDE SHARING APPLICATION FOR JMU STUDENTS

BS-ISAT

Production Systems,
Information
and Knowledge
Management

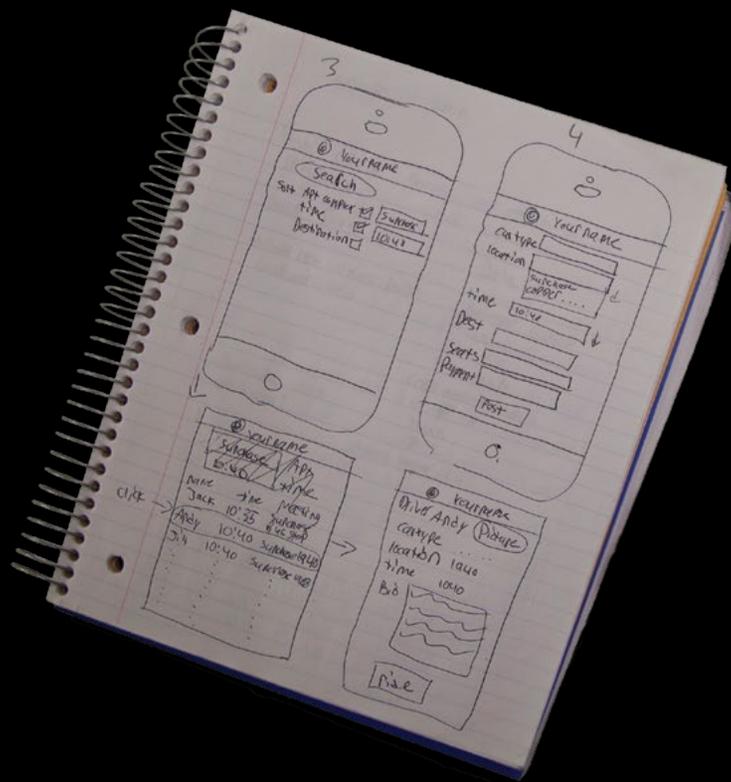
Presenters

Alexandra Astarita
Matthew Brown
Andrew Michon

Advisor

Dr. Morgan Benton





As JMU's student population and size continues to expand, the increasing demand for on-campus parking poses a significant challenge for the university moving forward. A progressive web application (PWA) is a website meant to be saved to a mobile device's home screen. The purpose of our PWA is to alleviate some of the demand for on-campus parking by providing students with a user-friendly way to set up carpools with fellow student commuters

via mobile device. Our PWA was designed exclusively for JMU students, and will allow students to set up carpools in any off campus location. In turn, this will theoretically decrease the number of single passenger vehicles. This project is a prototype created by ISAT seniors, and the project will continue its development in the coming year by three rising seniors.

MADISON CONSERVATION CORPS: SOFTWARE DEVELOPMENT FOR HOME ENERGY AUDITS

BS-ISAT

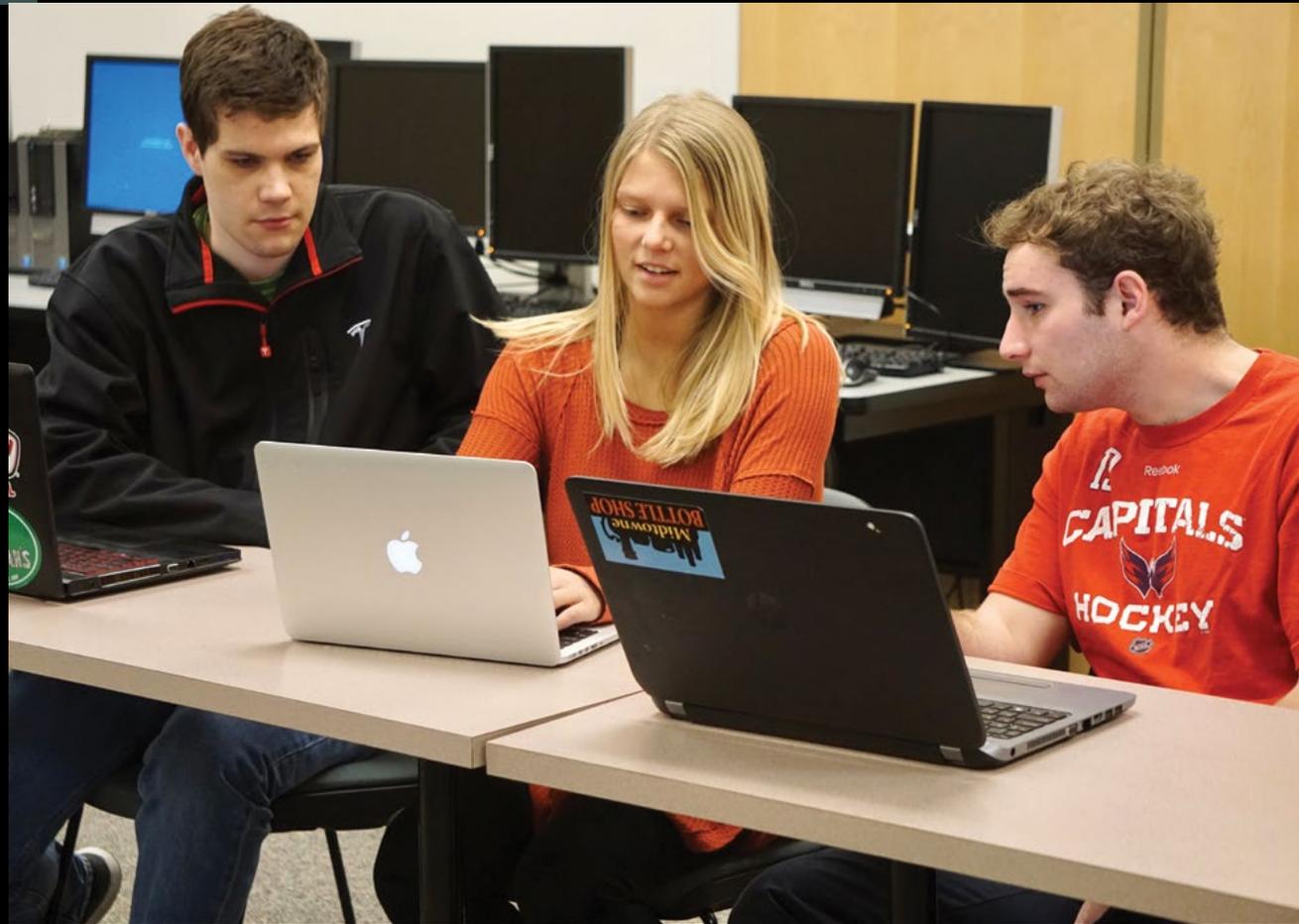
Information
and Knowledge
Management

Presenters

Conor Cousins
Alyssa Felice
Brantley Gilbert

Advisor

Dr. Morgan Benton



Brantley Gilbert, Alyssa Felice, and Conor Cousins review their code for the home energy auditing software to be used by the Madison Conservation Corps.



A thermal imaging camera, like the one shown, can be used to find areas of insufficient insulation during energy audits.

Fossil fuels are everywhere in our lives. They are in the cars that we drive, they are used in our homes to heat our water, and they are used by power companies to generate the massive amounts of energy used every day by the United States. However, this reliance on a finite source of energy is not sustainable. Fossil fuels such as coal and oil are non-renewable resources whose production will eventually be unable to keep up with the rate of consumption. Furthermore, the extraction of the stored energy in these fuels through

combustion releases harmful substances into the environment, including toxins and greenhouse gases. In order to take steps to end this reliance on fossil fuels, we need to make fundamental changes in our collective behaviors. One of the easiest behavioral changes to make toward this goal is to focus on conserving energy at home. By reducing one's home energy usage through a home energy audit, a person can save money on electric and heating bills, help reduce his/her impact on the environment, and even potentially increase

the market value of their home. However, traditional audit reports often fail to effectively change homeowner's energy consumption behaviors. The objective of this project is to determine if the home auditing process could be made more efficient and effective through the development of specialized software applications to address specific obstacles to energy usage behavior changes. We will perform trials of home energy audits in Harrisonburg using our software to determine the effectiveness of the process.

NATIVE AND INVASIVE AQUATIC: PLANT SPECIES IN VIRGINIA TROUT STREAMS

BS-ISAT
Environment

Presenter
Paul M. Lacy

Advisor
Dr. Thomas Benzing

Sponsor
Garden Club
of Virginia



Paul identifying different submerged macrophytes within the Jackson River.



The two small bottles contain macroinvertebrate samples collected off of Curly-Leaf pondweed from the South River. The three larger bottles contain water from the North River that were used for ion chromatography.

Aquatic plants, or macrophytes, are an important part of stream ecology and serve as energy producers in trout habitat. In addition to providing food for herbivorous fish and macroinvertebrates, macrophytes act as shelter and habitat for instream organisms. They also affect physical properties like stream height, sediment size, and help control nutrient and pollution concentrations within rivers. Invasive species disturb natural ecosystems. My first hypothesis is that invasive macrophytes will reduce the richness and diversity of the macroinvertebrate communities they support.

The second hypothesis is that streams with greater numbers of invasive macrophytes will exhibit

poorer water quality and habitat conditions. This project studied the ecology of native versus invasive macrophytes in three Virginia trout streams. Plants and their associated macroinvertebrate communities were sampled from three rivers; the North River in Bridgewater, the South River in Waynesboro, and the Jackson River in Monterey. Together with these samples, water quality measurements were taken for comparison to Virginia state standards.

All three rivers contained elodea (*Elodea canadensis*), a submerged native macrophyte, and both the North and South Rivers contained curly-leaf pondweed (*Potamogeton crispus*), a submerged invasive. Based upon

the Simpson's Diversity Index, native elodea appears to support a greater diversity of macroinvertebrates than invasive curly-leaf pondweed. However, no trend could be seen in total macroinvertebrates found or macroinvertebrate richness for the different macrophyte species. The results of this project will be presented to the Garden Club of Virginia's conservation committee who awarded me a Conservation and Environmental Studies Fellowship to help pay for the research materials and reimbursement for miles traveled during the project.

36 STREAM QUALITY ANALYSIS & MONITORING OF THE PROPOSED INTERSTATE PIPELINE THROUGH GEORGE WASHINGTON NATIONAL FOREST

BS-ISAT
Environment

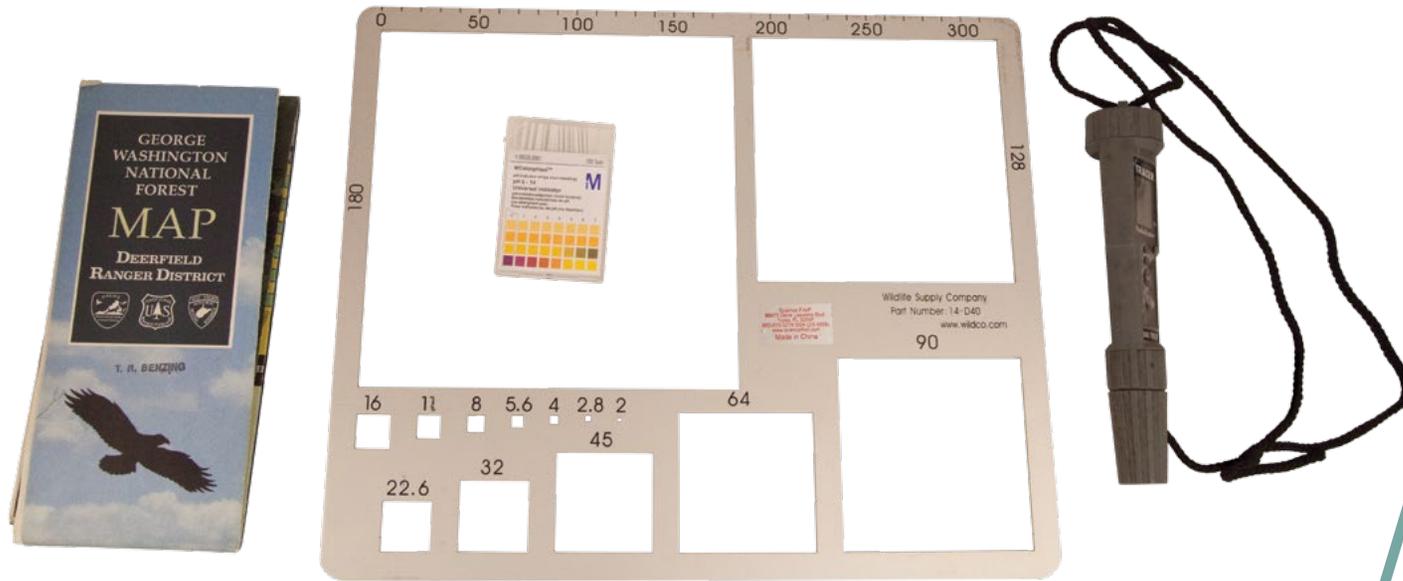
Presenter
Kevin Walling

Advisor
Dr. Thomas Benzing

Sponsor
Trout Unlimited



Kevin conducting his monthly streamside visits, monitoring and recording different water quality parameters, which ensured a baseline of data that can be used in the future to see if any effects come from implementing the Atlantic Coast Pipeline.



An essential display of the field instruments used to monitor the various site locations provided by the Trout Unlimited WV-VA Water Quality Monitoring Project.

The Atlantic Coast Pipeline is proposed in the coming year to cross through the George Washington National Forest in Virginia. This 564 mile long transmission pipeline is designed to carry natural gas, stretching across three different states. Possible impacts associated with construction of the instream crossings include changes in turbidity, pH, water temperature, conductivity, and stream channel conditions. The objective of my study is to monitor and record water quality for two trout streams in Augusta County, Ramsey's Draft and Hodges Draft, before pipeline construction. As

part of the Trout Unlimited's WV-VA Water Quality Monitoring Program, I collected baseline stream quality measurements and submitted this data online to a national database. I selected six site monitoring locations based on the proposed pipeline route for the purposes of comparing a control stream to a possible impacted stream. Overall, both streams are healthy and had very similar water quality. Our field measurements of conductivity were confirmed through laboratory analysis at Eastern Mennonite University. Water

temperatures varied by season as well as distance downstream. The acidity of the water, measured by pH, was generally high and did not change significantly. Both streams showed high water clarity and very little impact on turbidity during runoff events. With the baseline data collected and established, any significant environmental impact of future pipeline construction can be evaluated and quantified for future projects.

GAUNTLET GOLF COURSE ENVIRONMENTAL IMPACT ASSESSMENT AND REDUCTION PLAN

BS-ISAT
Environment

Presenter
Taylor Byrd

Advisor
Dr. Robert Brent

Sponsor
Golf Course
Specialists



Taylor Byrd compiling data collected over the summer in order to help the Gauntlet Golf Course make educated environmental decisions.



Aerial view of the Gauntlet Golf Course and the neighboring Curtis Lake.

The hospitality, tourism, and recreation industry is a major source of pollution and waste in America. The Audubon International Corporation strives to incentivize major companies in this industry, like golf courses, to reduce their impact on the environment through sustainability and conservation practices. Specific areas of focus include considerations for wildlife and habitat management, chemical usage, and safety, water conservation, water quality

management, and outreach and education. The project applied these objectives to the Gauntlet Golf Course in Fredericksburg, Virginia. The two major goals for the project were to reduce the golf course's impact on the local environment and ultimately to achieve Audubon certification for the property. Each of the Audubon objectives were individually examined to determine potential environmental impacts and assist the golf course in making decisions that would reduce those impacts.

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A GIS ANALYSIS OF STORMWATER FACILITIES IN ROCKINGHAM COUNTY: POLICY AND GEOGRAPHICAL DISTRIBUTION

BS-ISAT

Environment,
Information and
Knowledge
Management

Presenter

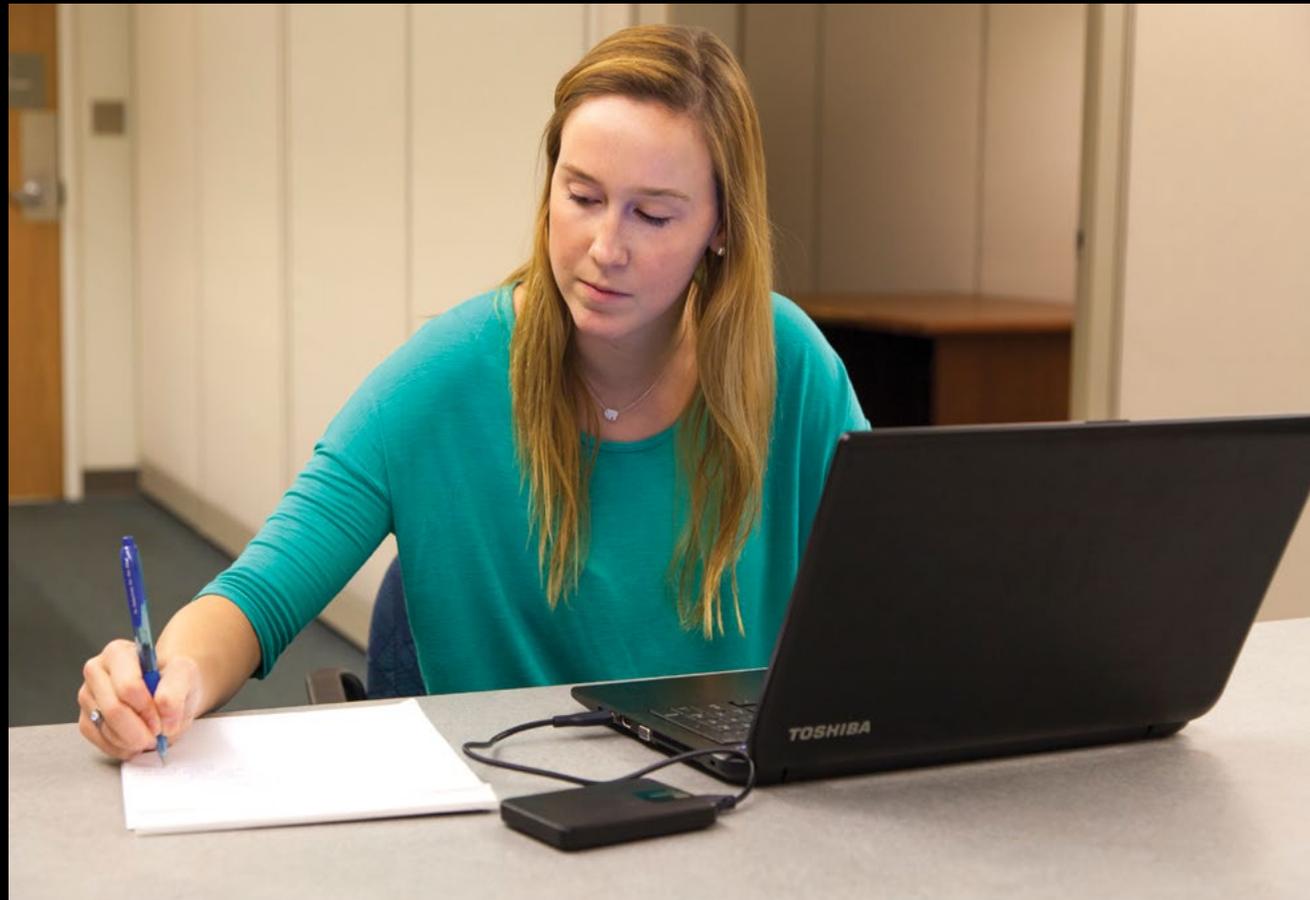
Andria
Grossenbaugh

Advisor

Dr. Robert Brent

Sponsors

Ms. Helen White,
Rockingham
County Community
Development,
Rockingham County
Public Works



Andria works diligently on creating a GIS stormwater layer for Rockingham County to allow for improved identification of best management practices.



The wet pond/basin located in the Aspen Heights development in Harrisonburg, VA which was mapped using GPS coordinates and eventually transferred to a shape file that is included in the Stormwater GIS layer for tracking and maintenance.

As urbanization expands and rain events become more frequent and extreme, due to an increase in population and climate change, stormwater runoff has become an increasingly important area of environmental focus. The quantity and quality of stormwater runoff directly impacts downstream flooding and can damage property and infrastructure, and degrade downstream water quality. Stormwater quality and quantity is managed by best management practices, BMP's, which are installed by cities and counties in order to prevent or reduce the volume of polluted

stormwater flowing downstream. This project aims to identify and track the management of current (post 2012) permanent stormwater facilities in Rockingham County and make recommendations for future policy through the completion of a geographic information system (GIS) layer. GIS tools were used to map and analyze BMPs throughout the county, and the results were used to inform policy recommendations for improved tracking and maintenance. Covering six watersheds, 70 BMPs are currently identified in Rockingham County. Dry and wet ponds, basins,

bioretentions, and filters categorize these 10 different types of BMPs. These BMPs differ in their ability to remove solids and nutrients from stormwater before entering downstream water bodies. Bioretentions remove up to 90% of total suspended solids (TSS), detention basins remove up to 40-60%, and wet ponds remove up to 50-90%. This thesis sets out to outline the best management practices in Rockingham County and analyze the current policy in place in order to make future recommendations to improve overall water quality in the county.

VALIDATION AND USE OF HANDHELD X-RAY FLOURESCENCE SPECTROMETRY FOR MEASURING MERCURY IN SOIL

BS-ISAT

Biotechnology and
Environment

Presenters

Joseph Luther
Hunter Wines

Advisor

Dr. Robert Brent

Sponsor

Dupont



Handheld X-Ray Fluorescence Spectrometer (XRF) being used to measure the mercury concentration in soil samples from the banks of the South River in Waynesboro, VA.



Handheld X-Ray Fluorescence Spectrometer (XRF).

The purpose of this study was to demonstrate that a handheld x-ray fluorescence spectrometer (XRF) can accurately and efficiently characterize mercury contamination in the soil along the banks of the South River RCRA site in Waynesboro, VA. This study was divided into three parts: Method Validation, Method Interferences/Correction, and Field Characterization. Historically, XRF instruments have not been seen as an alternative to traditional laboratory methods for measuring mercury, because of poor sensitivity. In this study, improved sensitivity was achieved with a site-specific calibration. In the first part of this study the instrument was used in a split study comparing the field XRF method with

laboratory EPA Method 7471A. The results of this split study showed that the two methods agreed with an R-squared value of 0.93 and a median coefficient of variation of 15%. The precision estimates from sample duplicates and triplicates showed that precision was influenced more by sample heterogeneity than method capabilities. The Method Interferences/Correction portion of this study was conducted by spiking field-collected soils with known amounts of mercury and then adjusting the moisture levels of the soils to a range of 0-30% moisture. This study found that moisture creates a systematic bias in the measurements, but this bias is no more significant than the variation associated with sample heterogeneity.

Finally, the Field Characterization portion of this project was a 6-day sampling campaign that analyzed 2,000-ft of contaminated banks along the South River near Hopeman Parkway, Waynesboro, VA. This study showed that the handheld XRF can provide fast, in-situ results that allow decision makers to more quickly identify and target high priority contamination areas. In summary, this three-part study demonstrated that the handheld XRF with site-specific calibration can be used as a quicker and cheaper alternative method for characterizing mercury-contaminated banks with similar accuracy, precision, and sensitivity.

ENERGY AUDIT OF A COMMERCIAL BUILDING: JMU BOOKSTORE

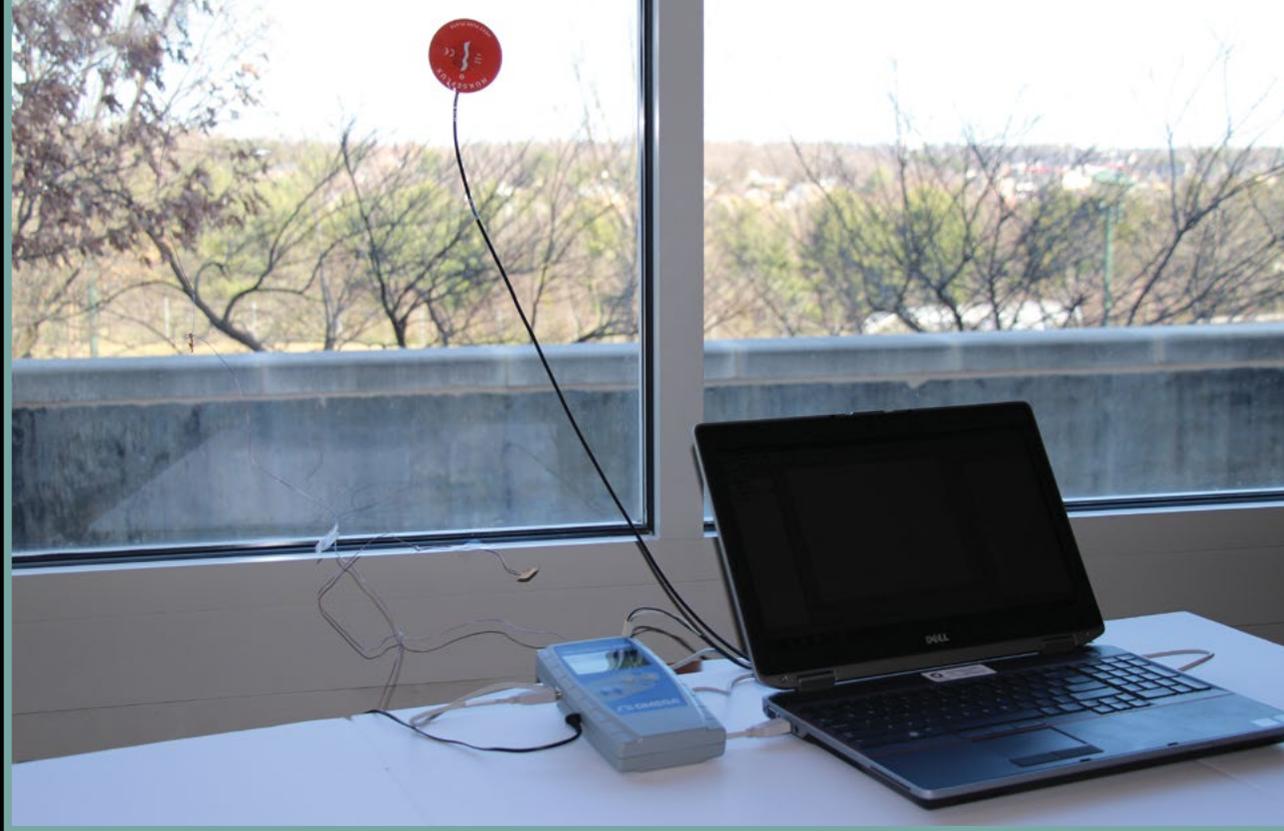
BS-ISAT
Energy

Presenters
Connor Ganley
Nathaniel Sohn

Advisor
Dr. Tony Chen

Sponsor
JMU Facilities
Management





R-value of building envelope was measured by using a Hukseflux® HFP01 heat flux sensor together with two pairs of thermocouple wires, one on the inside and another on the outside of the building.

For our capstone project, we are conducting an energy audit on the JMU campus bookstore. The purpose of this energy audit is to analyze the energy flows of the building in order to find areas where building energy efficiency can be improved. The auditing process consists of four increasingly detailed levels of analysis. Level zero is the benchmarking audit where we compare the building's energy use to other buildings that are both similar in size and climate inhabitation. Level one is the preliminary audit where we conduct a walk-through of the site in order to identify obvious problems within the building. Level

two is the standard audit where data is collected about specific energy systems. In order to understand the site's insulation the heat flux and temperature gradient of walls and windows are measured. This level also usually involves a negative pressure blower-door test in order to test for air leaks. Level three is the simulation stage which is the final step in the energy audit process. The simulation stage requires the data collected from the previous three levels. The data is used to develop an energy savings model to display to the client through programs like eQuest®, BEopt®, and RETScreen®. By using these softwares and their training courses,

we are gaining professional development certification in LEED™ and modeling simulation. For our capstone project, we will put the most emphasis on levels two and three because those are the stages where the most useful data is collected. Once all the stages of the energy audit are completed, the client can make energy saving improvements as they see fit based on all the information provided.

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EXPERIMENTAL REFRIGERATION REPLACEMENT

BS-ISAT
Energy

Presenter
Kyle Heesen

Advisor
Dr. Tony Chen



An Air-Conditioning Laboratory Unit, TAAB by Edibon® was employed in the project to investigate the system performance of an air-conditioner with different refrigerants such as R-134a, R-410A, and R-22.



TAAB Laboratory air conditioner unit tested for heat loss and COP.

Refrigerants are used in everyday appliances including air conditioners for a car or house and freezers used on the household and industrial levels. While refrigerants help improve quality of life they release compounds that could be detrimental to the environment and cause damage to the atmosphere. Since the creation of refrigerants back in the late 1800's the compounds released from the refrigeration process directly impact the ozone and climate change. Many policies including the Montreal and Kyoto Protocol to help control the amount of these damaging compounds released

into the atmosphere. Different refrigerants have different inefficiencies, economic performances, safety levels and global warming potentials. New refrigerants are being created at a very slow rate but advances need to be made. The objective of this study is to examine how different refrigerants react with the environment and how breakthroughs in cleaner refrigerants can help minimize the negative effects to the environment and atmosphere. An air conditioning lab unit was used to compare the system performance with refrigerants R-134a, R-22, and HFO-1234yf.

ENVIRONMENTAL SUSTAINABILITY OF MUSIC FESTIVALS: AN INTEGRATIVE APPROACH TO REDUCING THE ENVIRONMENTAL IMPACT OF FESTIVALS

BS-ISAT

Applied
Biotechnology and
Environment

Presenters

Hope Barnstead
Taylor Garrenton
Jack Shea

Advisors

Dr. Shannon Conley
Dr. Steven Frysinger



Driven by their shared passion for music and the environment Hope Barnstead, Taylor Garrenton, and Jack Shea work diligently on their capstone thesis.



Team members conducted field research at various festivals including Lockn' Festival, pictured here, located in Arrington, Virginia.

Present day music festivals are built on a strong foundation: freedom, community, and an undeniable love of music. But, as these festivals continue to grow and expand on these values, one critical value often tends to be overlooked: their impact on the environment. It is important that music festivals openly promote environmentally sustainable practices and devise ways in which festival goers can easily put these practices into place and festival planners can actively challenge themselves to continuously reduce their environmental impact. This project aims to take a deeper look into current environmental practices

implemented on small and large scale festivals, and provide practical steps and insight into increasing the effectiveness of those practices in the future as well as develop new ones. This will be accomplished through meetings with festival directors and environmental specialists, volunteer field work at multiple festivals, and an in-depth literature review. A guide book containing specific ways to increase environmental consciousness for both festival planners and goers will be developed to serve as a tool in the planning and execution of music festivals.

SCIENCE FICTION FOR SCIENCE POLICY: SCIENCE FICTION AS AN ETHICAL LEARNING DEVICE FOR STUDENTS AND POLICY MAKERS

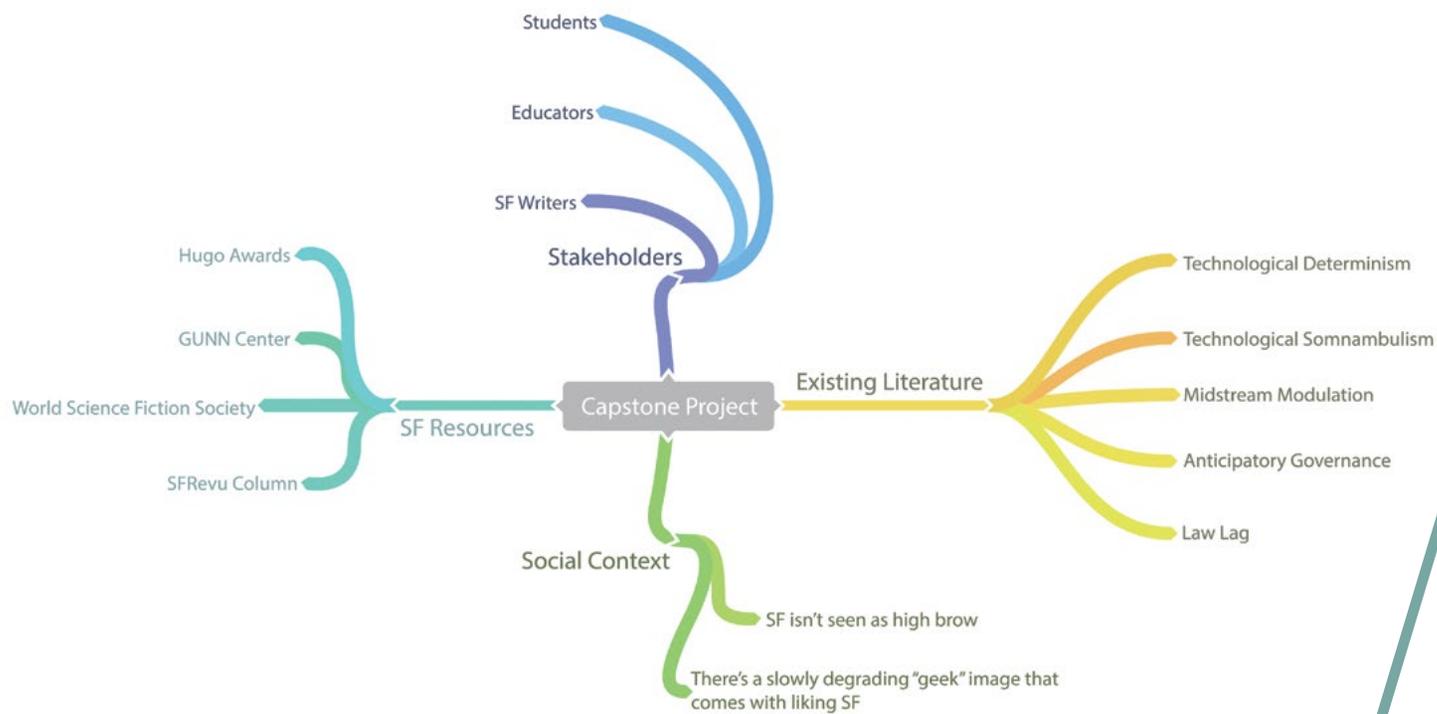
BS-ISAT
Applied
Biotechnology

Presenter
Gregory Glasgow

Advisor
Dr. Shannon Conley



One of Gregory's favorite parts of of this project was having the opportunity to teach ISAT students about bioethics.



This is a concept map that displays the actors and institutions that could potentially be invested in his project.

Scientific and technological advancements often appear to manifest themselves before our abilities to govern them. Once a technology has been invented, it sparks an effort to determine how society should handle it. This creates a crucial period of time in which involved actors and institutions can attempt to regulate the new technology in a way they see fit or decide not to regulate it at all. The goals of this project involve finding ways to shift the start of this time of deliberation to a point before the technology has been invented, finding the uses of science fiction, analyze pedagogical strategies used in teaching ethics and other critical thinking styles, and combining them to

see if science fiction can be used as an effective teaching tool. Although science fiction can be used as a tool to catalyze the emergence of thoughts relevant to anticipatory governance in many fields, my project will focus on emerging medical technology and bioethics. Using science fiction, society can foresee problems before they emerge, lessen the potential damages, and expedite the process of benefitting society that may be caused by the new technology. For this project specifically, students will be guided through multiple modules in their ISAT 231 class with the help of Dr. Shannon Conley.

STUDENT PERCEPTION OF GMOS AND THEIR PREVALENCE ON CAMPUS

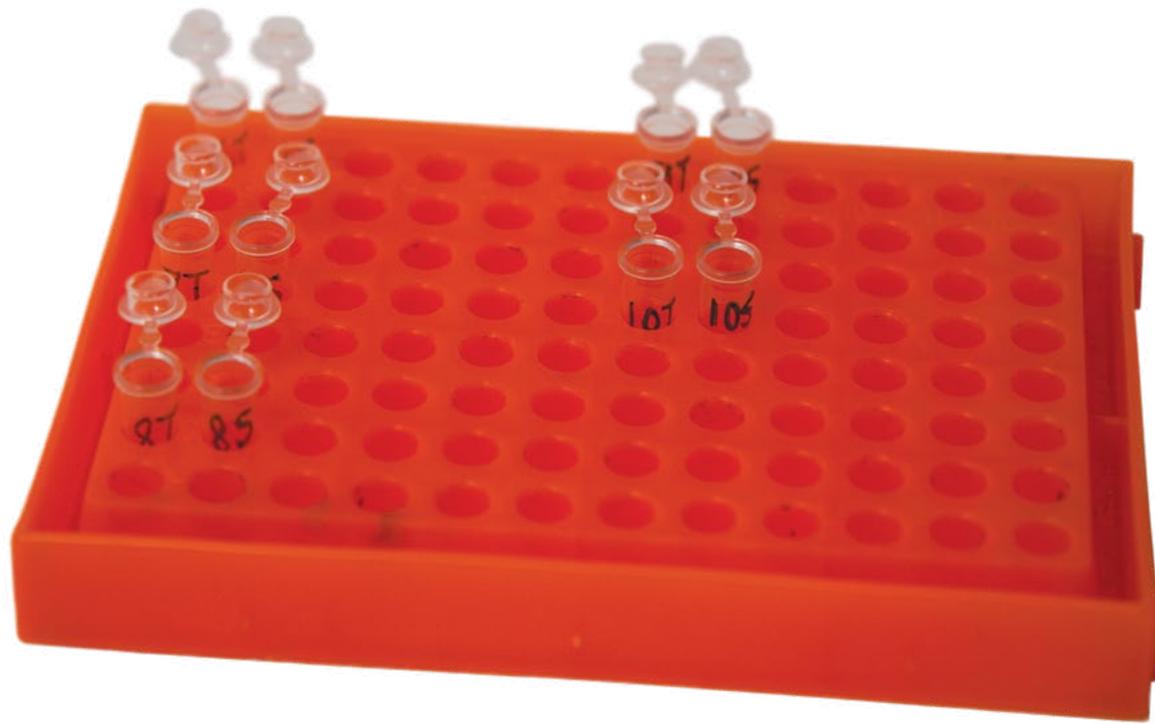
BS-ISAT
Applied
Biotechnology

Presenters
Sarah Di Croce
Travis Hooven
Adam Turosky

Advisors
Dr. Shannon Conley
Dr. Amanda
Biesecker



Travis Hooven, Adam Turosky, and Sarah Di Croce preparing samples for PCR in order to amplify DNA isolated from food samples.



Labeled tubes containing reagents for a polymerase chain reaction.

Genetically modified foods have become commonplace in today's grocery stores. However, recent state and federal GMO labeling legislation has sparked debate about the use, consumption, and required labeling of GMOs. In light of these recent dynamics, we have partnered with Aramark and JMU dining services to understand what issues, if any, JMU students have in regards to genetically modified (GM) foods on the campus, and present a feasible plan to address these problems. In order to explore these issues more in depth, and to understand

the technical underpinnings of genetic modification, the project was divided into three stages. Firstly, an Institutional Review Board-approved survey was designed and distributed via email to gauge the interest and perception regarding GM foods in JMU dining halls. The survey was designed to focus specifically on students' perception of GM food safety, their overall knowledge of GM foods, and their preferred options regarding GM foods in JMU dining halls. Secondly, laboratory testing of common food options in JMU dining halls was performed in order

to gain professional hands-on laboratory experience, as well as investigating the presence of genetic modification in dining hall foods. Lastly, the survey and laboratory results were analyzed to create and present a feasible plan to Aramark and JMU Dining Services, in order to address findings from the survey data.

A CYBER PHYSICAL SYSTEM TO LOCATE: LOCALIZATION OF HEALTH CENTER PATIENTS & STAFF THROUGH AN IOT ENVIRONMENT

BS-ISAT

Telecommunications,
Networking
and Security

Presenter

Dylan McAllister

Advisor

Dr. Samy El-Tawab





The rapid increase of modern wireless technology opens the door for several new applications using the Internet of Things (IoT) technology. In the medical field, medical staff members of a specific hospital are in need for a system that tracks where any patient/medical staff/devices are at a certain time. LoCATE, which is Localization of Health Center Assets Through an IoT Environment, provides a near-real time tracking tool for medical systems using existing 802.11 WiFi infrastructure. The primary goal of this system is to track assets and personnel at any hospital (e.g. Sentara® RMH hospital) and continuously log real-time

location data on a cloud computing platform (AWS). Using LoCATE, administrators can view the location of doctors, patients, and assets in real-time via a web UI or a mobile app. The collected data, stored in the Cloud Storage, is then analyzed to expose inefficiencies in daily operations and improve the health care system. The low-level functionality of the LoCATE system is not unlike that of typical RFID technologies. However, the spirit of the IoT paradigm employed by LoCATE makes the system both flexible and scalable by leveraging collaboration between embedded and Cloud systems. This flexibility will allow for the

future support of additional applications such as hardware integration or state monitoring. This can include data acquisition such as usage statistics and historical patient health data. Compiling this data might pave the way for future research into disease vectors or could be used to optimize care delivered for specific conditions. Nevertheless, while the implication for an IoT system such as LoCATE in a healthcare environment are wide-ranging; its primary objective is to provide an easy to use, low-cost solution to track the location of medical assets in real-time.

FLOATING ISLAND TECHNOLOGY: WATER ECOLOGY ENHANCEMENT TECHNIQUES

BS-ISAT
Environment

Presenters
Joel Kaminski
Brenden White

Advisor
Dr. Steven Frysinger

Sponsor
Floating Island
International





Floating Treatment Wetlands (FTWs) are an emerging private sector technology created from observing naturally occurring floating islands. These islands hold an abundance of life, and create shelter for a variety of aquatic microorganisms. As these microorganisms grow they form a substance called biofilm, which is rich in nutrients that are absorbed from the surrounding waters. Plants interact with these microorganisms to increase nutrient uptake by both species, as well as provide surface area, through root structure, for more biofilm to adsorb to. Man-made floating islands are created with one goal in mind: to improve water quality by cycling nutrients out of the

aquatic system and into plant or animal biomass as to mitigate toxic algae blooms effects on aquatic life.

Some private companies claim to have found the “perfect ratio” of surface area to water circulation to improve water quality faster than their competitors. This capstone focuses on testing whether a company's FTW's matrix is better than a standard clay pellet hydroponics setup for up taking nitrogen, which is one of the nutrients found at high levels in fresh waters across the nation and contributes to algae blooms formation. The method will start with germinating our own lettuce plants,

then transferring them to 1 liter Tupperware containers filled with DI water. Plant food will be added to the individual containers at a concentration of 150 ppm nitrate and data will be collected over two weeks each day as to the current concentration in the water to receive a 14-point decay curve in each Tupperware container.

It is expected that there will be minute differences in performance between the hydroponics and matrix setup, but that is why the sample size is large (18 trials for each setup and 22 measurements for each days reading in each container).

FOOD WASTE STUDY OF JAMES MADISON UNIVERSITY

BS-ISAT
Environment

Presenter
Nicole Raftery

Advisor
Dr. Steven Frysinger





This is an image of a trash bin on JMU's campus. It is clear that anything entering this trash bin will be sent to a landfill. However, some of the items spilling over the top of the bin are recyclable. Even worse, the recycling bin is directly to the left of the landfill bin.

Food waste is a problem felt around the world. Rich or poor, developed or undeveloped, no country is innocent to this ever-growing problem. However, it is smaller scale food waste and disposal that combines to make up the vast amounts of waste seen today. In order to make a difference, small scale changes need to be made on a global scale. James Madison University is a large-scale educational institution located in Harrisonburg, Virginia. JMU, like any college, disposes of copious amounts of food each year. JMU itself is taking strides to reduce overall waste from the

school, but the real problem lies with the JMU community members. In order to significantly and permanently reduce wasted food at JMU and increase proper disposal of said waste, community members must change their careless, thoughtless, and wasteful dining habits. By developing an understanding of why people waste food and improperly dispose of waste, appropriate actions may be implemented to bring about change among the people at JMU now and the people in the years to come. These actions could help JMU community members reduce their waste for the rest of their lives.

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LIVING TINY LEGALLY

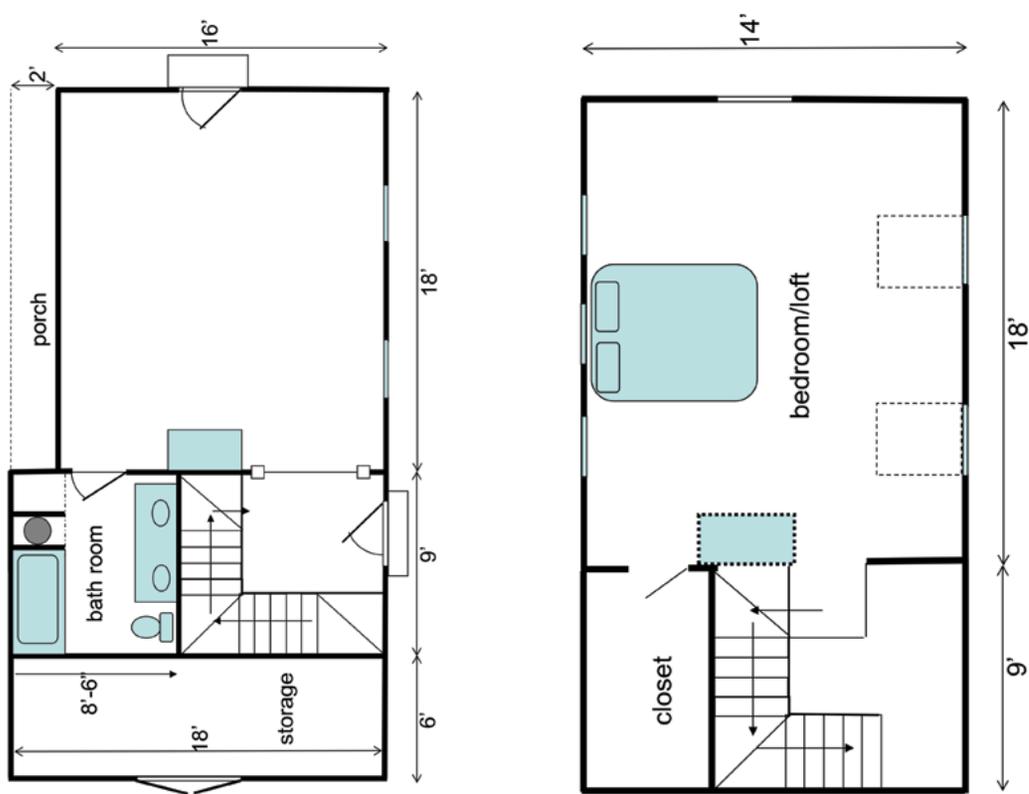
BS-ISAT
Environment
and Energy

Presenters
Hollyn Busby
James Rollin

Advisor
Dr. Steven Frysinger



Looking at ways to implement tiny homes in Harrisonburg to address the problem of affordable and sustainable housing.



Floorplan for a 500 square foot tiny house that we are currently looking to renovate.

The average home size in the U.S. increased 61% since 1973 to over 2600 square feet. In that same time period there was a 91% increase in home square footage per inhabitant and a decrease in average household size. According to the U.S. Census Bureau, the average home in the United States costs approximately \$358,000 to build, an increase of roughly \$200,000 since 1998. Meanwhile, the average annual income in the United States has remained unchanged for the last several years, at approximately \$52,000. As costs increased, U.S. home ownership rate fell to the lowest in more than 50 years, since 1965, down to 62.9% in the second quarter of 2016.

These trends have created a dire need for affordable housing. This project addresses the problem while proposing tiny houses as a solution which follows the triple bottom line. This is an economic model that focuses on economy, ecology, and equity as the dimensions of success. Tiny homes are sustainable as they are more energy efficient and require less materials. Technology such as passive solar design, high R-value insulation, or energy star appliances can drastically reduce energy costs. Depending on the size, tiny homes use only 10% of the lumber as a traditional home. The cost of a tiny home is comparable

to the down payment of a traditional single family home. A typical down payment on an average-sized house is \$72,000, whereas the cost of new construction for a 200 square foot tiny house can be as low as \$35,000. Socially the tiny lifestyle promotes a greater sense of community, more socio-economic accessibility, and the benefits of minimalism. This project takes all of these principles and applies them to examine the feasibility of implementing tiny homes within the Harrisonburg area.

OPTIMIZING CRISIS SHELTERS FOR GREATER ECONOMIC, ECOLOGICAL, AND SOCIAL VALUE

BS-ISAT
Environment

Presenter
Terry Swift, Jr.

Advisor
Dr. Steven Frysinger





Critical afflictions associated with disaster, war events, and poverty include the loss of basic necessities, namely shelter. For those seeking asylum or a secure place to sleep at night, being displaced from house and home carries a tremendous burden. In light of the current refugee crisis and outstanding global poverty rates, the need to shelter those less fortunate is inescapable and undisputable. The objective of this capstone is to design a modular crisis shelter for temporary housing of those in distress and evaluate different aspects of cost-effective “sustainable housing” in the scope of

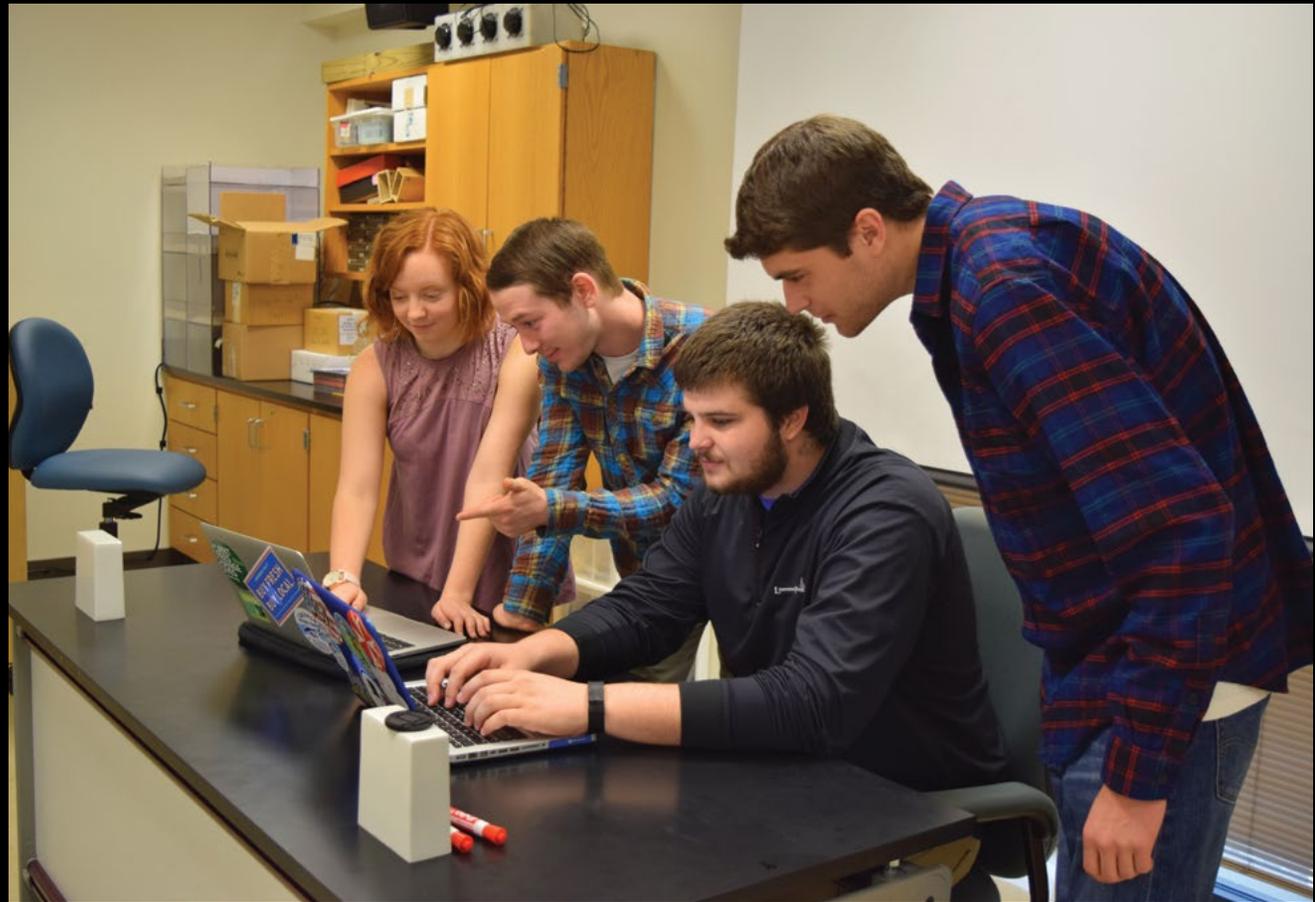
basic necessities. The criteria for sustainability acknowledged in this project include renewable energy resources, economic design, and social feasibility; these were investigated to create a structure that could be functionally integrated into governmental aid while encouraging environmental consciousness. Through research and analysis, appropriate technologies and design specifications have been adopted to produce a crisis shelter that offers the commodities of electricity, water-filtration, and ventilation as well as the basic necessities of security and protection for those without.

ENERGY AUDIT OF THE WOODROW WILSON PRESIDENTIAL LIBRARY AND MUSEUM IN STAUNTON, VIRGINIA

BS-ISAT
Energy,
Environment,
Information
and Knowledge
Management

Presenters
Patrick Francis
Nolan Johnston
Sam Menchel
Lindsay Proulx

Advisor
Mr. Paul Goodall





The Woodrow Wilson Presidential Library and Museum in Staunton, Virginia is one of the pillars of the Staunton community, providing history and education to city residents and visitors. The staff at Woodrow Wilson Museum felt strongly about reducing the museum's energy usage, utility expenses, and impact on the environment, while also developing material for community outreach and education. The staff reached out to James Madison University to inquire about students who may be interested in working with the museum to reach these goals. The JMU Woodrow Wilson Capstone team jumped

on the idea and launched a project to tackle the museum's goals. The goals of this project were to (i) perform an energy audit of the Woodrow Wilson Presidential Library and Museum in Staunton, VA, (ii) produce a report with the analyzed energy usage of all systems and recommendations on ways to increase the system's energy efficiency, (iii) implement these changes, as feasible, and (iv) relay these results to the community through means such as education programs. The Woodrow Wilson Capstone Team analyzed the lighting, HVAC, plug load, building envelope, and water systems at the museum complex using

a range of methodologies and technologies that were suitable to each of the five buildings. The information that the Woodrow Wilson Capstone Team was able to collect served as a way to qualitatively and quantitatively assess the systems at the museum complex and helped the team conduct a number of procedures, such as cost-benefit analysis, which led to appropriate recommendations for each system. The Woodrow Wilson Capstone Team hopes that the recommendations will ultimately improve the features in the museum, as well as properly demonstrate how improvements can be made to any residential or commercial building.

ENERGY POVERTY: SOS

BS-ISAT

Energy and
Environment

Presenters

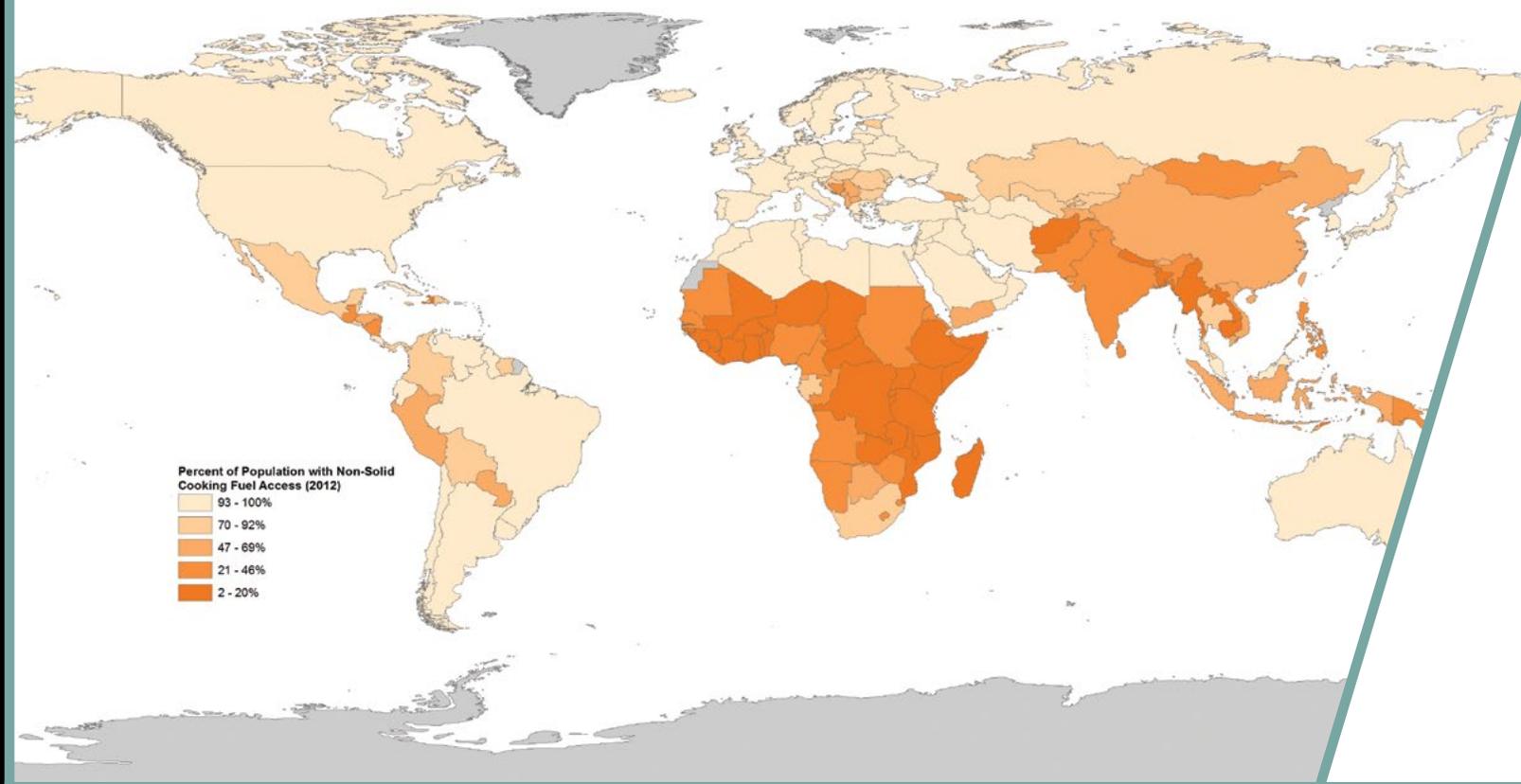
Kaitlin Tomlinson
Rachel Stukenborg

Advisors

Dr. Christie-Joy
Hartman
Dr. Maria Papadakis



Kaitlin Tomlinson and Rachel Stukenborg discuss one of their energy poverty lessons.



Data were obtained from the World Bank's Data Catalog, and a map showing access to non-solid fuels was created in ArcGIS.

The purpose of this project was to develop a set of university-level teaching and learning resources about energy poverty that incorporate a spherical display system, Science On a Sphere (SOS). Energy poverty, commonly understood as the lack of access to clean cooking fuels and electricity, is a complex problem that has detrimental health, economic, social, and environmental effects for both the people living in it and the global community. Furthermore, people living in energy poverty are trapped in a cycle of impoverishment because energy poverty interacts in a reinforcing feedback loop with global poverty. Individuals and societies suffering from energy poverty cannot escape it

on their own, and combatting the issue requires action from developed countries. The goal of this project was to increase awareness of energy poverty among university students, and SOS was incorporated to facilitate students visualizing differences in energy access and the resulting consequences on a global scale. This capstone contributes to the emergent use of spherical display systems for formal education by developing materials that facilitate use of SOS by faculty. Four separate lesson “packages” regarding energy poverty were created. The first three explore the nature and consequences of energy poverty and are presented on SOS, while the fourth delves into the social,

political, economic, and cultural dynamics of sustainable solutions and is taught after the SOS presentation. Each lesson package includes a background analysis, a comprehensive lesson plan, and supporting teaching and learning resources. The first three packages also include SOS “datasets” for select energy poverty indicators, such as access to non-solid fuels (% of population by country). Data were obtained from the World Bank's Data Catalog and the Center for International Earth Science Information Network. Maps were created in ArcGIS and exported as individual, static image files for SOS.

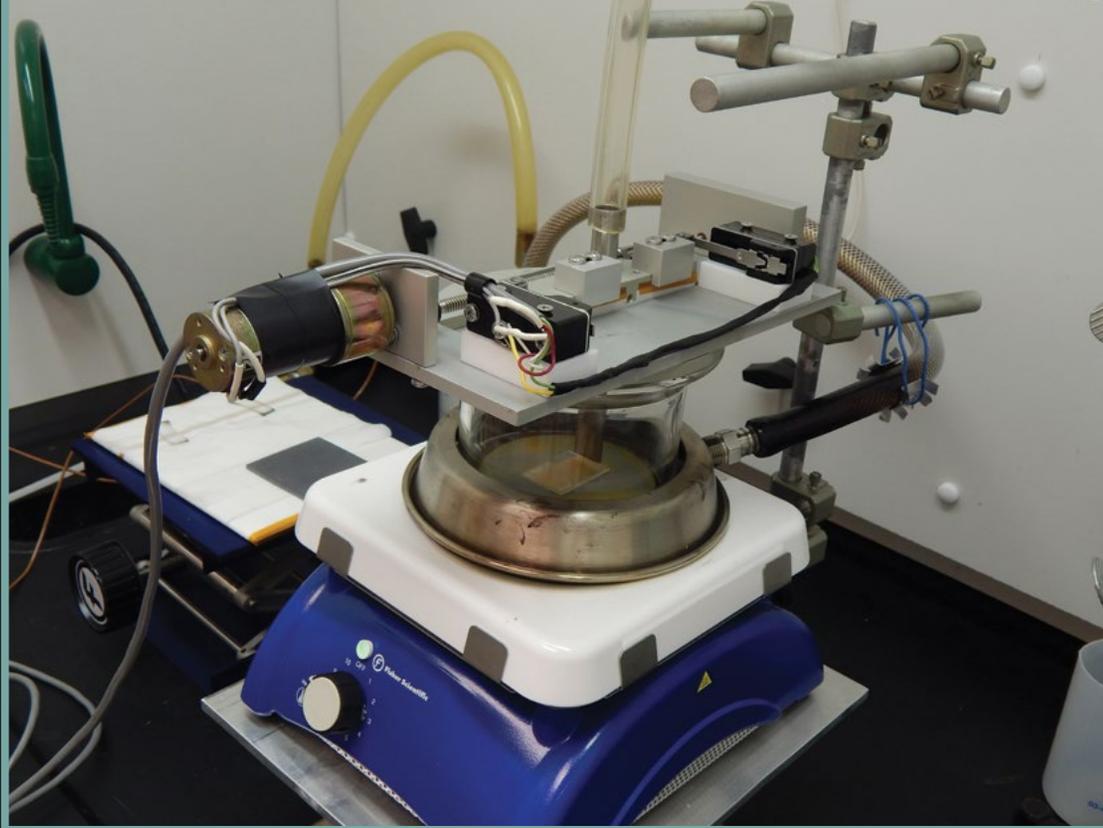
PHOTOVOLTAIC WATER SPLITTING FOR SUSTAINABLE HYDROGEN PRODUCTION

BS-ISAT
Energy,
Sustainable
Design and,
Renewable Energy

Presenters
Kyle Fakhoury
Anna Soyka

Advisor
Dr. David Lawrence





A spray pyrolysis technique is used to deposit a thin film of bismuth vanadate onto a substrate.

Increasing worldwide energy demand combined with the volatility of fossil fuel supply has called for a large scale increase of renewable energy production. One of the most promising renewable sources for electric power is solar energy from photovoltaics. However, solar energy is intermittent and lacks dispatchability. Various storage technologies are being developed in an effort to make solar energy more efficient and convenient. One way energy can be stored is with hydrogen gas. Through a process called electrolysis, water

can be split into O_2 and H_2 gases if an electric current of about 1.23 volts are applied. If the hydrogen gas is stored, it can be combined with atmospheric oxygen to reclaim the energy it took to split it initially. The purpose of this capstone project is to develop a device that can split water with sunlight, using Earth-abundant materials. In order to produce the required 1.23 volts, we are synthesizing a photovoltaic cell, made of Zn-doped GaAsP, combined with a photocatalyst, $BiVO_4$. In between the two photoanodes, we are also applying a layer

of SnO_2 to provide chemical protection as well as electrical conduction. In theory, our solar device will split water in the presence of sunlight, which is an imitation of the first step of photosynthesis. For this reason we refer to it as an artificial leaf.

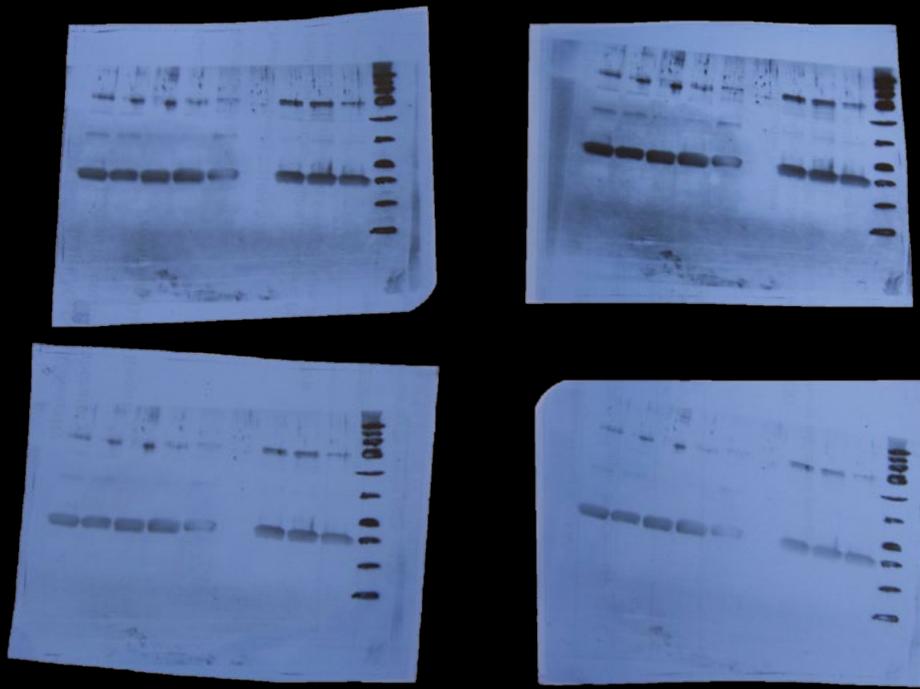
ANALYSIS OF STRUCTURAL STABILITY OF HUMAN PROSECRETORY MITOGEN LACRITIN BY CIRCULAR DICHROISM

BS-ISAT
Applied
Biotechnology

Presenters
Annie Desmarais
Casey Ramirez Cortes

Advisor
Dr. Robert McKown





Purpose: Lacritin is a human tear glycoprotein that has high thermal stability. Biological activities reside in the C-terminus amphipathic alpha helical region. The alpha helices contain three salt bridges; ionic bonds between neighboring oppositely charged amino acids. The purpose of this research is to investigate the hypothesis that the salt bridges within the alpha helices contribute to the high thermal stability.

Methods: Lacritin point mutants were prepared for each salt bridge by site directed mutagenesis that replaced the oppositely charged amino acids with serine. The point mutants were expressed in *E. coli* and purified. Protein concentrations and purity were determined

by BCA assay and SDS PAGE, respectively. Western blot analysis confirmed the identity of lacritin proteins. Circular dichroism (CD) was used to study conformational changes in the secondary structure of these mutants compared to two controls, Bovine Serum Albumin (BSA) and lysozyme, and unaltered lacritin. Data collected was analyzed with an alpha helix formula to determine the percent alpha helix structure at ten degree increments from 25-85°C, using poly-L-lysine as the standard.

Results: The mutated proteins reacted with lacritin specific antibodies in Western blot analysis. Under thermal denaturation conditions, the control proteins exhibited

significant decrease in alpha helical structure while the alpha helical structure of normal lacritin increased slightly. At 25°C the mutants had 12-25% less alpha helix than unaltered lacritin and increasing the temperature did not have a significant impact on alpha helix structure.

Conclusions: The salt bridges play a role in formation of the alpha helices but not in overall thermal stability of lacritin. This was shown by reduced percent alpha helix at 25°C for all salt bridge mutants and no significant structural change once temperature was increased.

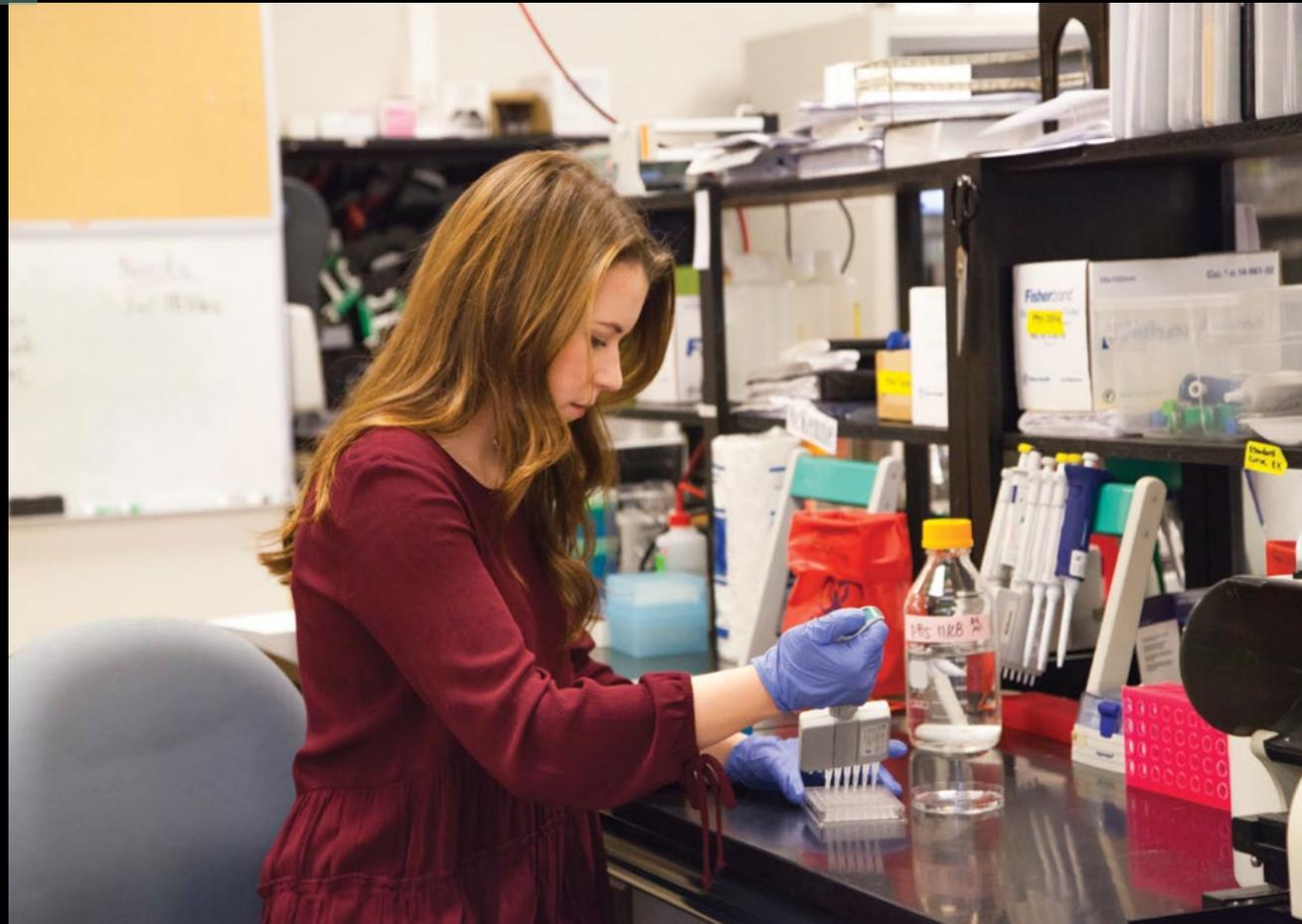
TOPICAL ADMINISTRATION OF LACRITIN PEPTIDE FOR THE TREATMENT OF CANINE KERATOCONJUNCTIVITIS SICCA

BS-ISAT
Applied
Biotechnology

Presenter
Eliza Gaylord

Advisor
Dr. Robert McKown

Sponsor
Dr. Julie Disney



Eliza Gaylord performing an enzyme-linked immunosorbent assay to detect protein concentrations in her samples.



An enzyme-linked immunosorbent assay standard curve used to find unknown concentrations of Lacritin protein in canine tear samples.

Keratoconjunctivitis sicca (KCS), also known as dry eye disease, causes a deficiency of tears in both humans and canines. Due to the lack of effective therapeutics for the treatment of dry eye disease, there is a market potential for a novel secretion enhancing factor. Lacritin, a naturally occurring tear glycoprotein, has demonstrated increased basal tearing in rabbits when topically applied to the ocular surface. This study aims to characterize Lacritin as a biomarker of dry eye disease and potential therapeutic for canines with KCS. A total of 46 canine tear samples, 24 normal and 22 diagnosed with KCS, were obtained through

a collaboration with the Virginia-Maryland College of Veterinarian Medicine and transported to James Madison University for analysis. After elution, a bicinchoninic acid assay (BCA) was used to determine total tear protein in the samples. An indirect enzyme-linked immunosorbent assay (ELISA) was then used to determine the total tear Lacritin concentration in each sample using previously cloned and purified canine Lacritin as a standard. Total tear protein of the samples was normalized and the proteins were separated using sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE). Western

blot analysis with canine Lacritin antibodies was used to visualize Lacritin proteins and densitometry was used to determine the amount of the active Lacritin monomer (~18 kDa) band present. This study demonstrated a correlation between reduced tear production in canines and reduced amounts of canine Lacritin present in tear samples as determined by both ELISA and western blot densitometry. Thus, canine Lacritin shows promise as a replacement therapeutic for the treatment of dry eye disease.

ESTABLISHING DISTRIBUTED WIND CAPACITY IN VIRGINIA

BS-ISAT

Energy,
Environment,
Social Context

Presenters

Nicholas Cooper
Julie Gentry
Patrick Landess
Emma Laurens

Advisor

Dr. Jonathan Miles

Sponsors

Ms. Remy Pangle
and Mr. Phil Sturm,
Center for Wind
Energy at James
Madison University





The 2014 Virginia Energy Plan set the goal of 25% for power generated in-state to be derived from renewable resources by 2025. Wind energy is one of the most abundant renewable energy resources in the state. The Virginia Department of Mines, Minerals and Energy seeks to incentivize both small-scale and commercial renewable energy projects. In light of government incentives, reduced costs, and technological advancements, the Center for Wind Energy (CWE) at James Madison

University established the Distributed Wind Assistance Program (DWAP) in 2015 which engages teams of faculty and undergraduate students and, to date, has identified four project sites through a rigorous application and scoring process. The potential sites that our group has analyzed in detail include Bradford Bay Farms, the Chesapeake Bay Foundation facility at Port Isobel, Fancy Gap Elementary School, and the Prince William County Landfill. Specifically, our

team provided technical support and conducted financial analyses; engaged in stakeholder engagement; and analyzed existing wind data, all to further advance distributed wind projects at these sites and to support wind development in Virginia.

NONDESTRUCTIVE TESTING OF WIND TURBINE BLADES USING THERMAL IMAGING

BS-ISAT

Applied
Biotechnology
and Energy

Presenters

Harold Barney
Michael Galford
Bahar Sayed
Aidan Williams

Advisor

Dr. Jonathan Miles

Sponsors

Albert Fisas and
George Hagerman,
Center for
Wind Energy





Offshore Wind offers great promise as a future renewable resource for the United States. Greater wind resources are located farther offshore. However, this resource presents inherently higher operation and maintenance costs. Our project aims to decrease these costs by developing a non-destructive inspection technique to identify blade erosion utilizing an infrared imager. Our technique is intended to identify wear on the blade by measuring temperature anomalies

associated with erosion on blades. A solar simulator was used to replicate the passive heating from the sun, thus as a blade is heated and cooled the eroded areas of the blade would emerge. The ANSYS engineering software package was used to model an eroded blade and simulate the impact of erosion on the aerodynamic behavior of the blade.

GEOGRAPHIC INFORMATION SYSTEMS AS A TEACHING TOOL FOR MIDDLE SCHOOL STUDENTS: LAND USE AND WATER QUALITY IN THE CHESAPEAKE BAY WATERSHED

BS-ISAT
Environment

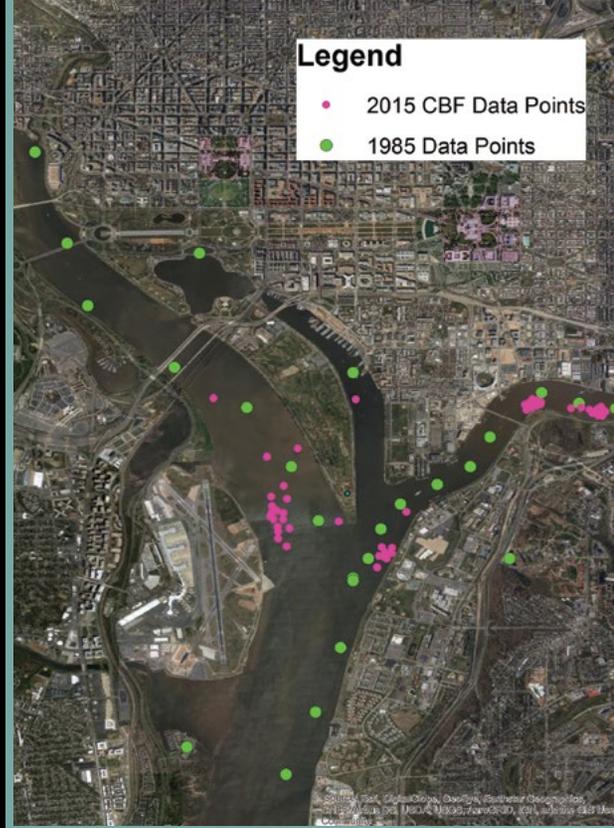
Presenters
Matthew Slater
Brandon Vidra

Advisor
Dr. Carole Nash

Sponsor
Chesapeake Bay
Foundation



Brandon and Matt hard at work in the Geographic Science lab analyzing land cover data and imagery of the Chesapeake Bay watershed.



The awareness of the importance of the Chesapeake Bay to the environmental and economic health of the Mid-Atlantic region is enhanced in K-12 students through web-based technologies that integrate environmental and place-based information. This capstone project, undertaken in partnership with the Chesapeake Bay Foundation (CBF), has two objectives tied to K-12 education: demonstrating, through geospatial technologies, how changes in land use over time impacts water quality; and creating a Middle School

curriculum unit, built on an ArcGIS platform, that provides teachers and students a case study on the effects of land use on water quality in specific locations within the Chesapeake Bay watershed. To do this, we worked with data sets from the USGS EarthExplorer (1985 and 2015) and correlated them with measurements of water quality from the Chesapeake Bay Foundation and Chesapeake Bay Data Hub. These measurements include levels of nitrogen, phosphorus, total suspended solids, and pH, as well as the turbidity and temperature of

the water. The learning unit we created for middle school students is tied to these data sets and the Standards of Learning for Grade 6 in Virginia and Maryland, including “Scientific Investigation, Reasoning, and Logic, Living Systems, Interrelationships in Earth, and Earth Resources.” The deliverable was enhanced with Guidance from the CBF and Rockingham County (Virginia) Public School staff, and research into best practices for teaching environmental science to middle school students with geospatial data.

80 STREAMBANK RESTORATION AT THE JMU FARM: MODELING AND BEST PRACTICES FOR STREAMBANK RESTORATION

BS-ISAT
Environment

Presenters
Grant Fabian
Sean Maher
Joshua Messick

Advisor
Dr. Carole Nash





The purpose of this project is to develop a restoration plan for the streambank at the James Madison University Farm through the use of low impact best management practices. The Farm property fronts the North River, and while a deciduous hardwood buffer is still in a section of the streambank, most of the native forest was removed post-1950. As a result, the riparian buffer zone was lost, contributing to the de-stabilization of the streambank. Previous capstone projects have highlighted the need for riparian restoration. This earlier

research, literature evaluation, and discussion with practitioners have allowed us to construct a remedial plan that includes techniques such as tree revetments, brush mattresses, and live stakes. One of the goals of our project is to determine the sections of the streambank most vulnerable to continued erosion and collapse and to recommend specific practices for those problem areas. 3D modeling with 123d Catch and Meshmixer were used to create simulations of the streambank in two locations. Among the areas needing the greatest attention is the

western end where the adjoining farmer's cattle have compressed the bank and denuded it. Two trees are rooted on the bank in this vicinity but are in danger of collapse. We are recommending a tree revetment to hold the trees in place and preserve the bank. Once this is completed, more plants can be added to restore the streambank and riparian buffer. A brush mattress and live stake arrangement are recommended for the area that has seen intensive foot and boat traffic from informal use as a boat launch.

82 STREAMBANK RESTORATION AT THE JMU FARM: LANDSCAPE DESIGN AND VIEWSHED PROTECTION

BS-ISAT

Environment

Presenters

Brielle Corry

Marissa Gross

Advisor

Dr. Carole Nash



Brielle and Marissa digitally compute a software model of their landscape design at the James Madison University Farm.



Model of a landscape design at the JMU Farm created using the software Realtime Landscaping Pro.

This capstone project includes the design of a landscape of native species for the James Madison University Farm streambank along the North River in Rockingham County, Virginia. The Farm, located approximately eleven miles east of the JMU campus, has been owned by JMU since 1929 and has seen changes in landscape use that have affected the integrity of the streambank. The riparian forest, much of which was in place through the 1950s, has been lost, subjecting the streambank to accelerated erosion. The focus of this design, which was completed with Realtime Landscaping Pro

(2016 version) and guidance from the staff of the Edith J. Carrier Arboretum, is directed to a small portion of the bank which can serve as a model for implementing native species plantings while preserving the historic viewshed from the 1850s brick house. This design not only improves the aesthetics of the property, but provides support for the stream bank. We have selected a variety of perennial grasses, plants and shrubs native to the region and whose root depth anchors them in minor flood events. Their mature height will enhance the viewshed and contribute to an increase in overall

biodiversity through habitat development. Over time, we hope the native landscape becomes vital to the JMU Farm and continues to assist the streambank in its recovery.

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STREAMBANK RESTORATION AT THE JMU FARM: STRUCTURE AND STABILITY

BS-ISAT
Energy and
Environment

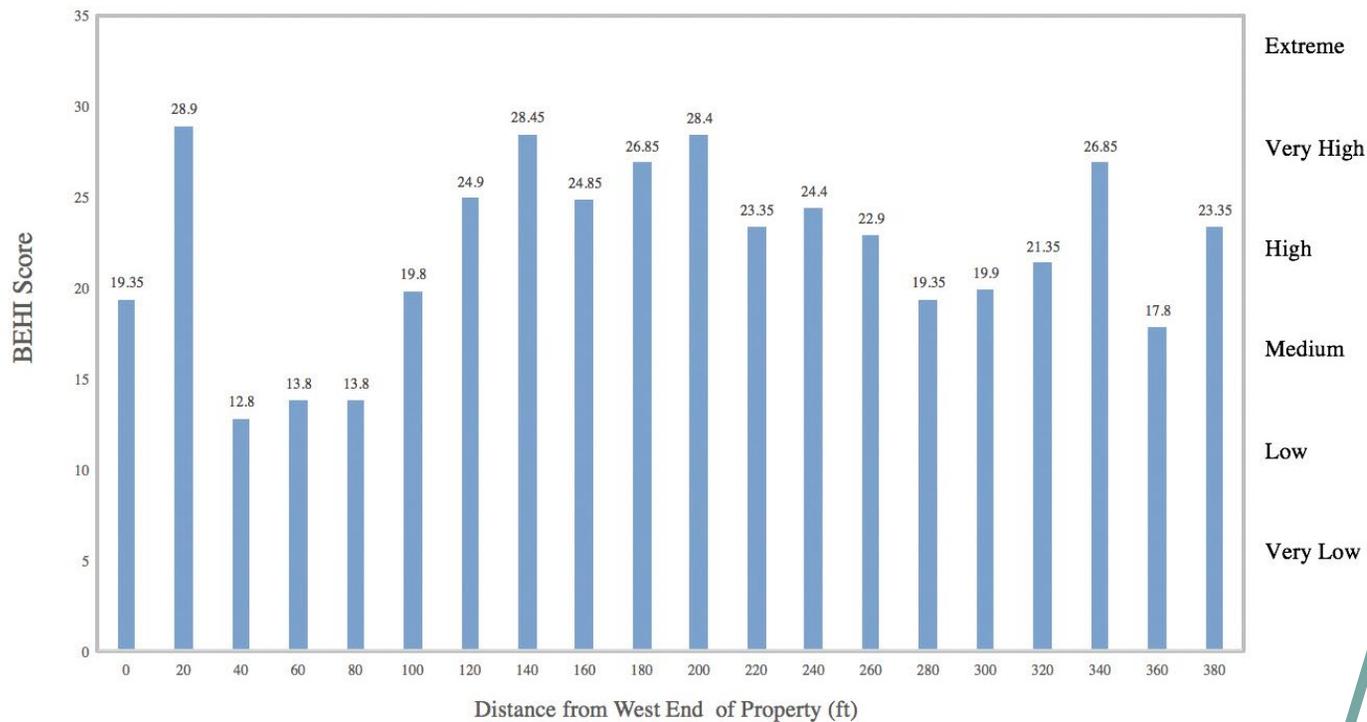
Presenters
Breanna Cordova
Madelynn Danhires

Advisor
Dr. Carole Nash



Madelynn Danhires (left) and Breanna Cordova (right) waded into the North River in order to assess stream bank vulnerability and determine stabilization techniques that will work given the current conditions at the James Madison University Farm.

BEHI Results- North River at the JMU Farm



This figure displays Bank Erosion Hazard Index (BEHI) scores calculated across the 400 feet of river front at the James Madison University Farm. Dividing the length of the bank into 20 foot intervals, this test was used to determine areas which are most vulnerable to erosion depending on exposed soil, lack of vegetation and steep slope gradient.

The James Madison University Farm near Port Republic, Virginia has 1,000 feet of frontage on the North River in Rockingham County, Virginia. Given its location, the property is subject to flooding during high precipitation events, and the destabilization of the streambank from the historic loss of vegetation cover has resulted in significant erosion. This capstone project is focused on understanding the structure of the bank: its soil composition, slope, vegetation cover, and vulnerability to erosion. Rosgen’s Bank Erosion Hazard Index (BEHI) was implemented to assess the severity of soil erosion along the bank, using a

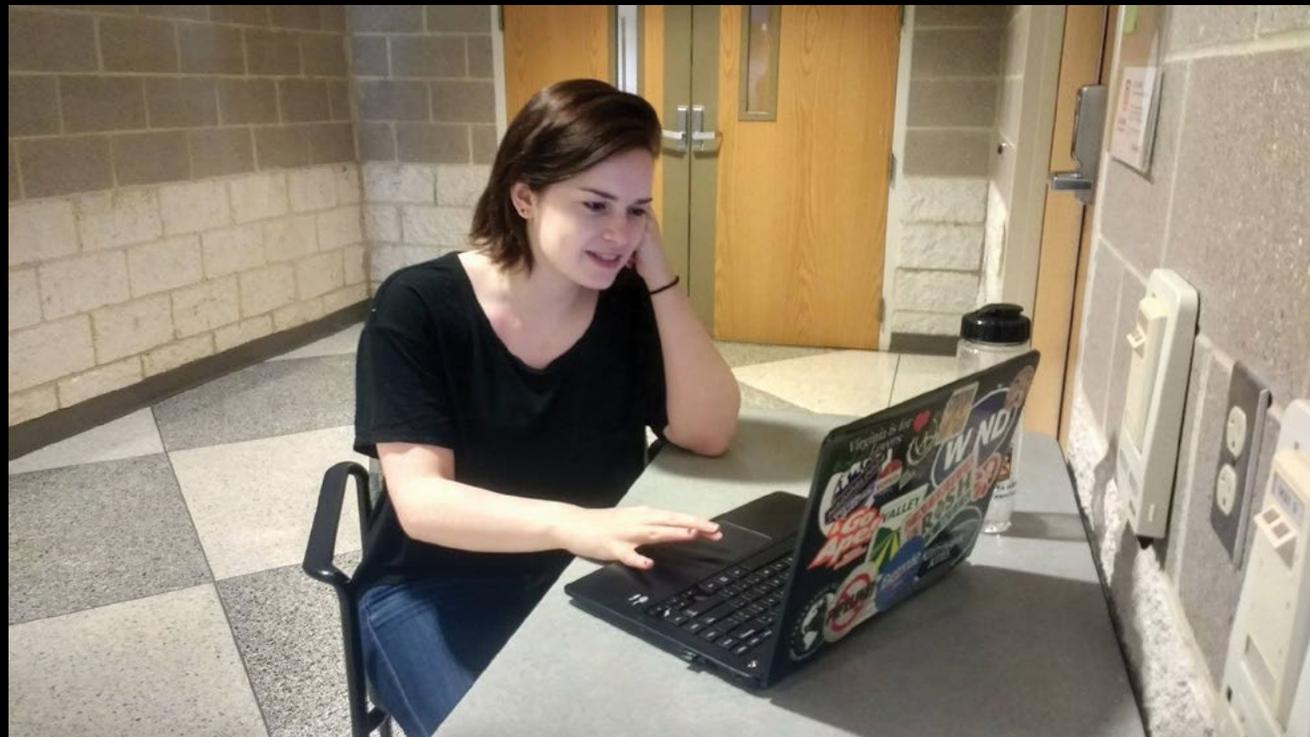
sampling interval of 20 feet. This assessment includes measurements of height, root depth to root height ratio, bank angle and percentages of both surface protection and root density. However, the BEHI does not account for soil cohesiveness, which can be a better immediate measure of vulnerability; therefore, a soil analysis was performed to measure composition, moisture content, and density of the soil. We combined these two methodologies to fully assess the stability of the bank, to determine best remediation/restoration practices, and to recommend leverage points where these should be implemented.

86 SCIENTIFIC COMMUNICATION AND THE WEB: A CASE STUDY OF THE JAMES MADISON UNIVERSITY FARM

BS-ISAT
Energy and
Environment

Presenter
Molly Bohan

Advisor
Dr. Carole Nash





This Pavilion located on the James Madison University farm is not only an example of the property's potential for recreational and educational use by JMU and the surrounding community, but also of one of the many features that necessitates information that is easily accessible to students, faculty, and the local populace.

The JMU Farm, a valuable piece of James Madison University's history, is also a useful setting for research and study. Though environmental research projects have been conducted on the property by JMU faculty and students, many of our current community members are unaware of the farm's history, uses, and importance for understanding the North River Valley landscape. To develop awareness of the property and facilitate future studies, this project designed a user-friendly web page as an example of scientific communication for the public, with a focus on

the potential of the Farm as a research setting. Done in tandem with the larger JMU Farm Streambank Restoration Capstone project, the web page functions as a clearinghouse of information about that project and others done in the past. It includes photographs (modern and historic), an informational video, specialized information on the North River's environmental health, links to agencies, and information sources for further study. The website was built with Dreamweaver software and will be maintained by JMU's Creative Services.

TRASH SEPARATION AND RECYCLING FACILITY: A FEASIBILITY STUDY

BS-ISAT
Energy

Presenter
Phillip Volz

Advisor
Dr. Carole Nash



Student PJ Volz conducting research on materials recovery facilities (MRF's).



A materials recovery facility (MRF) in Roanoke, Va in the first stages of separation.

The Shenandoah County Landfill in Virginia, like many landfills, disposes of municipal solid waste (MSW) through burial. A proposed trash separation and recycling facility, also known as a Materials Recovery Facility (MRF), has been proposed by entrepreneur Darryl Bates. This capstone is a feasibility study of the MRF, which will consist of a new building fit with a dual stream recycling system to separate recyclables from non-recyclables. One stream will be fit for household, retail and restaurant waste, and the other for construction waste, yard clippings, furniture and unrecyclable

plastics. The Shenandoah County landfill currently takes approximately 25,550 tons of MSW annually, and an estimated 24,000 tons could be recycled with the new system. The recyclables will be separated and sold, and the rest sent through a shredder to reduce the volume of the landfill. This feasibility study will outline the economic and environmental benefits of the proposed MRF system. The trash separation and recycling facility could result in more sustainable practices at the landfill and prove to be financially profitable.

IMPROVING OROGRAPHICALLY INDUCED SNOW FORECASTS IN ROCKINGHAM COUNTY

BS-ISAT

Environment
and Information
Knowledge
Management

Presenters

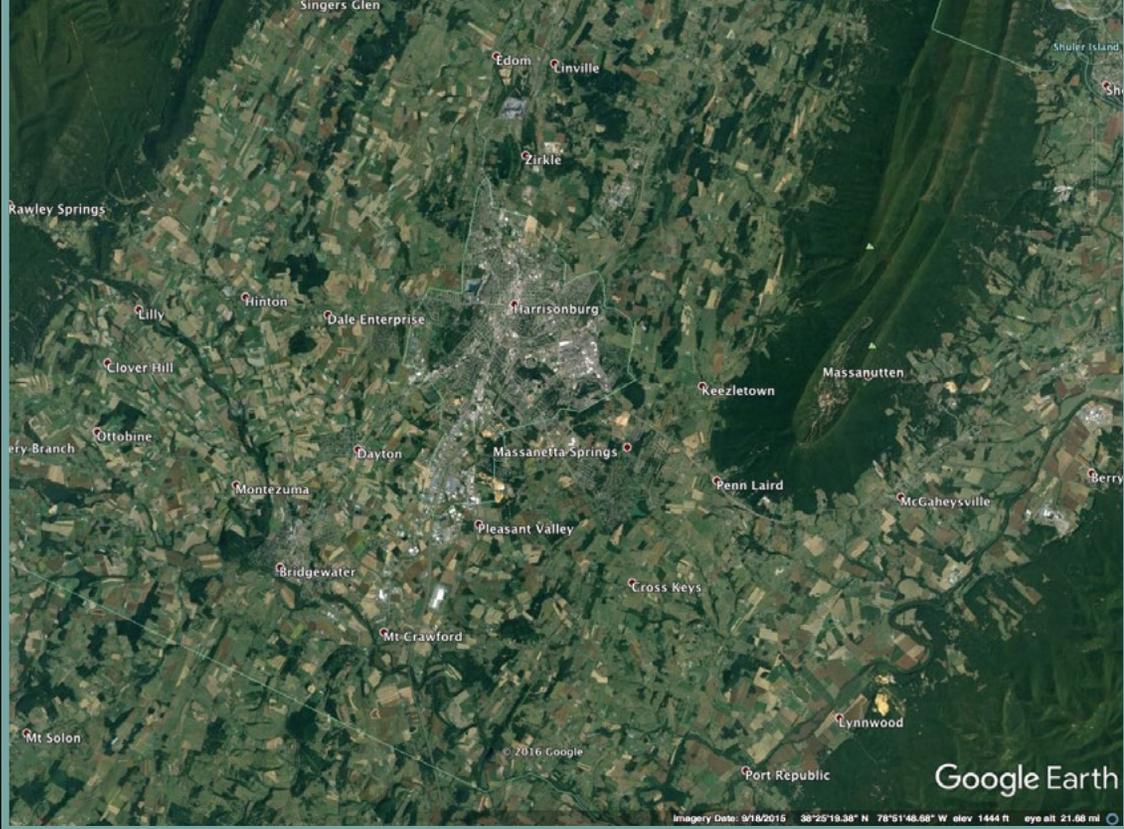
Shanna Bishop
Mikayla Kelley

Advisor

Dr. Nicole Radziwill



Capstone team observing past Harrisonburg winter weather conditions.



Rockingham County, VA is located in the Shenandoah Valley, between the Allegheny Mountains to the northwest and the Blue Ridge Mountains to the southeast. Because of the complex orography, it is difficult to accurately predict future weather events in Harrisonburg, particularly during the winter season. The goal of this study was to analyze past Harrisonburg winter weather data in order to improve winter precipitation type forecasting (freezing

rain, sleet, rain/snow mix, rain, snow). Using Weather Underground and the R Statistical Software, data for the past three winter seasons was collected. We explored and evaluated several prediction models to determine the onset and type of precipitation, including binary logistic regression, neural networks, and random forecasts. The results directly benefit JMU facilities, who use winter precipitation forecasts to decide when to close the university.

INVESTIGATION OF INDUSTRIAL HEMP FOR COMMERCIAL PRODUCTION IN VIRGINIA

BS-ISAT

Production Systems,
Energy and
Environment

Presenters

Nick Gentile
Evan Hylton
Justin Ngo

Advisors

Dr. Nicole Radziwill
Dr. Mike Renfroe



Students performing research and collecting data on industrial hemp.



Industrial hemp fully grown and ready for harvest.

Although the cultivation of *Cannabis sativa* was substantially halted in the United States with the Marihuana Tax Act of 1937, Canada reintroduced licenses for industrial hemp research and commercial production by the mid 1990's. This led to a resurgence of interest in exploring the potential for this industry across North America, and by 2016, permits were granted to grow industrial hemp in Virginia. The ultimate goal of this project is to explore the agricultural feasibility of growing industrial hemp on small and medium-sized

farms in Virginia, and integrating small-farm production with a potential supply chain for three key products: hemp fiber, hemp seed for livestock feed and human consumption, and hemp oil for biofuel. This phase of the project focused specifically on determining crop characteristics and yield. In May 2016, we planted industrial hemp on two ten-acre fields, one at Rodes Farm (Grottoes, VA) and the other at Walden Farm (Afton, VA). Each farm has unique soil characteristics and microclimate. In August 2016, the seeds and stalks were

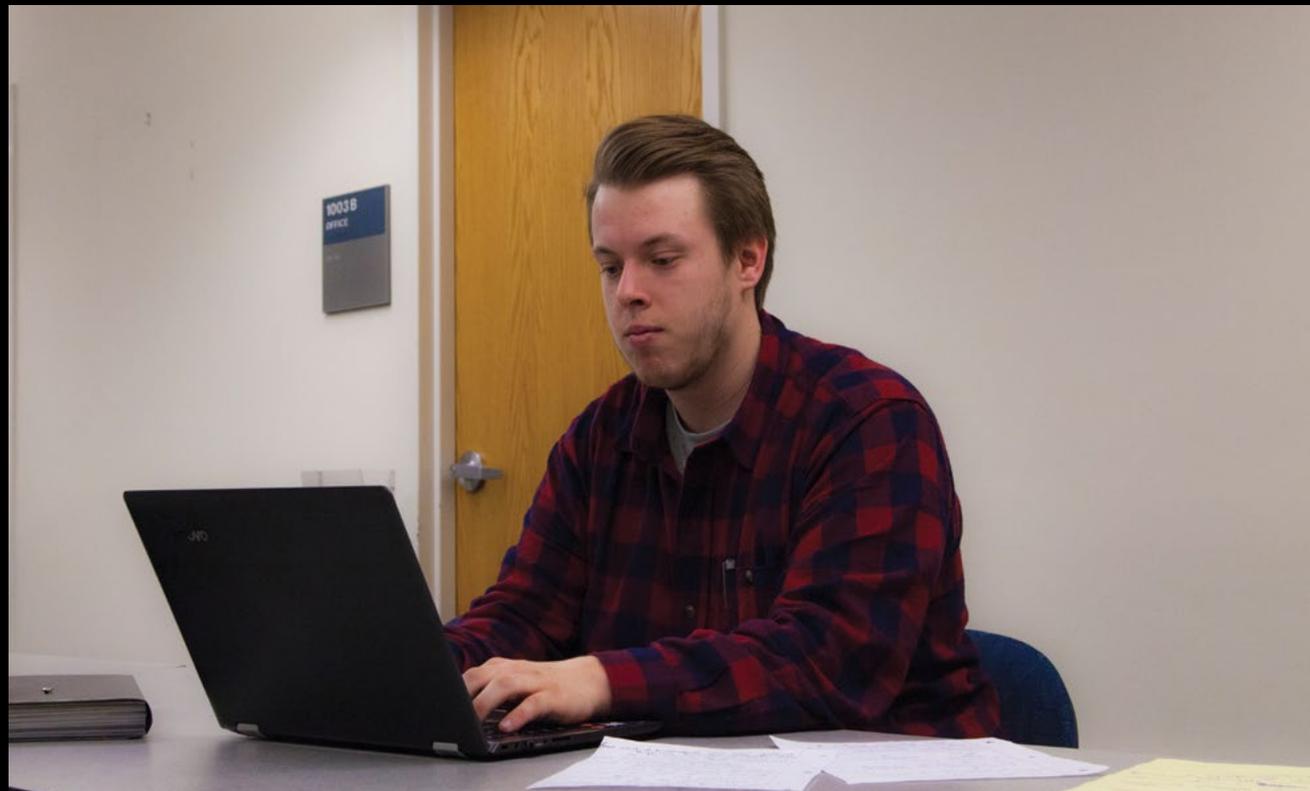
harvested. Seed weight, total number of seeds, total number of plants, stalk length, and stalk diameter were captured after harvest to measure crop characteristics and yield. We examined the differences in crop characteristics and yield based on farm and fertility levels, and explored strengths and weaknesses of the experimental design used in 2016 to recommend new strategies for planting in 2017.

LATENT DIRICHLET ANALYSIS (TOPIC MODELING) OF INDUSTRIAL HEMP IN PRODUCT DESCRIPTIONS, ACADEMIC ARTICLES, AND LEGISLATIVE COMMUNICATIONS

**Information
& Knowledge
Management**

Presenter
Benjamin Steen

Advisor
Dr. Nicole Radziwill



Benjamin Steen uses R to analyze public, academic, and legislative industrial hemp documents in order to determine the predominant themes in each group of literature.



One of four public institutions in Virginia authorized by the Virginia Department of Agriculture and Consumer Services (VDACS), James Madison University students conducted research with licensed local farmers to determine how effectively industrial hemp can be grown in the Shenandoah Valley using conventional farming equipment.

Industrial hemp is a versatile resource crop that has been grown all over the world for thousands of years, but until recently, it has been illegal in the United States. Due to prolonged prohibition, stakeholder attitudes about hemp farming vary significantly. This project explores conceptual themes in products, academic literature, and the legal and regulatory environment regarding industrial

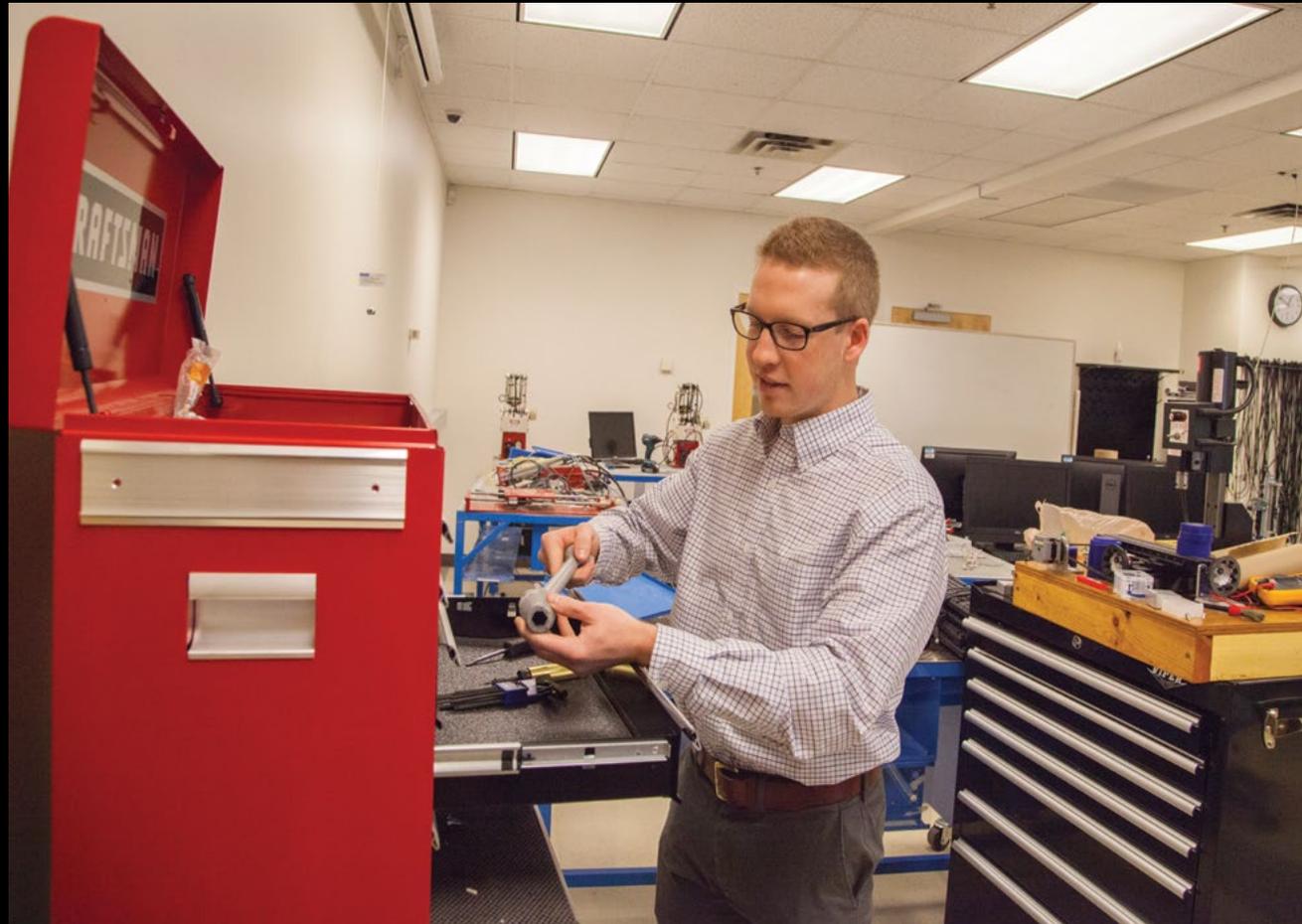
hemp to better understand the assumptions held by different stakeholder groups. This was done using Latent Dirichlet Analysis (Topic Modeling) in the R Statistical Software. Topic models for each category were generated and used to inform a literature review exploring the social, economic, and political dimensions of the emerging industrial hemp industry.

IOT SENSORY TUBE: PROTOTYPE TO PRODUCTION

BS-ISAT
Production Systems

Presenter
Christopher Bell

Advisors
Dr. Nicole Radziwill
Dr. Rebecca
Simmons



Christopher Bell utilizing the Production Systems lab and work space to further improve prototype base designs.



Sensory technology is being introduced in schools, specialty centers, and homes to alleviate the sensory challenges that often accompany autism.

According to the CDC, up to 1 in 68 people have physical or cognitive characteristics that place them on the autism spectrum. To mitigate the sensory challenges that often accompany autism, sensory technology is being introduced in schools, specialty centers, and homes. Although this includes haptic interfaces, brain-computer interfaces, and affective computing, participative art and “sensory rooms” are emerging as a market niche. Most components of sensory rooms, however, are prohibitively

expensive. The purpose of this project is to make one component of these sensory rooms, an IoT-enabled sensory tube, more accessible to potential customers by significantly reducing the production cost. This is done by applying various techniques from affective design, DFMA (Design for Manufacturing and Assembly), and supply chain management.

REDUCING THE COSTS AND ENVIRONMENTAL IMPACT OF JMU ON-CAMPUS SALT TREATMENTS PRIOR TO SNOWSTORMS

BS-ISAT

Production Systems

Presenter

Yusra Wahbah

Advisor

Dr. Nicole Radziwill



Yusra Wahbah is analyzing data from the past winter weather conditions to reduce the costs and environmental impact of JMU on-campus salt treatments prior to snowstorms.



The application of salt on roads is a common strategy that is used to manage ice during the winter. However, this practice can be extremely harmful to the environment. At JMU, salt is one of the ice management strategies that is available. However, this practice threatens the surrounding ecosystem in the JMU community. The proposed project is to explore the economic and environmental sustainability of the use of salt treatment and the available options. The

project will be based on cost-benefit analysis with the aim of assisting the campus to adopt alternative and cost-effective ways of managing ice during winter. The proposed project will provide alternatives that can be employed to strike a balance between the costs of keeping JMU open, and negative environmental consequences. As such, the project will use cost as the primary metric. The objective will be to assist the institution to reduce the costs.

1000 WEATHER VARIABILITY IN THE SHENANDOAH VALLEY: A STUDY TO SUPPORT THE INDUSTRIAL HEMP INDUSTRY

BS-ISAT
Environment

Presenter
Taylor Koontz

Advisor
Dr. Nicole Radziwill

Sponsor
Rodes and
Walden Industrial
Hemp Farms



After harvesting the hemp by hand we all came back to the lab to count and weigh the hemp seeds. Some of the seeds were what we referred to as “pops” due to the fact that the seeds were either dead, only containing the outer shell, or not fully matured yet and would consequently pop when squeezed. In this picture Dr. Renfroe and I were sorting through the seeds and finding the pops so we could be sure to not include them in our final seed counts and weights.



The Rodes farm hemp had a higher yield than the hemp at the Walden farm. This picture shows how tall the Rodes farm hemp grew to be and how plentiful the hemp plants were in this field.

The Commonwealth of Virginia is trying to decide whether legalizing industrial hemp would be a good policy decision. As a result, they are allowing JMU to plant hemp and conduct research on the crop and biofuel yields. Because weather influences plant growth during the growing season, we need to understand weather variability (particularly temperatures, precipitation, and humidity) in

the local area. This project takes the first step towards characterizing the microclimate of the Shenandoah Valley, with the ultimate goal of understanding what weather conditions (and farm locations) best support high hemp yields.

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ACCESS CONTROL AND VDI FOR A PRIVATE CLOUD

BS-ISAT

Telecommunication,
Networking
and, Security.
Biotechnology

Presenters

Joseph Dodd
Thomas Shaffer

Advisor

Dr. Emil Salib



Tom and Joseph hard at work troubleshooting for errors in configuration and administration files.



The capstone team's setup of their private computing "stack" on which they configured a cloud service called OpenStack.

Many students at James Madison University require access to certain computing resources in order to complete their assignments. Quite often, the access and availability to these resources at James Madison University is strictly limited to the campus boundaries and workstations that provide these resources. This issue was addressed in the past using vSphere and Horizon View suite. However, we found access to the VMware product and support are prohibitive. Also, it appears to be always lagging when it comes to new functionality and their level of maintenance is rather limited and inflexible.

In this project, we are seeking to implement OpenStack, an open source platform, as a flexible and cost-effective alternative.

OpenStack is a cloud operating system designed to control large pools of both computing and networking resources through a datacenter. It can be managed through a dashboard that gives administrators centralized control while also empowering users to be able to provision resources through OpenStack's virtual network computing (VNC) user interface. The focus of the project is to prove that OpenStack is a viable alternative by integrating it with (a) Windows 2012 Active Directory (AD) for resource access control and authentication, (b) a VDI platform, such as Leostream (Connection Broker) and (c) client resources redirection and pass-through. We will perform a number of pilot studies with the participation of interested students in order to identify the next set of challenges towards a fully operational solution.

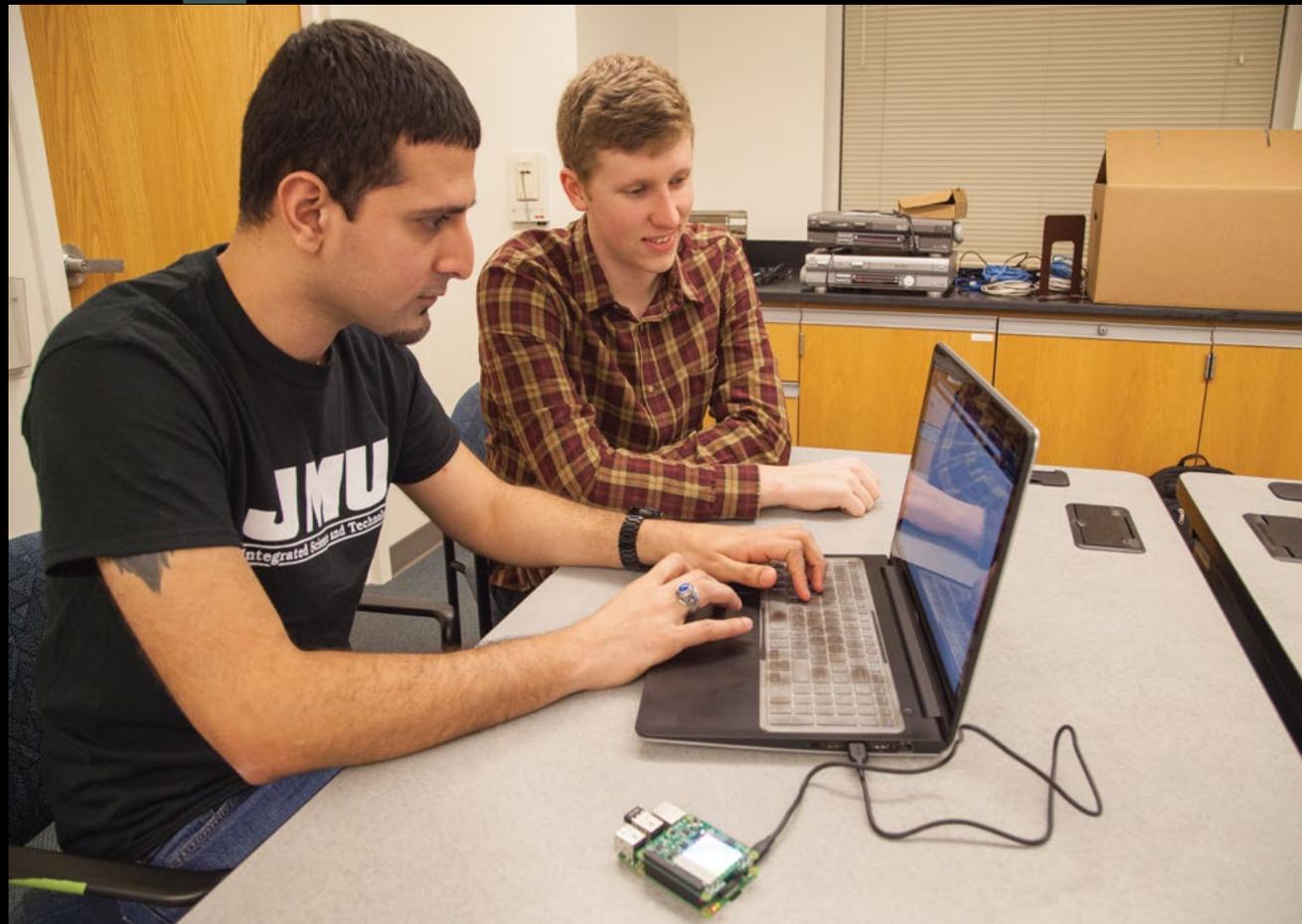
We will deliver a working prototype of OpenStack integrated with Windows AD for user access control and the Leostream connection broker which supports VDI access services including resource redirection and pass-through. We will then present the results of our pilot studies and next steps for future development in order to have full integration with JMU's Active Directory

CYBER-PHYSICAL SYSTEMS: AN INVESTIGATION OF SECURITY IN THE INTERNET OF THINGS

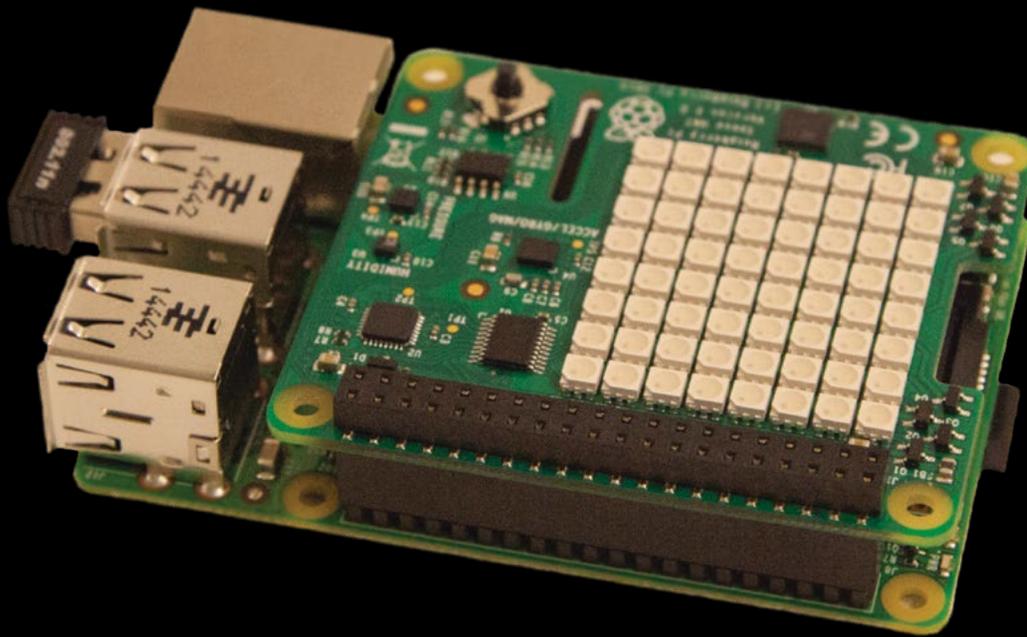
BS-ISAT
Information
and Knowledge
Management,
Telecommunications
Networking
and Security

Presenters
Kadar Anwar
Devon Richards

Advisor
Dr. Emil Salib



Devon and Kadar prepare their device's sensor for testing.



'Smart' devices such as smart refrigerators, thermostats, etc. are becoming more and more prevalent as innovative ideas, such as the Internet of Things (IoT), are transformed into appealing products and online services to consumers and businesses. A popular example is Amazon's IoT platform, which illustrates how IoT architecture and protocols are applied in vital modern day big data applications such as The Weather Channel. A major concern is that the IoT community does not have a security standard that is specific to its components (services, devices, etc.) If IoT follows the current growing trend of adoption, we could soon have a massively insecure network of IoT devices being used in sensitive applications, such as controlling the U.S. power grid and households across the US.

The focus of this project is to provide an easy to use penetration testing approach and environment focusing on evaluating known and potential unknown security vulnerabilities of IoT services, devices and platform implementation. By creating our own IoT platform from the ground up, we were able to better determine the challenges of not only implementing IoT services, but securing them as well. Our project utilizes this custom-built IoT platform in order to facilitate real-time communication between "smart" IoT devices and a user-friendly web interface. Our platform is customizable and is used to test known vulnerabilities and security issues related specifically to IoT services, data sources, devices and protocols.

The results of our penetration and vulnerabilities testing of the custom built IoT platform will be presented and a number of different test cases will be demonstrated in detail. We will also provide a complete virtual machine-based package for interested students to be able to practice IoT penetration testing and develop their own test cases.

SOFTWARE-DEFINED NETWORKING

BS-ISAT

Information
and Knowledge
Management,
Telecommunications
Networking
and Security

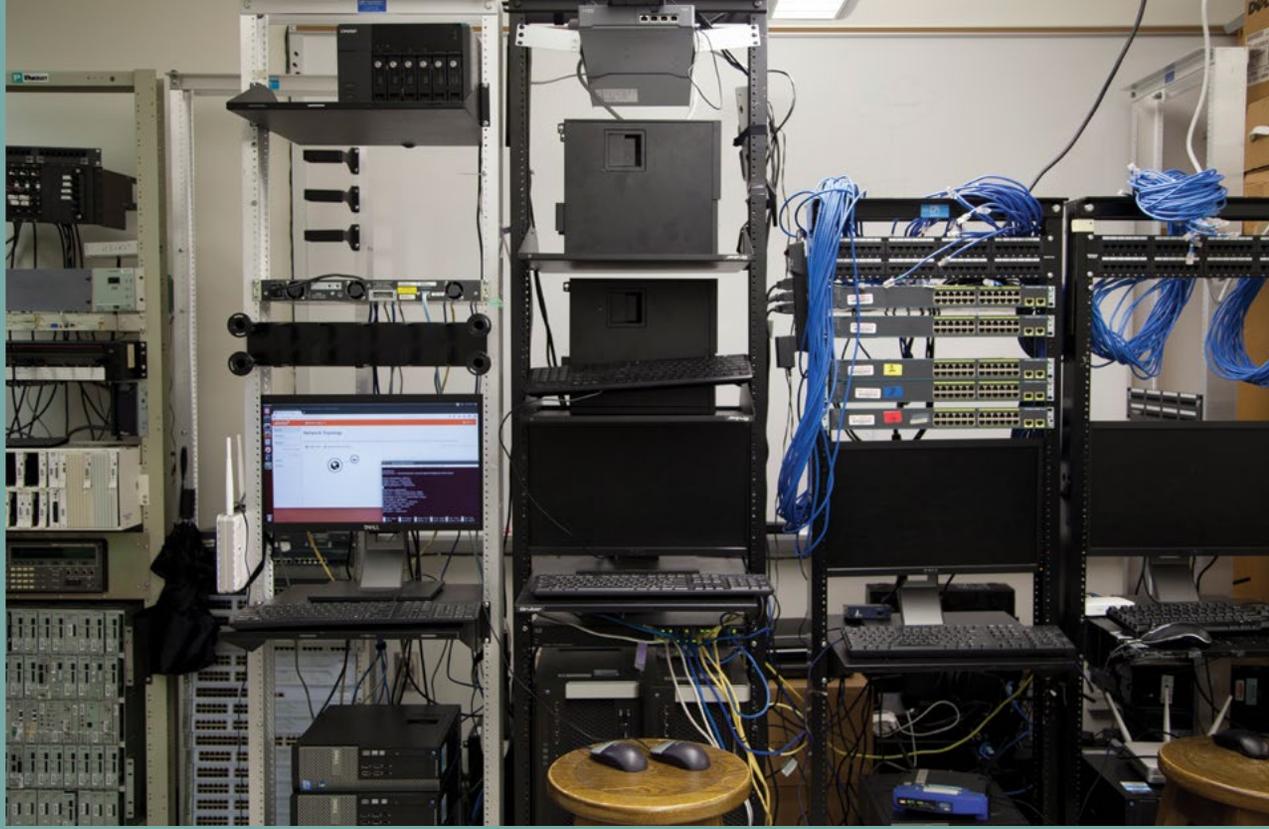
Presenters

J.D. Lester
Josie Salcedo

Advisor

Dr. Emil Salib





Software-Defined Networking (SDN) is a new networking paradigm that has gained significant attention recently within the networking community. SDN was developed by researchers to control the switching hardware used in packet switches through open interfaces. Because of the momentum the SDN implementation has recently scored, our goal is to develop hands-on understanding of SDN as a whole in an effort to demonstrate its architecture, functionality, use cases and evaluate its security at an undergraduate level.

In order to achieve the objectives of our project, we identified a number of SDN related

components. We used them to develop a platform that can be adopted by teachers and students in the process of mastering SDN. First, we selected OpenDaylight as the SDN controller, OpenFlow as the interface to the data plane, Open vSwitch as the virtual switch that supports the OpenFlow protocol, and Mininet to rapidly create the network topology. Second, we evaluated different northbound interfaces and determined their strengths and weaknesses. Third, we used the DELTA SDN security evaluation framework to perform penetration testing on known SDN architecture and specific security vulnerabilities at the data plane and controller levels.

We will deliver two complete hands-on working demos. The first is to demonstrate how SDN makes network management easier by orchestrating network services using well-defined, high level interfaces. The second is to demonstrate how DELTA is used for SDN penetration testing of known or controlled vulnerabilities. Also, we will deliver a set of virtual machines already configured for working SDN and DELTA environment so that educators and students can start learning about SDN without the labor-intensive navigation of configuring their own working environments.

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OPEN-SOURCE EXOSKELETON

BS-ISAT

Production Systems,
Environment
and Social Context

Presenters

Benjamin Baker
Scott Utterback

Advisors

Mr. Mark Showalter
Dr. Jonathan Spindel





Despite its recent prominence in video games, television, and movies, assistive exoskeleton technology is still out of reach for most people. Assistive exoskeletons have many benefits, including increased strength, endurance, and restoring user mobility. However, current exoskeletons are under development and prohibitively expensive. Our goal was to create an upper body frame with bicep assistance. Inexpensive and easy to manufacture, our DIY design is accessible to a wider group of individuals. Our approach to this was the

development of an open-source prototype made with easily acquirable tools and materials. In order to achieve this we researched several types of actuators and chose the McKibben pneumatic actuator due to its low cost and ease of construction. Tests of our actuators evaluated the impact of operating pressure on displacement and force. We developed several prototypes and created a website as a means to share our progress, and foster interest in a rapidly growing field.

DEVELOPMENT OF A COMPREHENSIVE STRATEGIC GUIDE FOR YOUNG ADULTS WITH ACUTE LYMPHOBLASTIC LEUKEMIA

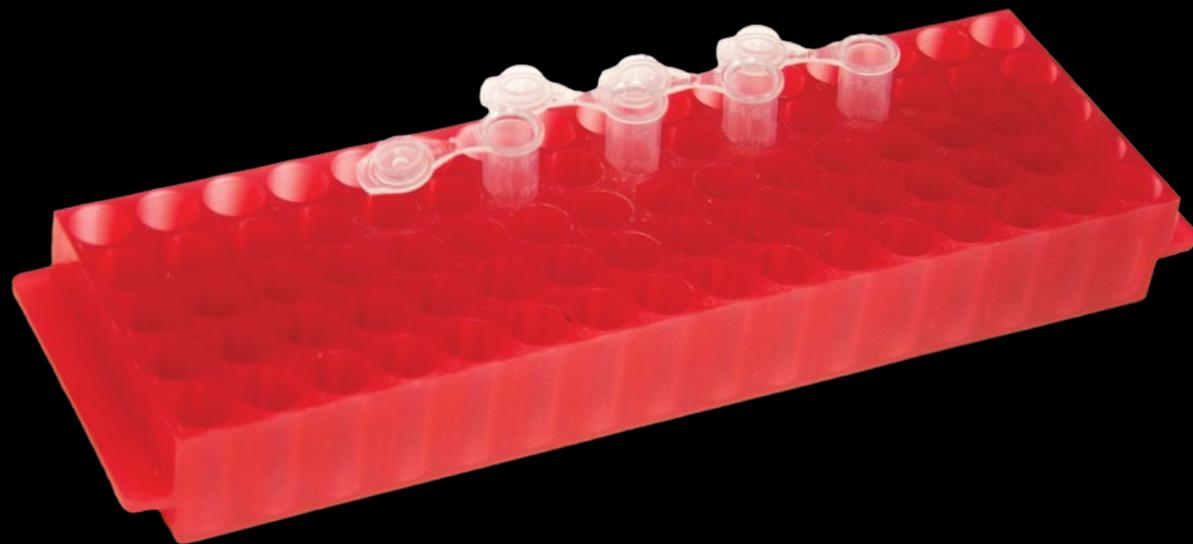
BS-ISAT
Biotechnology

Presenter
Zachary Yorio

Advisor
Dr. Stephanie
Stockwell



Zachary investigating treatment protocols for acute lymphoblastic leukemia.



PCR test tubes used in cancer diagnostics and research.

Acute Lymphoblastic Leukemia (ALL) is commonly considered a childhood disease, having a comparatively good prognosis with survival rates close to 90% (Rizzari et. al). However, for the few thousand adolescents and young adults (AYA) diagnosed each year in the United States, the overall survival rate drops down to as low as 46% (Muffly et. al). A major reason for this discrepancy is that most young adults are treated on an adult chemotherapy regimen versus a more disciplined and intense pediatric inspired protocol. Some studies have shown as much as a 30% increase in overall survival rates for AYAs who receive modified pediatric treatment (Muffly et. al).

Unfortunately, many adult oncologists are unaware of the treatment options available for younger patients under their care because these findings are recent and not well publicized. In an effort to improve the survival rate of AYA with ALL, I have created a guide for the leukemia community focused on actively pursuing the best course of personalized ALL treatment for AYA patients and providing first-hand insight into navigating the tumultuous months of intensive chemotherapy. Sections of this guide include: common chemotherapy drugs and their mechanisms of action, nausea management and hydration, chemo-induced fatigue and practical exercises, healthy

eating throughout chemotherapy phases, and community support for patients during treatment. Compiling information from current scientific literature, specialized healthcare professionals, patient interviews, and life experiences as an ALL patient, this guide will bridge an audience gap within the current publications. This guide aims to empower AYAs to have informed dialogues with their physicians and feel engaged in the decisions concerning their treatment plan, as studies have shown the positive impact that patient activation and engagement has on health outcomes and medical care experiences.

HIKR.DB – CROWDSOURCING OF HIKING TRAIL DATA THROUGH MOBILE APPLICATIONS

BS-ISAT

Information
and Knowledge
Management,
Telecommunications
Networking
and Security

Presenters

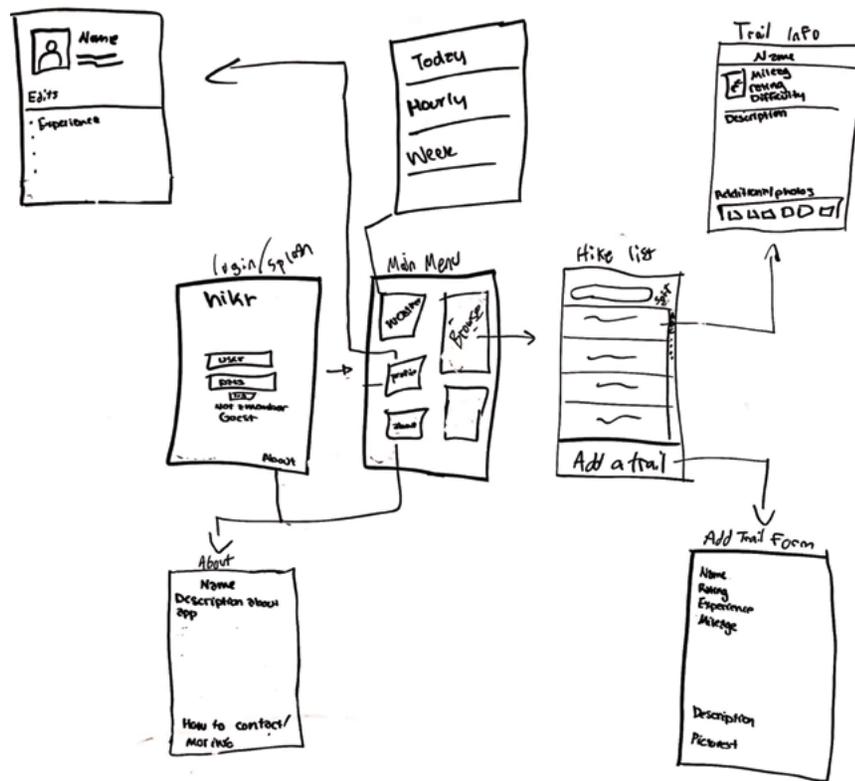
Brian Elliott
Victoria Wilson

Advisor

Dr. Anthony Teate



Brian Elliott and Victoria Wilson programming and testing their hiking application HIKR.DB.



Wireframing and planning of android mobile application.

Mobile applications that provide dynamically updated information have been on the forefront of the technology craze. Bringing together current information that is accessible anywhere at anytime has been demanded by customers worldwide for years. The goal of this project is to allow users to have access to up-to-date information on hiking trails in and around the Shenandoah Valley, as well as the ability to submit information about the trails to inform other hikers. In order to achieve this goal we are developing, designing, and deploying an Android and web application to

access a database we developed called Hikr. db to support users across the Valley. We first created an API using the Loopback framework in conjunction with a MySQL database backend that is hosted on an Amazon EC2 server running the Ubuntu Server OS. We used this API to connect our front end applications to our backend database in order to transfer data between our applications in a safe and clean manner. Our web app front end application was built using the AngularJS framework, and taking advantage of the Loopback SDK to make easy data transactions with our API.

For the mobile app, we made use of Android Studio to create a functional user interface to display and post information to our database. Android Studio is a complete IDE that uses the Java programming language for development along with XML to create the user interface and to implement the functionality of the app. We were able to successfully get information from the database and display it to the user in a readable manner and post information back to the database through the use of APIs with web and android applications.

HOME ENERGY AUDIT APPLICATION FOR ANDROID DEVICES

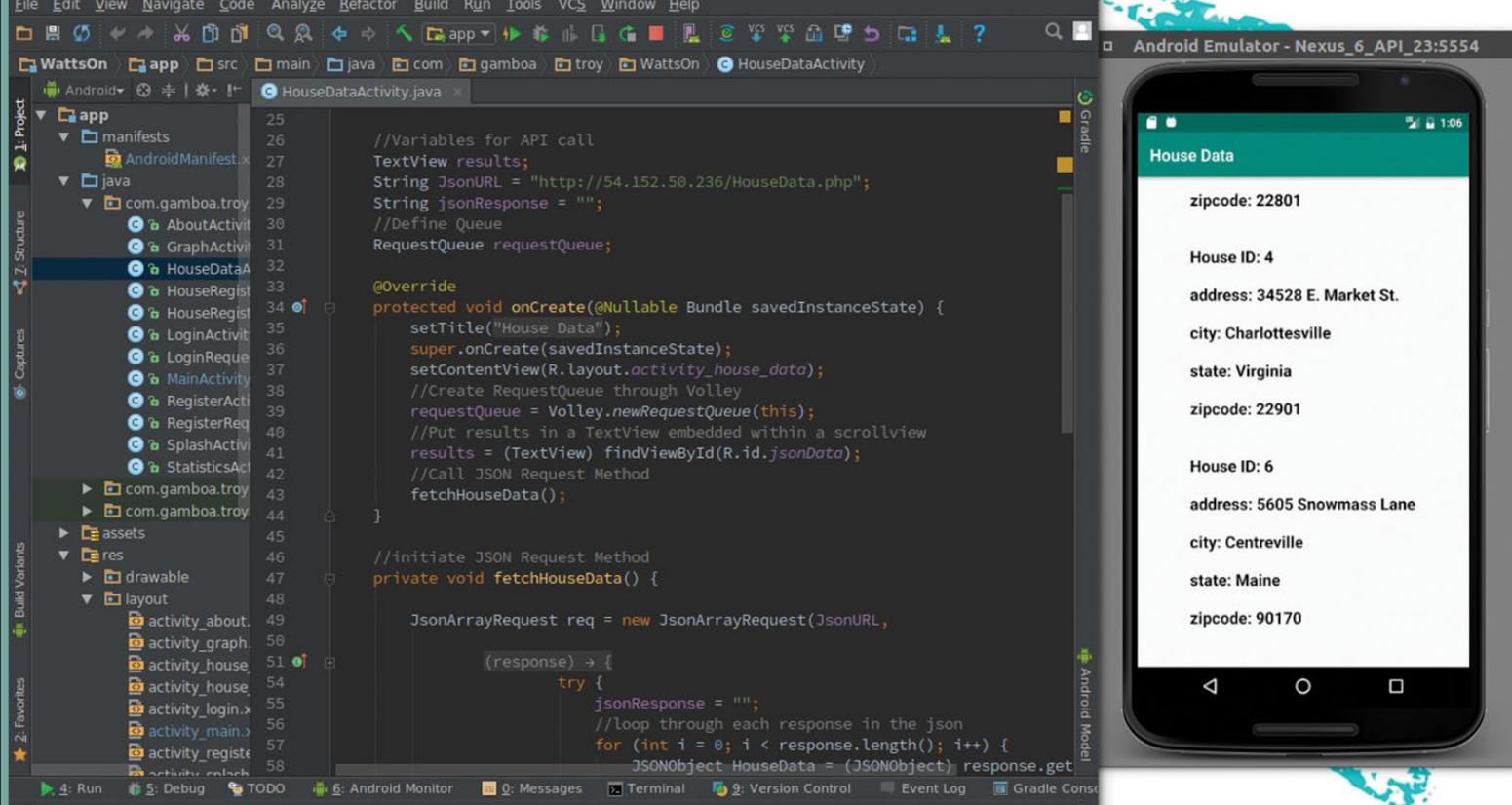
BS-ISAT
Energy,
Environment,
Information
and Knowledge
Management,
Telecommunication
Networking
and Security

Presenters
Troy Gamboa
Jacob Hagen
Julian Hermes
Bryan Potter

Advisor
Dr. Anthony Teate



Developing the Android app to connect to the home energy audit database.



Our application returns different options of alternative energy efficient appliances based on the user's current appliances and multiple factors, such as power draw. The figure shows an example of a user viewing the house data that they have registered. The data shown represents our API connected to our cloud database.

Energy consumption in the United States is not the most conscientious habit for much of our nation, but this is something that affects our daily lives and should not be taken lightly. If everyone in the city of Harrisonburg was able to acquire convenient and simple alternatives to energy monitoring on their own, we as a whole could see drastic drops in prices of energy bills. This is precisely what our project sought to accomplish. By combining a knowledge of energy and computer programming in Android Studio, we were able to create a mobile application for home energy audits. This project was designed to provide ordinary families with no energy experience whatsoever

with an easy to use application on their mobile device in order to effectively cut back on energy prices around the home. By simplifying the calculations of energy use, managing an energy budget in a standard American home is far more effective and convenient than hiring an outside source.

Prior to the creation of our mobile application, preliminary research was conducted to ensure we had the best possible accuracy when determining the energy consumption of our city to average costs as a whole. Once a better understanding of those factors was obtained, we moved onto the actual development stages.

Using a MySQL database (hosted on an Amazon server) consisting of appliances with their respective power draws, an Apache web server hosting this information was linked to our final application. The application would display a section where users can select from a list of appliances based upon brand, power consumption, and price. Then, the user would be able to determine an alternative and efficient appliance that would be suitable to their needs. It is our hope to provide our community a no-cost method to save money and energy with this application.

MACHINE LEARNING AND OBJECT RECOGNITION FOR AUTONOMOUS VEHICLES

BS-ISAT

Information
and Knowledge
Management

Presenter

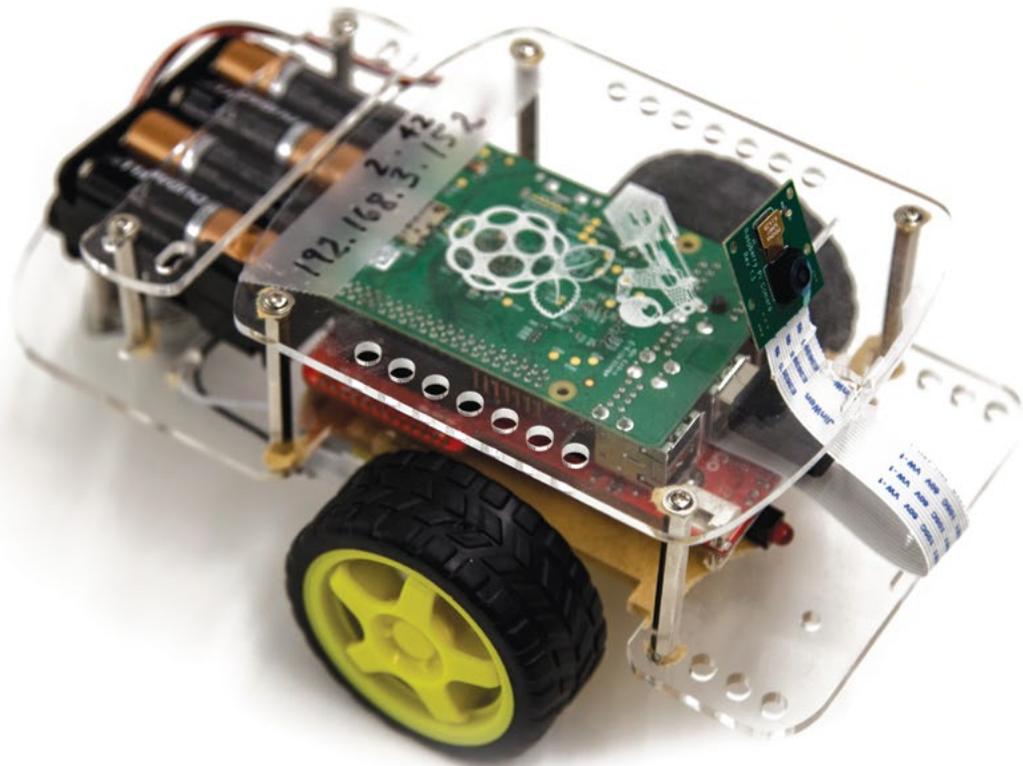
Martin Mayiani

Advisor

Dr. Anthony Teate



Martin Mayiani initiating a wireless connection to the Raspberry Pi self-driving car.



Fully assembled Raspberry Pi self-driving car.

This project's goal was to use a small electronic working model of a car to build a self-driving, autonomous vehicle. To meet this goal, we have developed a machine learning model that was implemented on a Raspberry-Pi-controlled car to create a platform to introduce users to autonomous vehicle technologies. The model's algorithms were developed using the Python programming language and several Python packages. Classification and Image Recognition algorithms from SciKit-Learn were used to train the machine learning model on statistical

pattern recognition of a dataset of images of traffic signs downloaded from the web. The car was fitted with a camera and uses OpenCV, an open source computer vision and machine learning software library designed for image recognition and classification. When used with our algorithms, OpenCV enables our car to dynamically respond to traffic signs in "real time." The car's self-driving performance will be measured by its statistical predictive capability using standard evaluation metrics. As we evolve and enhance this project, our

machine learning algorithms embedded in our Raspberry Pi car will become a scaled-down version of autonomous vehicles. We believe it will facilitate the study and understanding of how these technologies will play a role in more efficient transportation that will increase safety and reduce accidents caused by human error while driving or those related to drunk driving or texting while driving.

USING ANCIENT PRACTICES TO FIX MODERN PROBLEMS: THE EFFECT OF BIOCHAR ON EINKORN WHEAT AND SOIL QUALITY

BS-ISAT
Environment

Presenter
Sarah Miller

Advisor
Dr. Wayne Teel

Sponsor
Mr. Glenn Rodes



The crucibles are weighed after drying and burning to determine the percent of soil organic matter.



The two crucibles on the left contain soil that has been burned at 700 degrees Celsius for one hour. The two on the right contain soil that has been dried but not burned.

As farmland soils become more and more depleted, the importance of effective soil amendments grows. Biochar is a potential soil amendment and carbon input that could improve water and nutrient holding capacity and foster growth of beneficial microbes and fungi. Biochar does not contain nutrients but acts like a sponge, absorbing nutrients around it. It is so effective at holding nutrients that in the first year, if applied alone, it can make the nutrients unavailable to plants and lower crop yields. To get the best results biochar must be saturated, also referred to as inoculated or charged, with nutrients. Once the biochar is

saturated, the nutrients become easily available to plants. In this study, two different charging components, compost and manure, were mixed separately with biochar and applied to square meter plots. There were five different treatments with four plots of each: biochar and compost, biochar and manure, manure, compost, and control. Due to an unexpected surge in weed growth, the field study was changed to a pot study. The soil from each field plot was shoveled into pots, with two replicates of 20 pots in two locations for a total for 40 pots. Two einkorn seedlings were planted in each pot. Tentative results

from soil testing suggest there is statistical difference between soil amendments. While there is no significance between the charging components, there was a significant difference between the bulk density, carbon content and percent moisture of soils with and without biochar. Based on the average data of soil with and without biochar, soil with biochar had 7.5% higher moisture content, 48% more carbon, and a lower bulk density of 15%. The preliminary data based on tiller count, which is a possible way to predict grain yield, is inconclusive.

VERMICOMPOSTING: THE RESPONSIBLE ALTERNATIVE TO SYNTHETIC FERTILIZER USE IN AGRICULTURAL, URBAN, AND SUBURBAN AREAS

BS-ISAT
Environment

Presenter
Corie Lambright

Advisor
Dr. Wayne Teel



Senior Corie Lambright visually assessing the physical properties, biological activity, and positioning of soil moisture and temperature sensors within a vermicomposting system.



Eisenia fetida, commonly known as red wiggler worms, break down organic waste material to produce vermicompost: a nutrient rich and eco-friendly alternative to synthetic fertilizers.

Since the industrialization of ammonia, NH_3 , nitrogen based fertilizers have posed a major threat to the environment and to human health. Agricultural and domestic runoff laden with fertilizers harms aquatic life and contaminates drinking water. Synthetic fertilizers also deplete the soil of its natural properties and prompt denitrifying bacteria in the soil to release nitrogen gas, N_2 , into the atmosphere. Often this nitrogen is released in the form of the potent greenhouse gas, nitrous oxide, N_2O . The purpose of this project is to investigate and carry out a composting technique, called vermicomposting, that utilizes the castings of the worm species, *Eisenia foetida* (commonly

known as Red Wiggler worms), to produce a viable and eco-friendly alternative to synthetic fertilizers and their use on small scale agricultural operations, as well as in urban and suburban areas. A vermicomposting bin was built to house the worms and the compostable material in which they will eat and digest. Concepts of mass balance were applied to maintain the proper 25-30:1 carbon: nitrogen ratio. This is done by balancing addition of carbon-rich material, or “brown material”, and nitrogen-rich material, or “green material”. The bin was also equipped with sensors to monitor parameters, such as moisture and temperature, which are vital to

the health of the compost and the biological organisms within it. To assess the biological activity of the bin, a carbon dioxide, CO_2 , sensor was placed inside of the bin as well. The CO_2 levels inside the bin will be compared to the CO_2 levels found outside of the bin in the surrounding environment. The data gathered will provide insight on the response a vermicomposting system will have to changes in the parameters previously mentioned. Maintaining an appropriate carbon to nitrogen ratio, and monitoring the health and biological activity of the bin, will result in a nutrient rich fertilizer alternative.

THE CONSTRUCT OF A HETEROLOGOUS VACCINE CANDIDATE AGAINST B. AVIUM AND C. JEJUNI FOOD POISONING UTILIZING THE B. AVIUM AUTOTRANSPORTER, BAA1

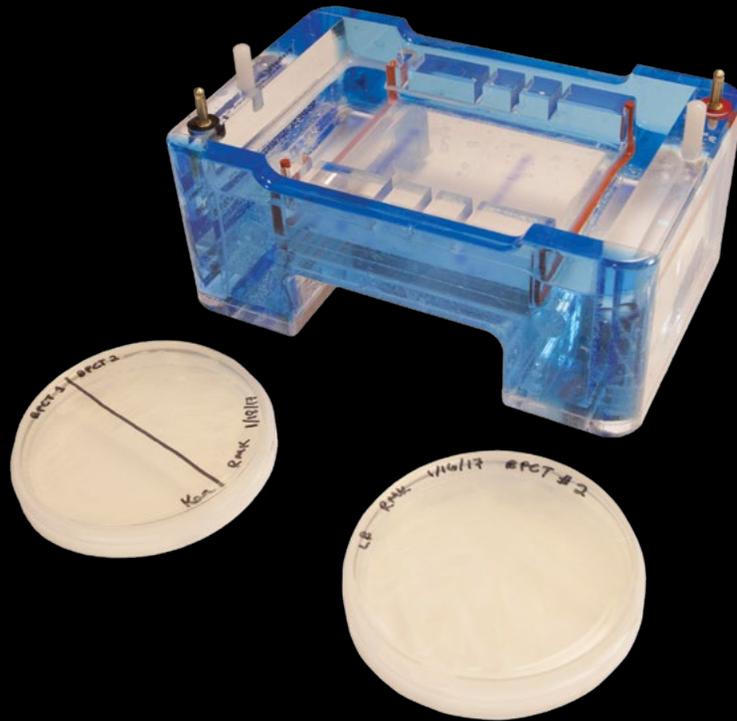
BS-ISAT
Applied
Biotechnology

Presenter
Rachel Korba

Advisor
Dr. Louise Temple



Rachel Korba streaking her mutant *Bordetella avium* strains on petri dishes.



Rachel Korba's mutant *Bordetella avium* strains on various media, and a gel electrophoresis set up used to verify PCR results.

Bordetellosis is a disease in turkeys commonly caused by the Gram negative bacterium *Bordetella avium*. *B. avium* also colonizes chickens, but does not cause disease. In spite of treatment and vaccine regimens, bordetellosis continues to cause financial losses in the poultry industry. Vaccines against bordetellosis could also be formulated to deliver a heterologous antigen to help protect against other poultry diseases or contaminants, such as *Campylobacter jejuni*, which causes human

food poisoning from contaminated meat. There are more cases of food poisoning each year due to *Campylobacter* than *E. coli* and *Salmonella* combined. In this study, I am investigating whether an autotransporter gene, *baa1*, which is expressed in *B. avium* may function to deliver such a foreign antigen (i.e. *CjaA* or *FlaA* from *C. jejuni*), and the removal of the naturally occurring passenger region renders the strain non-virulent in turkeys under laboratory conditions. This would lead to a dual live vaccine combatting

both *B. avium* and *C. jejuni* and furthermore, protecting human health. A plasmid was synthesized containing a codon-optimized *cjaA* gene portion between the *baa1* promoter and transporter regions. The construct was introduced in the *B. avium* chromosome through homologous recombination. Transconjugants were confirmed and will be tested for expression of the *baa1/cjaA* hybrid gene. Once expression of the *C. jejuni* region is confirmed, attachment studies will be done to further a vaccine development.

EVALUATION OF CURRENT AND POTENTIAL CITIES FOR REFUGEE RELOCATION COMMUNITIES IN VIRGINIA

Intelligence Analysis

Presenter

Gavin Jackson

Advisors

Dr. Stephen Marrin

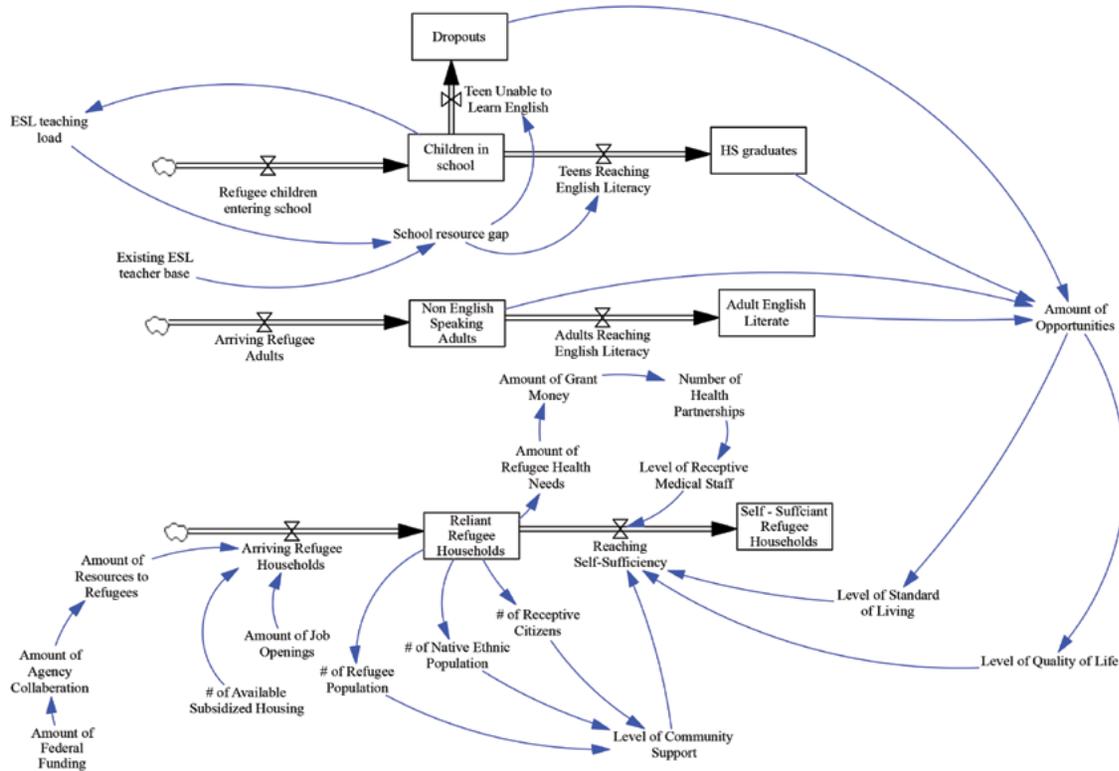
Dr. Michael Deaton

Sponsor

United States
Department
of State



Designing a systems model to determine diverse factors contributing to refugee integration into case study sample city, Harrisonburg, Virginia.



The purpose of this research is to understand the conditions between relational factors associated with successful refugee resettlement into a community. This research is of particular importance to the United States Department of State's Bureau of Population, Refugees and Migrations (PRM) for assessing potential national security threats within the Reception and Placement Program. This study examines the refugee integration process in the city of Harrisonburg, VA and draws on the ability of proficient English speaking abilities and an existing refugee community facilitates successful resettlement. The holistic view

of the local refugee resettlement process encompasses integration in communities through public-private partnerships, composed of multi-federal agencies and private non-governmental organizations. The research gathered throughout this project includes consultations with James Madison University faculty on analytic methods, private coordinators on refugee resettlement, scholarly articles, and official government documents. The conduction of System Dynamics, Key Assumptions Check, High-Impact/Low-Probability Analysis, and Brainstorming Techniques deliver viable intelligence and

provides innovative objective insights for the Reception and Placement Program. The use of technology software applications and geographic software provides the client effective visual insights on the possible national security threats within resettlement communities. The goal of this project is to improve the efficiency of resettlement communities' integration. This research also has the goal to identify possible national security risks associated in resettlement communities to increase safety levels of refugee and local populations.

DYNAMICS DRIVING INSURGENCY IN NORTH-WEST PAKISTAN



Intelligence Analysis

Presenters

C.J. O'Donnell
Aidan Martorana
Ryan Moore
Michelle Mungin

Advisors

Dr. Michael Deaton
Dr. Stephen Marrin
Dr. Timothy Walton

Sponsor

Matthew Downey,
Department
of Defense

Although the U.S. has given Pakistan roughly \$20 billion in military aid and equipment to help mitigate insurgencies in North-West Pakistan, the number of insurgent attacks has remained consistent. Additionally, Pakistan plays a significant role in maintaining stability in the Middle East, and a build up in insurgent activity in Pakistan will likely deteriorate U.S. efforts toward securing Pakistan. This analysis aims to identify the systematic causal variables that drive insurgent activity in North-West Pakistan, and how they affect the U.S. Department of Defense (DoD) strategy in the region. The purpose of this analysis is to:

- 1) identify how certain interactions among

- causal factors drive insurgencies in North-West Pakistan, 2) identify possible unintended consequences associated with the current U.S. DoD strategy toward mitigating insurgency in North-West Pakistan, 3) determine what factors, if any, pull more weight in driving the consistent level of insurgent activity in North-West Pakistan. In an effort to help U.S. DoD decision makers in deciding the best course of action for mitigating insurgency in North-West Pakistan, this analysis will utilize a systems dynamic approach to generate actionable insights into the underlying factors that drive insurgent activity in North-West Pakistan. The intended goal of this research is to develop a

deeper understanding of how the U.S. DoD strategy will likely impact the evolution of insurgencies over time.

SOCIAL ENGINEERING: NEGATIVE IMPACT ON CAPITAL ONE



Intelligence Analysis

Presenters

Caroline Desmedt
Samantha Fox

Advisor

Dr. Stephen Marrin

Sponsor

Capital One

Capital One currently has a cyber security policy in regards to social engineering in hacking, that while overall effective, has room for improvement regarding adaptability to prevent future social engineering attacks. Social engineering allows hackers to easily obtain information about individual customers as well as hack into company data, and poses a threat to the banking industry, and specifically to Capital One. Capital One does have in place many social engineering security measures, but they have still fallen under cyber-attack as recently as October 21, 2016, demonstrating

that there are still gaps in their policy that allow attacks like this to occur. Cyber security countermeasures are important and worth the expensive price, however, Capital One must weigh the costs vs. benefits when considering adjusting their current cyber security policy on social engineering. Capital One is aware of their social engineering vulnerabilities, but as the threat to their business continues to evolve, so must their defensive policy. Adjusting the focus of the cyber policy on social engineering could save the company money as well as prevent possible theft.

EVALUATING THE IMPLICATIONS OF A DEFENSE AND SECURITY SECTOR RESTRUCTURING IN COLOMBIA

Intelligence Analysis

Presenters

Michael Dunning
Kayla Graves
James Hurst, III

Advisors

Dr. Stephen Marrin
Dr. Noel
Hendrickson
Dr. Tomás
Regalado López

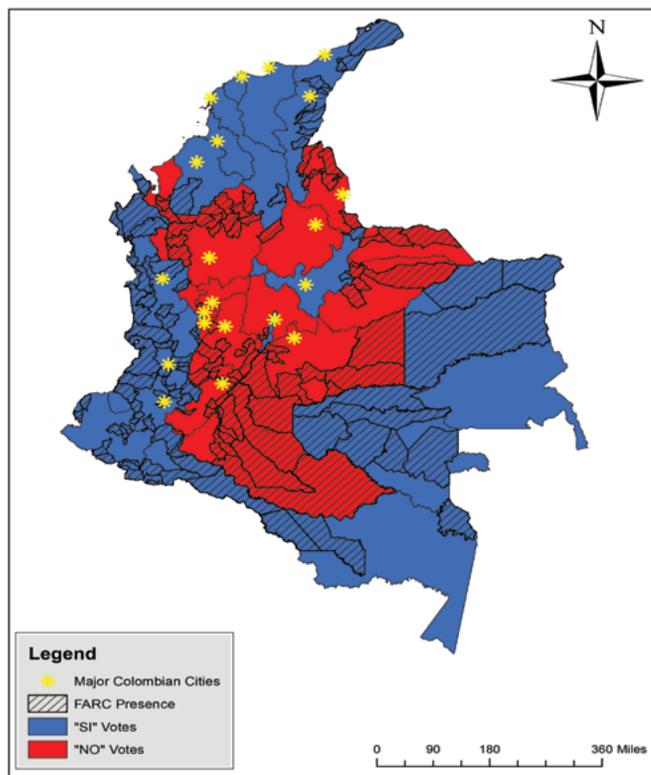
Sponsor

Department of
Defense



James, Michael, and Kayla review their quadrant analysis.

Regional Peace Vote Results and FARC Presence



On November 30, 2016, Colombian Congress passed a revised peace accord to establish “stable and enduring peace” within the country, signed between the Juan Manuel Santos administration and Las Fuerzas Armadas Revolucionarias de Colombia, or the Revolutionary Armed Forces of Colombia. This peace accord brings an end to Colombia’s 52-year civil war between the country’s democratic government and a Marxist-Leninist guerrilla movement known as FARC. Peace terms include comprehensive rural development, political participation

for FARC, illicit drug reform, reparations for victims of the conflict, and bilateral, definite ceasefire.

This project analyzes Colombia’s post-conflict transition and outlooks for “stable and enduring peace” with specific regard to the demobilization, disarmament, and reintegration process. An Analysis of Competing Hypotheses exercise is used to generate multiple hypotheses and compare each against a comprehensive list of evidence points. Alternative Futures Analysis is used to build eight plausible “futures” or

paths forward in the Colombian peace process and provide implications and indicators of each. Finally, a Red Team exercise is used to think from various perspectives to ensure thorough analysis. Analytic conclusions may be used to help guide United States Department of Defense strategy in Colombia during the post-conflict transition.

THE FUTURE OF CRIMINAL ANALYSIS: EFFECTIVENESS AND ACCURACY OF PREDICTIVE POLICING

Intelligence Analysis

Presenters

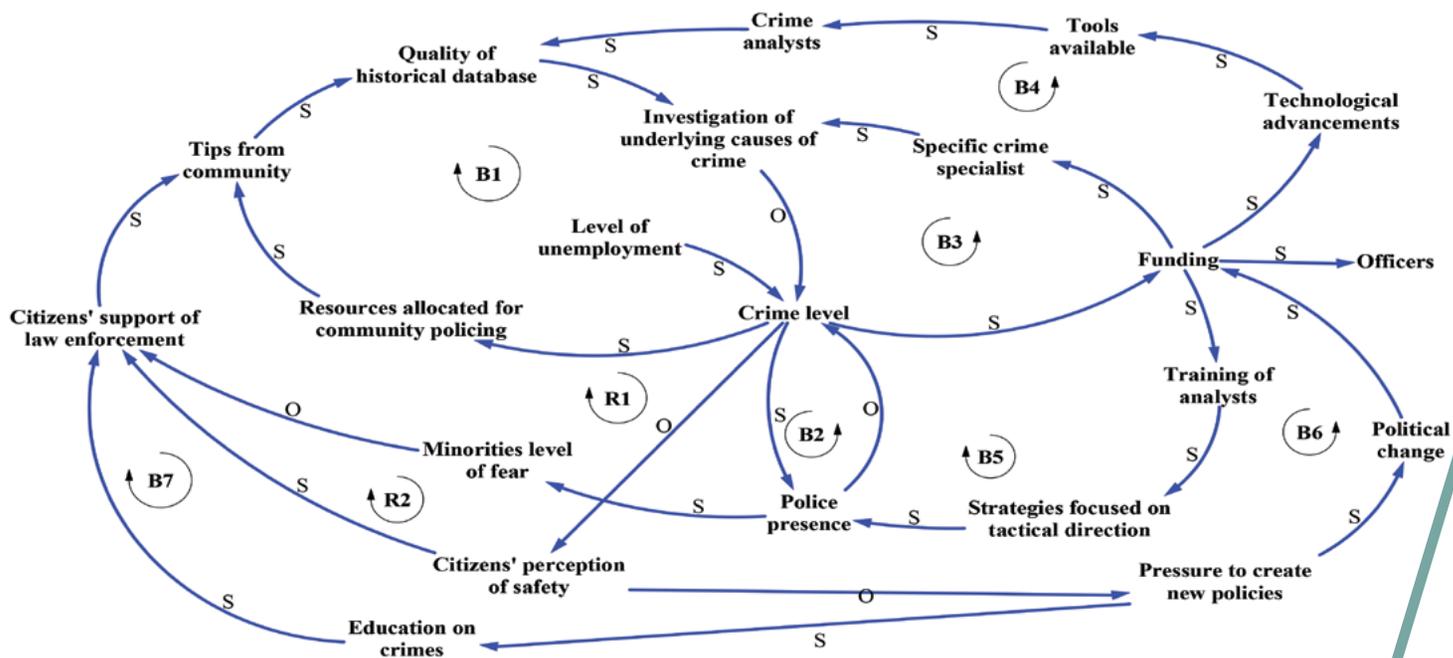
Alexandra Freeman
Olivia Parkhurst

Advisors

Dr. Michael Deaton
Dr. Noel
Hendrickson
Dr. Stephen Marrin
Dr. Benjamin Meade



Alexandra Freeman and Olivia Parkhurst work on their rough draft.



The team's causal loop diagram which displays the relationships between the various factors at play.

The purpose of this project is to evaluate criminal analysis tools' effectiveness and accuracy now and in the future to assist in improving police departments' law enforcement capabilities. It will address ways for mid-size police departments to best plan for their growing analytic abilities and strategically plan for the future in their crime fighting. This project will be useful for police departments that have established analytic capabilities and hope to reevaluate the tools for their crime analysis. This project can also assist departments to develop these skills if they have little experience with using many analytic tools.

To answer the question most effectively, structured analytic techniques and various

technologies will be utilized in order to create a comprehensive, well-supported project. Scenario Generation and Systems Dynamics will be two key methods applied to the analysis in order to better understand relationships as well as look to the future. These will be key in ultimately creating a strategy that will explain the best way to implement the conclusion to avoid wasting resources and time. Analyst's Notebook, ArcGIS, and VenSim will be utilized to support this project on the effectiveness of tools for criminal analysis and their accuracy in predicting future crimes. Some of these technologies are already implemented in law enforcement departments and have excellent visualization capabilities.

These techniques will help provide a holistic product that can be applied throughout the country. This understanding of effective tools used in criminal analysis will help any police department decide which tools to use while setting up their analytic division. These divisions help in the transition from traditional reactive policing to the relatively newer proactive policing. By utilizing proactive policing, police departments may be able to protect their communities more effectively through the use of analytic tools.

A POLICY AND FUTURES ANALYSIS OF THE NORTH RIVER RANGER DISTRICT'S COLLABORATION STRATEGY

Intelligence Analysis

Presenters

Sara Brown
Kaleigh Shorb

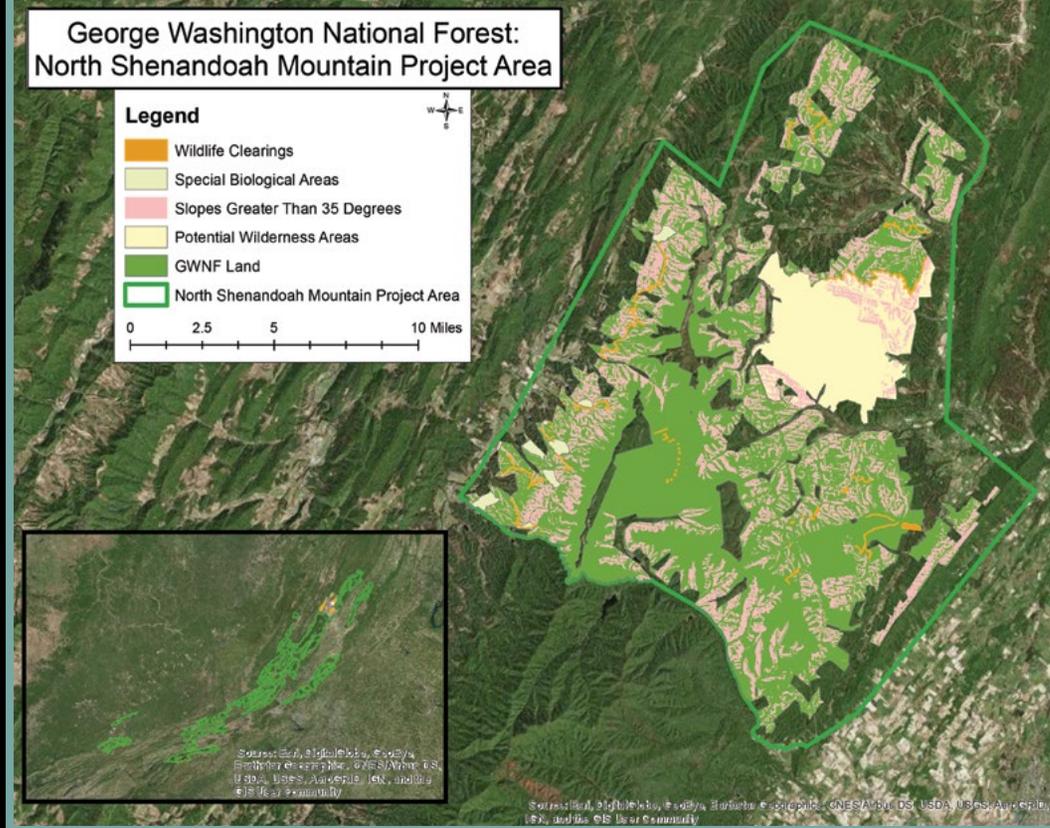
Advisor

Dr. Stephen Marrin

Sponsor

Meg McElveen,
North Zone
Wildlife
Biologist, US
Forestry Service





This project for the North River Ranger District of the U.S. Forest Service aims to provide a policy analysis of the current project implementation strategy, as well as to generate several scenarios for a more efficient strategy. Due to declining budget and manpower, the North River Ranger District must rely on collaboration with stakeholders to implement projects. This has created a challenge to meet goals of both multiple stakeholders and the District, as well as utilize stakeholders' resources most efficiently. Our team will first provide a policy analysis of the current

collaboration strategy, determine weaknesses and vulnerabilities, and then devise several future scenarios for a more efficient strategy. Our analysis uses analytical techniques such as Outside-In Thinking, Brainstorming, Red Team and "What If?" Analysis, as well as Strategy and Futures Analysis methodologies. We will be utilizing Causal Loop Diagrams to understand the interconnected relationships between stakeholders, Outside-In Thinking to understand which stakeholders are most impactful, and determining through Red Team why there are differences in goals for

some parties and which parties' goals conflict with others. Additionally, we will then utilize Brainstorming to form future scenarios, and then "What If?" Analysis to identify any assumptions or information gaps. The goal of this analysis is to make future collaborative projects less time costly, while enabling the District to create an improved strategy that balances the needs of every party. This analysis contributes in devising a new collaborative strategy that allows the District to utilize stakeholder resources more efficiently despite manpower and budget restrictions.

TIPPING POINT: RADICALIZATION AND DIGITAL PATTERN OF LIFE

This policy analysis seeks to recommend a policy solution for the best practice the National Media Exploitation Center (NMEC) can implement to identify the process of radicalization for terror suspects. By increasing NMEC's capability to identify the start of the radicalization process, NMEC can significantly decrease the turn around time for critical intelligence needed to prevent future terror attacks or identify other suspects involved in terror attacks or networks. The policy analysis looks beyond the traditional scope of study for radicalization in intelligence to consider practices taken from journalism, psychology, and technology used to increase knowledge of the radicalization process. External studies in the fields of psychology and journalism do provide insights into types of radicalization processes and profiling templates; however, placing significant reliance on these insights could mislead investigators by wasting resources

or time on false preconceptions. The best way to rectify the problem of timeliness and faulty profiling is to check all media devices through an automated process for review by analysts. In order to accomplish automated radicalization detection a global "radicalization" dictionary of forensics indicators is required to run against for automation. A new approach to organizational relationships between NMEC and its stake holders, such as the National Counter Terror Center (NCTC) will be needed for such a program to be successful; however, by accomplishing this all parties would stand to benefit immensely by increasing knowledge of terrorism and the radicalization process. Additionally, the program carries the future implication of being able to cost effectively implement "deep learning" techniques from the field of machine learning to increase the capability of cross-collection correlation and identify new trends in digital radicalization.

Intelligence Analysis

Presenter
Charles Fletcher

Advisor
Dr. Stephen Marrin

Sponsor
Andrew Staller, Defense Intelligence Agency

CLIMATE CHANGE TO IMPACT COCA PRODUCTION IN COLOMBIA



Intelligence Analysis

Presenter
Zane Rigney

Advisors
Dr. Stephen Marrin
Dr. Timothy Walton
Dr. Zachary Bortolot

The goal of this capstone project is to identify current and future impacts of climate change on coca production in Colombia for best utilization of U.S. and allied resources in the fight against illicit drug production. In order to effectively analyze this topic, a counterfactual approach was taken by identifying past and present trends to learn what's happening now and provide a for possible future scenarios. After researching the coca plant biology and historical climate data in Colombia, the most impactful drivers were identified to create several alternative scenarios ranging from most likely to least likely to identify their

occurrence possibility. This method identified climate change has little to no impact on coca production now, but is very likely to have an impact in 30 years. Utilizing the alternative scenarios can help the U.S and its allies align their resources to effectively counter illicit drug production in Colombia and South America.

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WOMEN IN TERRORISM: SOCIOLOGICAL FACTORS THAT INFLUENCE PARTICIPATION

Intelligence Analysis

Presenters

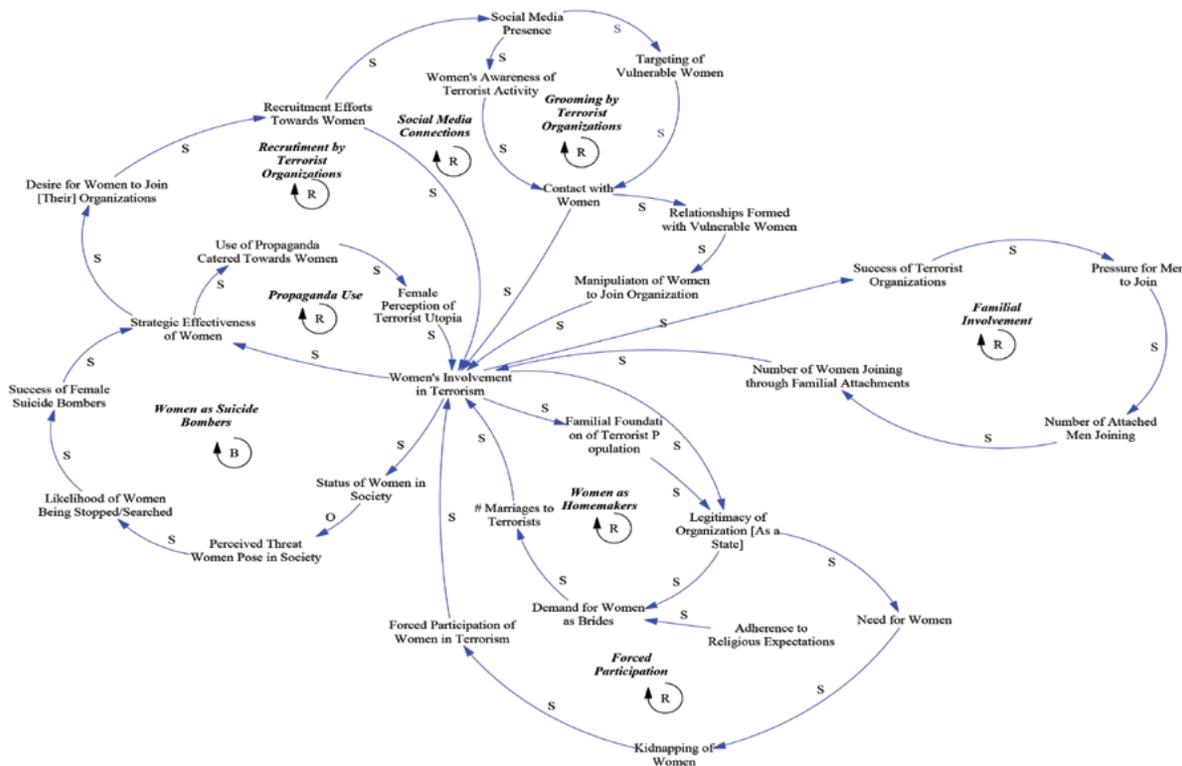
Sherrill Callahan
Allison Comparin
Paige Larsen
Dana Lee

Advisors

Dr. Michael Deaton
Dr. Noel
Hendrickson
Dr. Stephen Marrin



The capstone team discusses the terrorist groups that operate within the Middle East and North Africa region.



Preliminary Causal Loop Diagrams developed by the capstone team to better understand the goals and strategies of the various actors that influence women's participation in terrorist organizations in the Middle East and North Africa region.

In recent years, the global intelligence community has noted a shift in women's involvement in terrorism, specifically in groups such as the Islamic State in Iraq and the Levant (ISIL), Boko Haram, and al-Qaeda in the Arabian Peninsula (AQAP), located throughout the Middle East-North Africa (MENA) region. Women have come to hold more significance within these terrorist organizations at tactical, operational, and strategic levels. This analysis will look broadly at why women are recruited to join these groups in MENA countries. Further analysis will be conducted to look at what factors influence and draw women to fight for ISIL, Boko Haram, and AQAP, and how these

factors may change and influence women's involvement in the future. The motives behind women joining these terrorist organizations will be analyzed using Causal Analysis and Systems Dynamics to identify the sociological factors that drive women's involvement and how they interrelate and influence one another. The conclusions from conducting Causal Analysis will be used to extrapolate future trends and potential scenarios in women's involvement in terrorism based on the shifts of the determined driving factors. We hope to develop an extensive understanding of which factors most influence women's growing participation in terrorism and how these factors

may change women's involvement in the future. This analysis will provide policymakers and the international community with insight into causal factors that could help focus resources and efforts, and the future projections could help decision makers make plans for eradicating violent extremism in the long-run and mitigating the role of women in terrorism in the short-term. By identifying recruitment efforts and motivations for joining and remaining in terrorist organizations, particularly amongst women, our analysis could help U.S. and international security entities identify and neutralize trends and threats that draw women to these various terrorist organizations.

RESOURCE SCARCITY AND RADICALIZATION IN INDONESIA

Intelligence Analysis

Presenters

Charles Bill
Nicholas Barber
Joshua Clark

Advisors

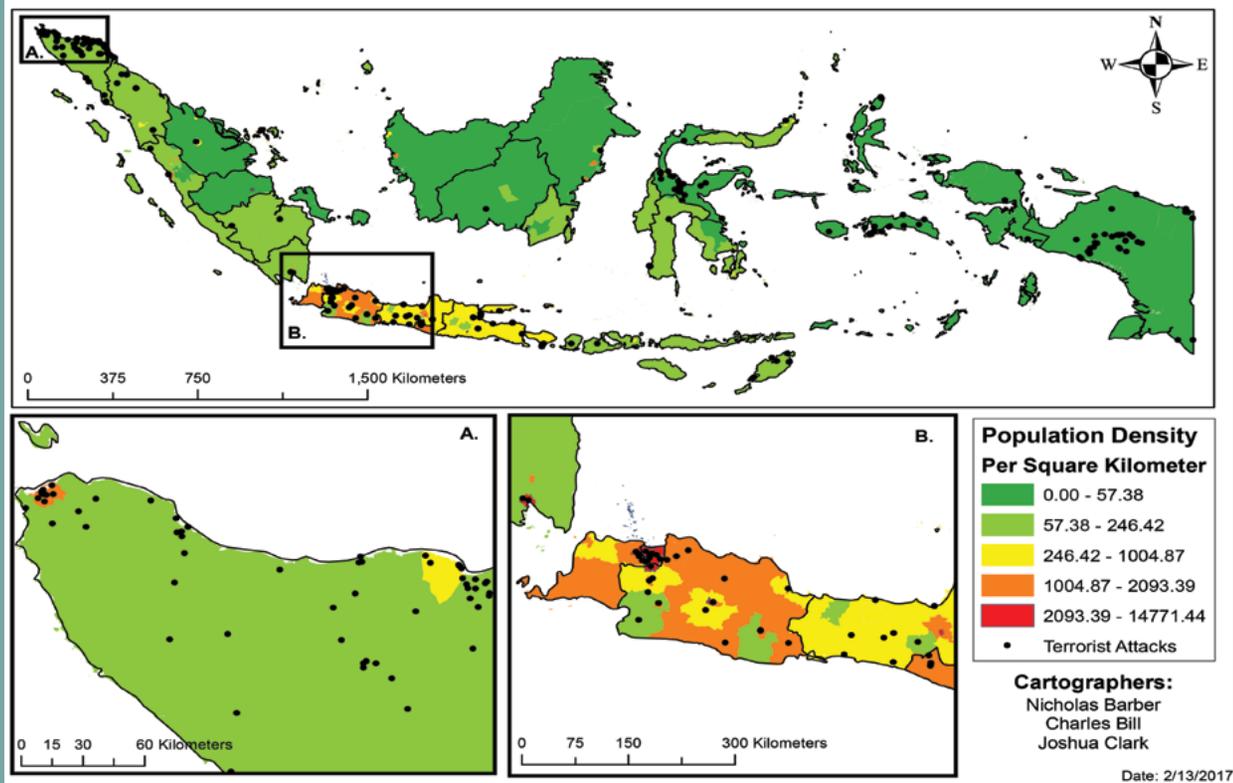
Dr. Stephen Marrin
Dr. Timothy Walton

Sponsor

Booz Allen Hamilton



Population Density in Relation to Terrorist Attacks Since 1977



For the past twenty years Indonesia has seen a significant rise in the number of terrorist attacks that have taken place. With Islamic radicalization becoming an increasingly prevalent transnational issue, and Indonesia having the largest Muslim population in the world, it becomes increasingly imperative to identify factors that lead to radicalization within the country. Indonesia is a newly industrialized country which has resulted in a detrimental effect on their environment. This can largely be seen in their vast deforestation, due primarily to palm oil farming, causing land disputes and conflicts with locals. While Indonesia has an effective democratic

system that has largely subdued large scale radicalization thus far, an existing correlation between resource scarcity and radicalization makes it an important case study.

This project evaluates the likelihood of resource scarcity having an impact on radicalization in Indonesia. The analysis relies on using an analysis of competing hypothesis (ACH) exercise which allows us to identify multiple hypotheses and assess their validity given the present factors in Indonesia. An alternative futures analysis has been employed to identify possible scenarios, possible

indicators of these scenarios, and address their implications. Additionally, various geographic information system (GIS) tools are used to identify relationships of various factors in the region and produce visualizations that facilitate the analysis. This analysis will help Booz Allen Hamilton anticipate possible radicalization in Indonesia in the near future.

TROUBLED WATER: FUTURE CHINESE THREATS TO CRITICAL WATER INFRASTRUCTURE

Intelligence Analysis

Presenters

Robert Hedrick
Matthew Murphy
Molly Wolpert

Advisors

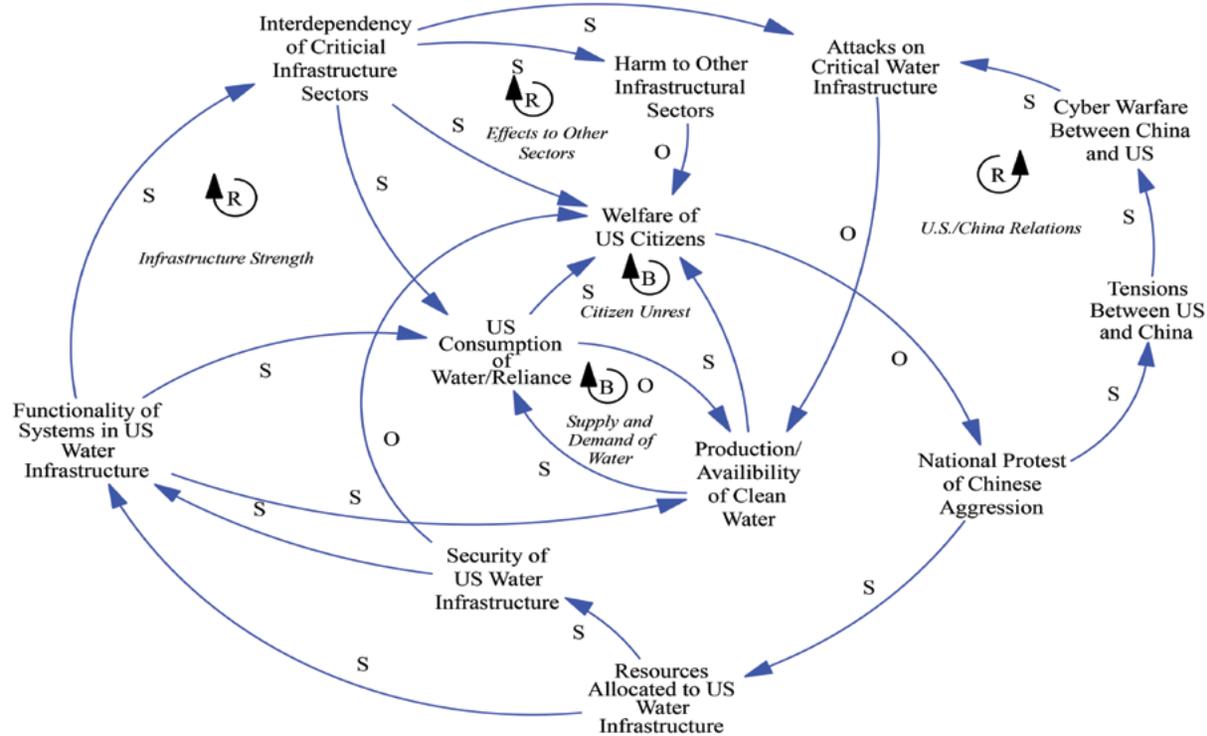
Dr. Stephen Marrin
Dr. Timothy Walton

Sponsor

Toffler Associates



Troubled Water: Future Chinese Threats to Critical Water Infrastructure



This is their Causal Loop Diagram, which shows the most significant factors in their analysis and how they interact with one another. Each loop tells a piece of the story of the analysis. This technique guided the generation of their future assessment on the Chinese Threat to U.S. Water Infrastructure.

The water and wastewater management sector is a crucial linchpin of the entire United States critical infrastructure apparatus and, as such, is a high impact target with the potential to cause irreparable damage to the security of the nation. Other sectors of critical infrastructure heavily rely on proper water management in order to operate efficiently. China and other state actors working against U.S. interests are particularly concerning, since they have the resources and capabilities to conduct significant attacks. This project aims to determine future

threats from the China to U.S. critical water infrastructure within the dynamic diplomatic relationship between the two countries. This specific threat has been relatively unexplored in the literature, and our research compiles the leading analyses and assessments on domains crucial to our question. The analysis employs both causal and futures-based methodologies such as Systems Dynamics Modeling and Scenario Generation to synthesize information, thereby providing valuable insight to our client Toffler Associates.

U.S. CRITICAL INFRASTRUCTURE CYBER SECURITY: CASCADING VULNERABILITIES IN AN INTERCONNECTED SYSTEM



Intelligence Analysis

Presenters

Jeremy Blanchard
Aaron Collins
William Gadzinski
Rachel Huber

Advisor

Dr. Stephen Marrin

U.S. Critical Infrastructure is made up of individual sectors, of which the disruption of a single sector might possibly have a significant negative effect on U.S. security. These sectors, while discretely identified by the Department of Homeland Security are interconnected and interdependent in a wide variety of ways. This project seeks to identify the areas of critical infrastructure most vulnerable to cyber-attacks, and the subsequent impact to the rest of the system were one to happen. The inherent interdependencies within the Critical Infrastructure network create focal points of increased criticality where disruption

could have the potential to cause significant failures in many connected sectors. These critical points represent areas of increased value to any threat actor with the intent of damaging or disrupting the United States' ability to function. Our analysis includes current cybercrime trends and the reasoning behind why attacks are conducted. Our project addresses the current state of cyber threat actors, whether state or non-state, and the factors that affect them in order to provide a multifaceted perspective on the environment in which our topic resides. Our assessment of the outcomes of successful cyber-attacks

also provides valuable insight into the mindsets and motivations of cyber threat actors. Our conclusions seek to provide guidance or reference arguments for a future restructuring or reframing of the U.S. Critical Infrastructure cybersecurity strategy.

AN EVALUATION OF THE ELECTRIC VEHICLE LANDSCAPE



Intelligence Analysis

Presenters

Christopher Chung
Jake Merhige Sebastian
Safaei Joseph Sterrett

Advisor

Dr. Qingjiu Tao

The green vehicle trend has been a popular subject among both environmentalists and automotive enthusiasts for the better part of a decade. In the United States, longstanding companies have released a collection of green vehicles that are seen on American streets on a daily basis. However, while the world is already familiar with this and has an established relationship with the hybrids of the past decade, new technologies have emerged creating the fully electric vehicle industry. While firms like Tesla are being spearheaded by charismatic leadership and becoming known as the leaders in the electric vehicle industry, long

standing companies in both the United States and abroad are working towards becoming the leader in both innovative conversations as well as market share.

This project is a global evaluation of the firms working in the fully electric vehicle industry. The project takes into account multiple facets of the industry including, but not limited to market share, patent portfolio strength, patent depth, and research and development budgeting. Through this evaluation, a thorough understanding of the current electric vehicle landscape will be developed, as well as a better

understanding as to which firms are likely to succeed in the future.

CHINESE-JAPANESE PACIFIC TENSIONS



Intelligence Analysis

Presenters

James Aguilera
Katherine Donovan
Noah Quay

Advisor

Dr. Qingjiu Tao

Sponsor

Bill Heinrich,
Division Chief
of INR/EAP

What do U.S. strategy and foreign policy decision makers need to know in order to better understand the current and future tensions between China and Japan in the East and South China Seas? As the second and third largest economies in the world, the importance of China and Japan, both now and in coming years, cannot be overstated. Given the recent expansion of activity across all domains in the China Sea, this region is likely to be key to understanding the dynamics between Japan and China. The immense impact on Chinese-American relations and Japan-American relations that any interactions between these

two countries will have make identifying how the next 30 years of Chinese-Japanese relations are likely to develop crucial to securing the United States interests.

This report examines the potential for future conflict between China and Japan countries in the China Sea Region by 2035. It will provide three different perspectives on future possibilities: Authoritative (what is very likely to occur), Alternative (what is less likely but still plausible), and Exploratory (what is very unlikely but still deserves consideration due to dire consequences). In each section,

scenarios for how the future could develop have been theorized based on the current activities, organizations, trends, and players involved. Implications for the U.S. have been identified based on 1) important intervention opportunities unique to each scenario and 2) commonalities between different scenarios that suggest future states likely to occur. It is our hope that these insights will provide policy analysts and decision makers with insights to navigate the future unknown waters in the region and beyond.

VALUE DRIVERS AND POTENTIAL THREATS FOR INTERNET OF THINGS (IOT) INTEGRATION INTO THE AEROSPACE AND DEFENSE (A&D) INDUSTRY



Intelligence Analysis

Presenters

Kelly-Anne Crowley
Connor Feroce
Connor Hamel
Luke Lyons
Lia Verdi

Advisor

Dr. Qingjiu Tao

Sponsor

Ghazanfer M. Sadiq, EY

The “Internet of Things” (IoT) is rapidly finding its way into industrial processes and allowing companies to harness vast amounts of data. The Aerospace and Defense (A&D) industry is constantly being fueled by technological innovation. As IoT technology functionality improves and implementation costs decrease, in what ways can A&D companies use IoT technology to improve business processes?

Projected growth in both the military defense and commercial aerospace subsectors, along with the aforementioned improvements in IoT

technology functionality, A&D enterprises should strive to integrate IoT technologies into critical business processes. However, one of the primary concerns surrounding IoT integration are the cybersecurity risks associated with these nascent technologies. A prerequisite for A&D firms seeking to integrate IoT should involve acquiring sufficient security measures that are capable of monitoring and resolving potential cybersecurity vulnerabilities.

The benefits of IoT integration into the A&D industry are plentiful. Firms stand to benefit from streamlined supply chains, increased

efficiency in inventory management and smarter manufacturing operations. All of these benefits should translate to higher profits, faster turnover, and streamlined processes across nearly every aspect of core operations. However, are the cybersecurity and other implementation risks too great for A&D firms to turn to IoT for a cutting edge?

FUTURES ANALYSIS OF CYBER SECURITY PRODUCTS: TRENDS, THREATS, AND RECOMMENDATIONS INTO 2037



Intelligence Analysis

Presenters

Andrew Castro
Zach Chrisp
Christopher Hendricks

Advisor

Dr. Qingjiu Tao

This report presents the results of a year-long analysis involving the future of cyber security products and services. The analysis accounts for a projection twenty years into the future and specifically addresses the concerns of its sponsor, Intel Security, whom have graciously assisted throughout this project. Cyber security is of utmost importance in the modern age due to the fundamental role it will continue to play in protecting citizens, industries, and governments from cyber threats. The cyber security industry is a constantly changing environment which requires ingenuity and rapid adaptation to operate in.

THE FUTURE OF U.S. SMART CITY WATER INFRASTRUCTURE



Intelligence Analysis

Presenters

Grace Chupka
Tara Gallagher
Chance Berry
Erica Schmitt
Matthew Smith

Advisor

Dr. Qingjiu Tao

Sponsor

Toffler Associates

Citizens and corporations in the United States are highly dependent on the water and wastewater sector, which is comprised of intricate pipeline systems, dams, sewage infrastructure, and water treatment plants. The current water infrastructure is in need of extensive repairs as degradation and natural aging is occurring. This degradation has started to provide cities and urban areas with the initiative to implement Smart technologies that would ensure a higher quality of life to its citizens. Certain applications of Smart solutions would include the implementation of advanced warning sensors, a more integrated network towards water efficiency, and increased

budgeting safeguards. The purpose of this capstone project is to identify key security and structural vulnerabilities, adaptations of Smart technologies, and examine the division of financial responsibility for water infrastructure development for the Smart city water sector.

The intention of this project is to analyze the future of water infrastructure in the U.S. from the current standing of critical infrastructure to the implementation of Smart city water solutions. Water security in the United States is increasingly threatened. Many utilities are facing major supply issues (water quantity and/or water quality), aging infrastructure, and drastic funding shortfalls.

Currently, more than 80% of the nation's water pipelines are public utilities, with approximately 86% of the population relying on these pipelines. As a result, there is a high demand and expectation from the United States population that their water needs will be met currently by the public sector. In order to ensure the safety of the public, policymakers must take into account the impending risk of a degrading water infrastructure and how water quality violations have become widespread. As these violations begin to increase, policymakers must focus on finding Smart solutions through new methods and technologies that will lay the blueprint towards 21st century water infrastructure.

FUTURE ASSESSMENT OF POINT OF SALE TRANSACTIONS: CHIP READERS VS. NEAR FIELD COMMUNICATIONS

Intelligence Analysis

Presenters

Justin Beale-

Richardson

James Bowles

Sean Knowlan

Thomas Newsome

Advisor

Dr. Qingjiu Tao

Sponsor

Nick Lowrie



Discussing factors to be considered in a cost benefit analysis of transitioning to the chip reader.



In recent years, chip readers have slowly become the norm in American check out lines as it is the next step for better security of personal credit card information. Companies across the United States are forced to decide if, or when they should upgrade their point of sale machines. This decision carries a lot of weight such as where the liability falls when fraud is committed.

The purpose of this study is to research, understand, and analyze how the chip reader point of sale technology, could or could

not improve the security and revenues of Legends Hospitality within the 37 LiveNation Amphitheatres, otherwise known as LiNA. The analysis will be completed through the use of SWOT, Stakeholder, Scenario Generation, and Cost Benefit Analysis. With all of this, our project aims to inform Legends on how to move forward with their clients in regards to point of sale technologies.

THE EFFECT OF FUTURE SEA LEVEL RISE ON STORM INUNDATION OF MAJOR HURRICANES IN TAMPA BAY

**Geographic
Science
Applied
Geographic
Information
Science (AGIS),
Environmental
Conservation,
Sustainability and
Development
(ECSD)**

Presenters

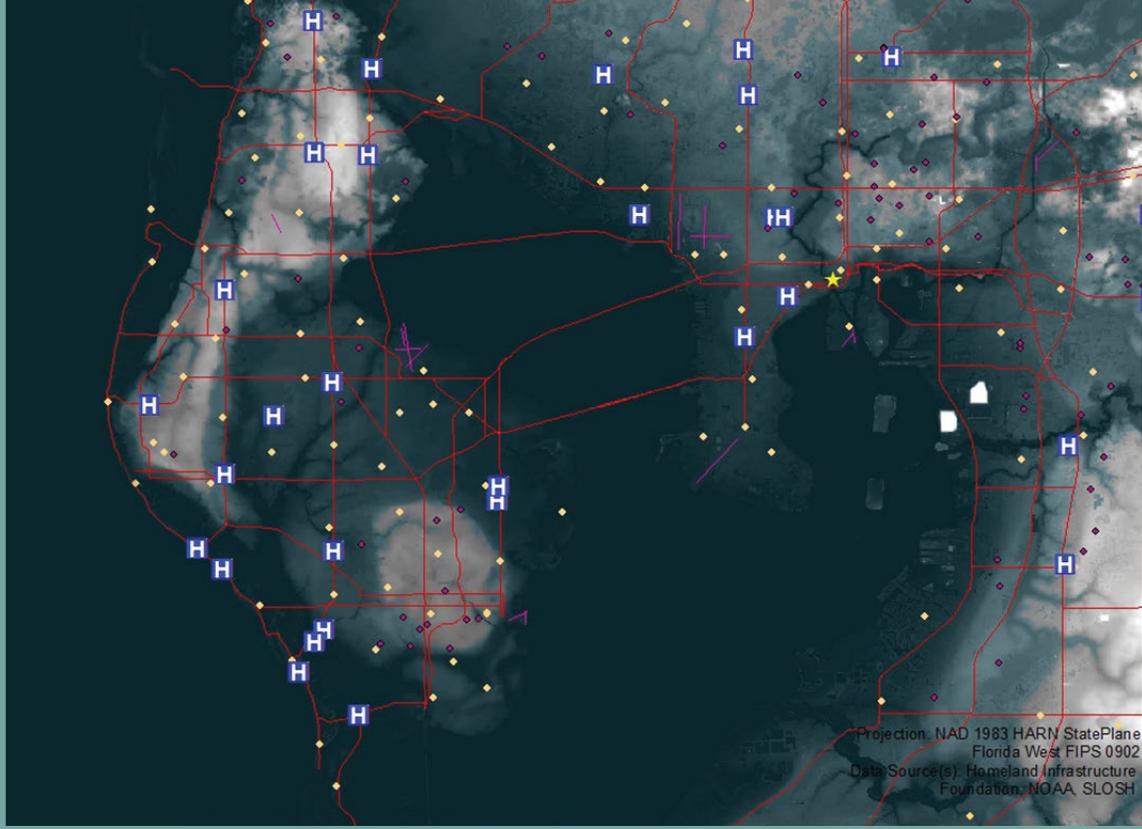
Kara Chipiwalt
Marcus Gloe
Hannah Smith

Advisor

Dr. Mace Bentley



The team is converting sea level rise with storm surge data into a raster file containing a binary series where areas are either wet being 1 and dry being 0.



Their project uses data from a SLOSH model of the Tampa Bay Hurricane in 1921 and creates the storm surge for a Category 3, Category 4, and Category 5 hurricane on the Saffir-Simpson scale. We then combined the surge data with 1.2 meters of potential sea level rise to show the impacts on the Tampa Bay area. Using this data, we are able to show how current evacuation routes, schools, airports, and impoverished areas will be affected by storm surge with the addition of sea level rise.

This capstone project intends to analyze the impacts of sea-level rise and hurricane storm surge in Tampa, Florida. In this analysis, we chose to use a real hurricane scenario, the 1921 Tampa Bay Hurricane, to assess the differences in storm surges produced by hurricanes of Saffir-Simpson Hurricane Wind Scale levels three, four, and five, at current-day sea level, to storm surges produced by the same hurricane levels with future projected sea level. Sea level rise is a potential hazard to populations along

coastlines due to global climate change. If the sea level continues to rise in the future, there will be many potential impacts, including increased storm surge of hurricanes. Tampa is our focus of study due to its vulnerability. Level three, four, and five hurricane scenarios were assessed namely because of the intensity of the storms and major impacts associated with the intensities. In order to assess these potential hazards, we used programs intended to model both storm surge at various hurricane

levels as well as implications of sea-level rise. These programs include the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model, ArcMap, and Hazus. The results from this analysis support assessments of evacuation routes, emergency response strategies, and social vulnerability in Tampa.

AN OBSERVATIONAL INVESTIGATION OF LONG-LIVED BOW ECHO PRODUCED METEOTSUNAMIS IN LAKE ERIE

**Geographic
Science
Applied
Geographic
Information
Science (AGIS),
Environmental
Conservation,
Sustainability and
Development
(ECSD)**

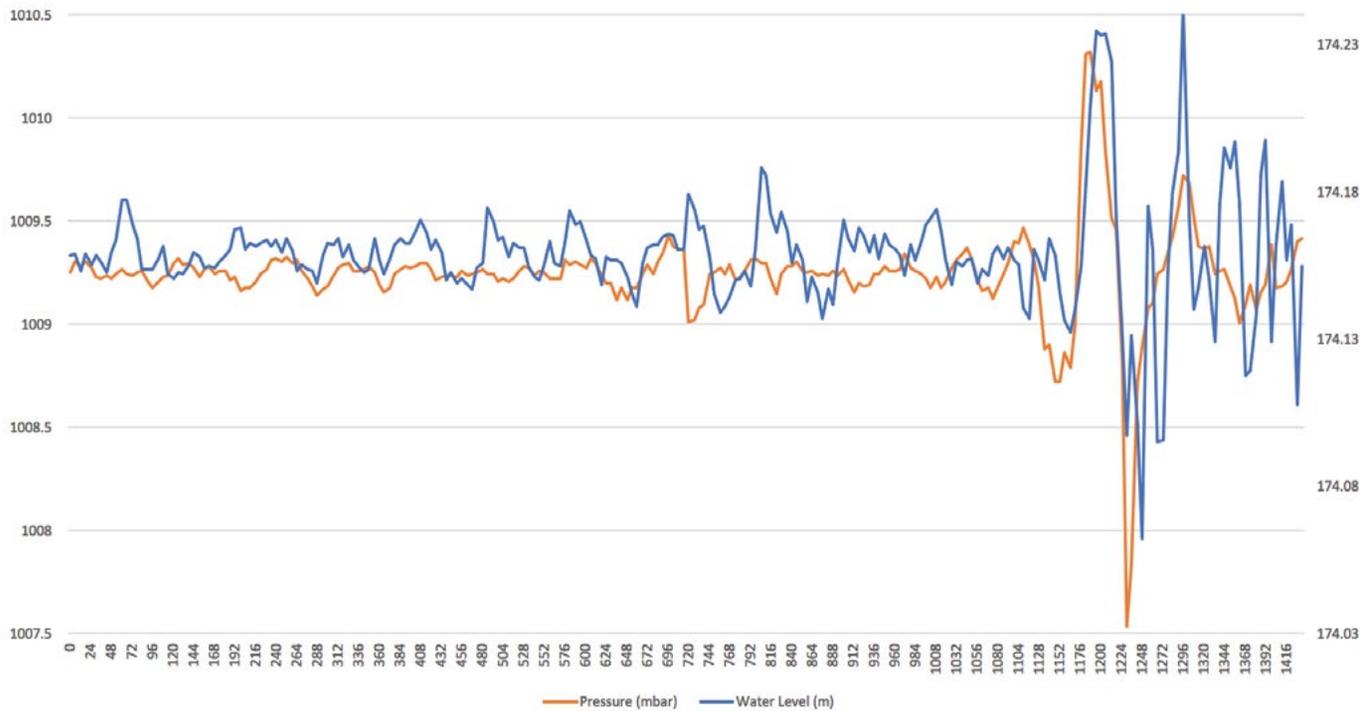
**Presenter
Elise Mazur**

**Advisor
Dr. Mace Bentley**



Elise running pressure, wind, and water level data from Lake Erie through a high pass filter in MatLab.

Pressure and Water Level



Pressure (orange) and water level (blue) after run through a high pass filter to highlight correlation on 7/04/03.

Although the Great Lakes are shallow compared to oceans, large waves can accumulate on them. These waves can be caused by both strong winds and pressure jumps. Large waves caused by changes in pressure are called meteorologically induced tsunamis, or meteotsunamis. These waves are hard to predict and therefore the public cannot be warned. There have been a few instances of destruction of boats and shorelines as well as some fatalities from meteotsunamis on the Great Lakes. This paper will be an observational investigation of long-lived bow echo, or straight-line wind mesoscale convective systems, produced meteotsunamis in Lake Erie.

Data were gathered for eleven different days with bow echoes evident in the radar data. Events were chosen if they went over Lake Erie, and narrowed down to events that passed over Cleveland. The majority passed over the water level gauge and pressure sensor at similar times. Most events travelled from west north-west towards the east or east south-east. Straight-line wind mesoscale convective systems are most common in warmer months. The variation in time of day, direction, and intensity provide a diverse sample of data.

These data allow the comparison of time and amplitude of pressure, wind, and water waves. After passing the data through high-pass filters,

some correlation is evident in magnitude of pressure wave to water wave. Studying all three variables from multiple events provides data that shows that meteotsunamis can be produced when there are not large wind gusts. This small sample of events may be generalized for other bow echoes passing over the west end of Lake Erie with similar characteristics. Research assessing more events and in different locations should be performed before utilizing this research for predictions of time and duration of meteotsunamis on Lake Erie.

A WINTERTIME LIGHTNING CLIMATOLOGY FOR THE CONTIGUOUS UNITED STATES

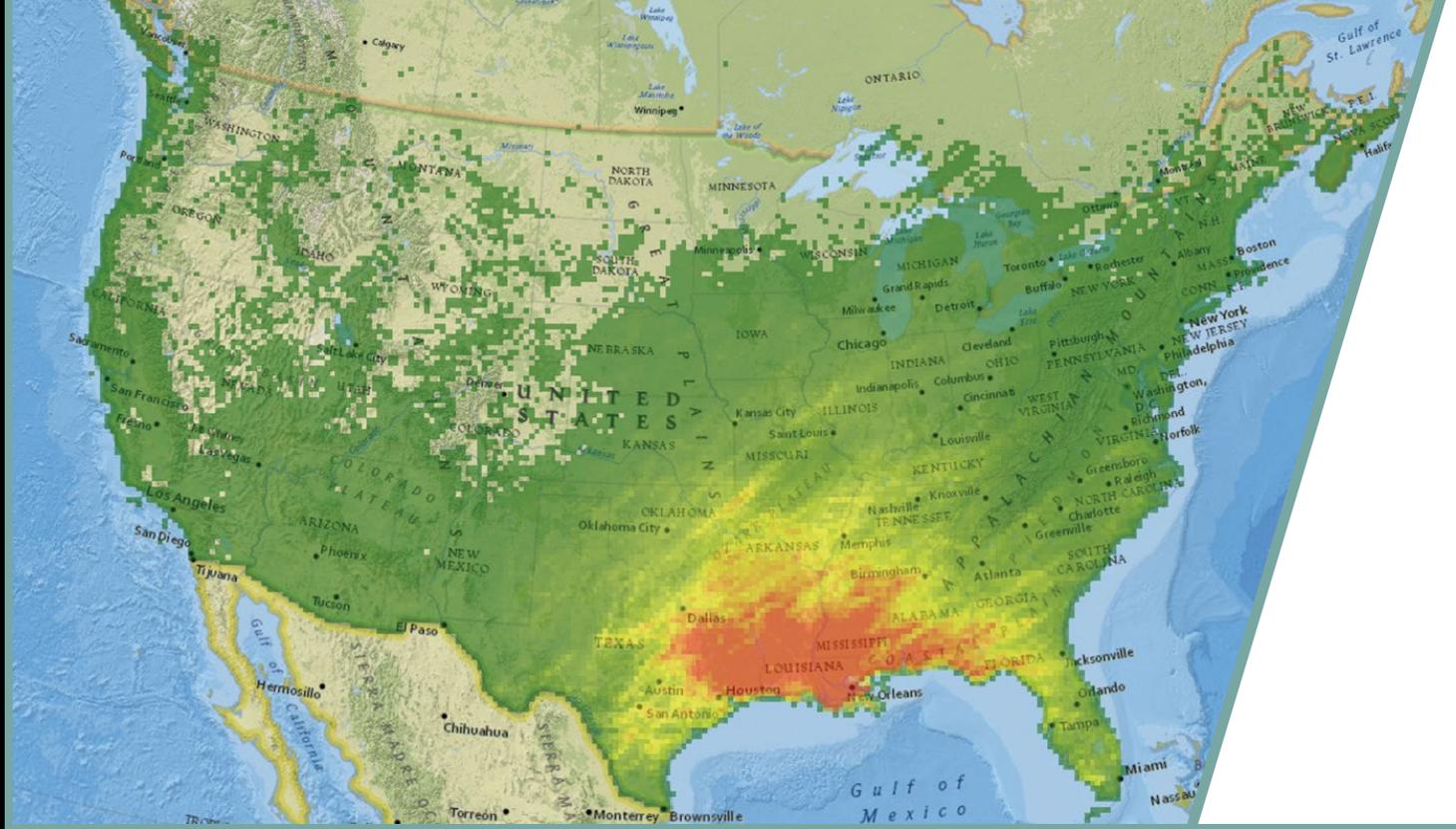
**Geographic
Science
Applied
Geographic
Information
Science (AGIS),
Environmental
Conservation,
Sustainability and
Development
(ECSD)**

Presenter
Collin Riley

Advisor
Dr. Mace Bentley



Collin Riley works on displaying historical wintertime lightning data in a GIS format.



During the Northern Hemisphere winter, lightning activity in the continental United States is greatly diminished compared to that of the summer. Lightning during the summer often follows a diurnal pattern, with activity peaking in the afternoon due to solar energy striking the earth throughout the day. In the winter months, the energy provided by the sun in the mid-latitudes is much less than it is in the summer, so lightning activity is often driven by synoptic scale events, rather than diurnal variation in solar heating. This project aimed to analyze the spatiotemporal distribution of wintertime lightning as well as to look at relative lightning frequency in various air mass types.

For this project, analysis of data from both the National Lightning Detection Network and the Spatial Synoptic Classification covering the months of December, January, and February, from 2002 through 2015 were conducted. Individual lightning strikes were matched with the air mass that they occurred in, and from this the data was gridded at a 20 kilometer resolution across the United States. Grids were created to show lightning frequency, as well as the number of days in which each grid cell experienced lightning activity.

From these data, it can be shown that there are differences in the spatial distribution of

lightning in the winter compared to that of the summer. In addition to this, different air mass types contained dramatically different levels of lightning frequency throughout the study period. Lightning frequency also showed a distinct orographic influence, especially in the western United States, and higher resolution grids of specific focus areas were used to illustrate this effect.

THE IMPORTANCE OF POLLINATOR DIVERSITY IN SCHOOL GARDEN MANAGEMENT

**Geographic
Science
Applied
Geographic
Information
Science (AGIS),
Environmental
Conservation,
Sustainability and
Development
(ECSD)**

Presenters

Michael Colombo
Rachel Halterman
Kathleen Withers

Advisor

Dr. Amy Goodall



Analyzing pollinator photography and survey results.



Photo of Pollinator
taken June 2016 by
Rachel Halterman.

The purpose of this study was to gain an understanding of common pollinator species of Harrisonburg so that effective, pollinator friendly planting recommendations could be made. Included was the objective to provide garden management information to the Harrisonburg Public School system in order to increase pollinator habitat within elementary school gardens, while also considering elementary student favorite garden plants and insects. Photography of bees, butterflies, and flies was used at four local study sites to collect information about species and their

relative abundances. Study sites were selected based on diversity of flowering vegetation. Pollinator identification sources were obtained through guides written by experts within the fields of entomology and garden management, and through confirmation by faculty at JMU. Communications with elementary teachers and students took place in order to develop holistic management plans for increasing pollinator habitat and student learning. We found photography useful for determining the most commonly encountered pollinators. However, we often experienced it challenging

to identify to the species taxonomic level for bees and flies. To improve the quality of our results, other pollinator identification methods were compared to use of photography. We present the most common pollinators photographed and make recommendations for garden plantings that attract these species as well as native species not observed. We balance recommendations with preferences of elementary school students for their favorite garden vegetables and flowers as well as the need to provide a garden space useful for course learning requirements.

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IMPROVING GARDEN DESIGN FOR INCREASED USE

**Geographic
Science**
Environment
Conservation,
Sustainability and
Development
(ECSD)

Presenters
Demetri Beard
Erin Brennan

Advisor
Dr. Amy Goodall





Capstone students in the ISAT Geographic Science program planned and built a garden at W.H. Keister Elementary School in 2012. The garden program has been successful in providing a learning environment for students of all ages. Since the garden was implemented six years ago, raised beds have shifted, soils have moved, and perennials have multiplied. As well, some of the wooden planters have weathered. The objective of our project was to assess current garden design and make recommendations about increasing accessibility and enhancing safety while also increasing biodiversity. We conducted a literature review

of garden designs and an assessment of Keister Elementary School garden features. We also communicated with teachers and other Geographic Science students researching the garden. We found that 20% of aging infrastructure needs replacement. Modifications of 30% of the perennial garden will benefit biodiversity. As well, extension of pathways will improve accessibility. We present a map of the suggested changes as well as propose a design to expand the garden to include a wildflower meadow and a shade tree placed within a reflection space.

SPATIAL ANALYSIS OF CRIME IN HARRISONBURG: BURGLARY AND ROBBERY

**Geographic
Science
Applied
Geographic
Information
Science(AGIS) and
Environmental
Conservation,
Sustainability and
Development
(ECSD)**

**Presenter
Avery Smith**

**Advisor
Dr. Helmut
Kraenzle**

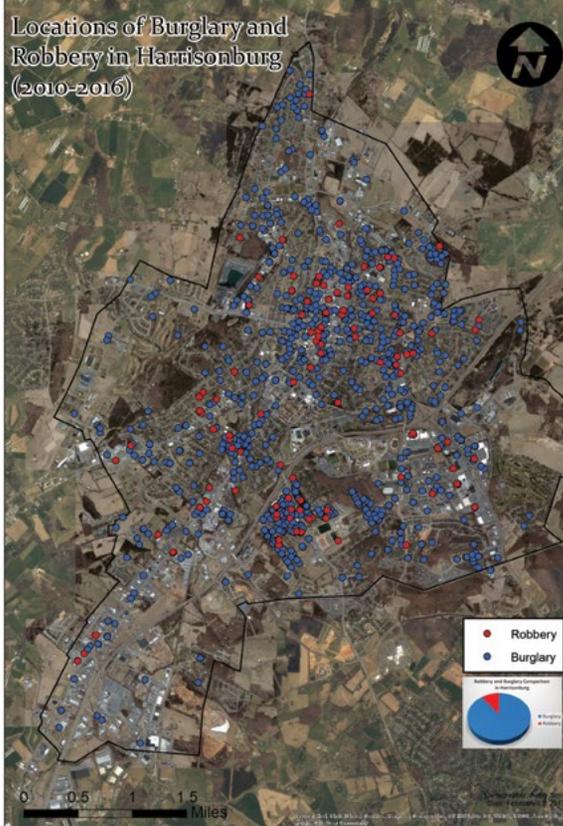


Geographic Science Senior Avery Smith initializing GIS analysis for crime research in Harrisonburg.

Crime Level by Streets in Harrisonburg (2010-2015)



Locations of Burglary and Robbery in Harrisonburg (2010-2016)



Map created by Avery Smith (B.S., Geographic Science) shows crime level by streets and distribution of burglaries and robberies in Harrisonburg, Virginia following processing of crime data using GIS technology and python scripting.

The purpose of this research was to inquire into the spatial and temporal patterns of crime in Harrisonburg, Virginia, particularly burglaries and robberies. The temporal sample used to construct analyses was the period from the year 2010 to 2016. GIS analyses facilitated by python scripts were used to make inferences about the spatial nature of crime in Harrisonburg.

Statistics after processing data received from the Harrisonburg police department, revealed a steady increase in crime throughout the studied period. Crime rates increased by 16% from the early to the latter portion of the period. Major crimes were vandalism, assaults, and drug crimes which accounted for 18%, 17%, and 16% of all crimes respectively. Burglaries and robberies accounted for 5% and 0.5% percent of all crimes respectively.

The occurrences of burglaries and robberies from 2010 to 2016 were virtually evenly distributed in clusters in the northern and southern areas of the city. Statistical analysis of the spatial clustering of burglaries revealed a less than 5% percent likelihood of occurring by random chance, as opposed to robbery where clustered patterns were revealed as random. This indicated burglary as an organized crime in the city and robbery as a more spontaneous crime. In northern Harrisonburg, in the vicinity of the downtown area, temporal homogenous occurrences of burglaries at specific locations were well established. Such occurrences were less in southern Harrisonburg with increased randomness southward. Holistically, analyses revealed a spatial shift northwards in Harrisonburg for the occurrences of both burglaries and robberies.

JMU off-campus residences were a major host for burglaries and robberies with at least 30% and 20% of all occurrences committed in or near those units respectively. Robberies tended to occur in high to medium developed areas, where as burglaries were more likely to occur in medium to low developed areas.

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DETERMINING DEVELOPMENT LEVELS OF UNITED STATES COUNTIES BASED ON A COMPARATIVE AND SPATIAL ANALYSIS OF MULTIVARIATE CRITERIA

Geographic Science

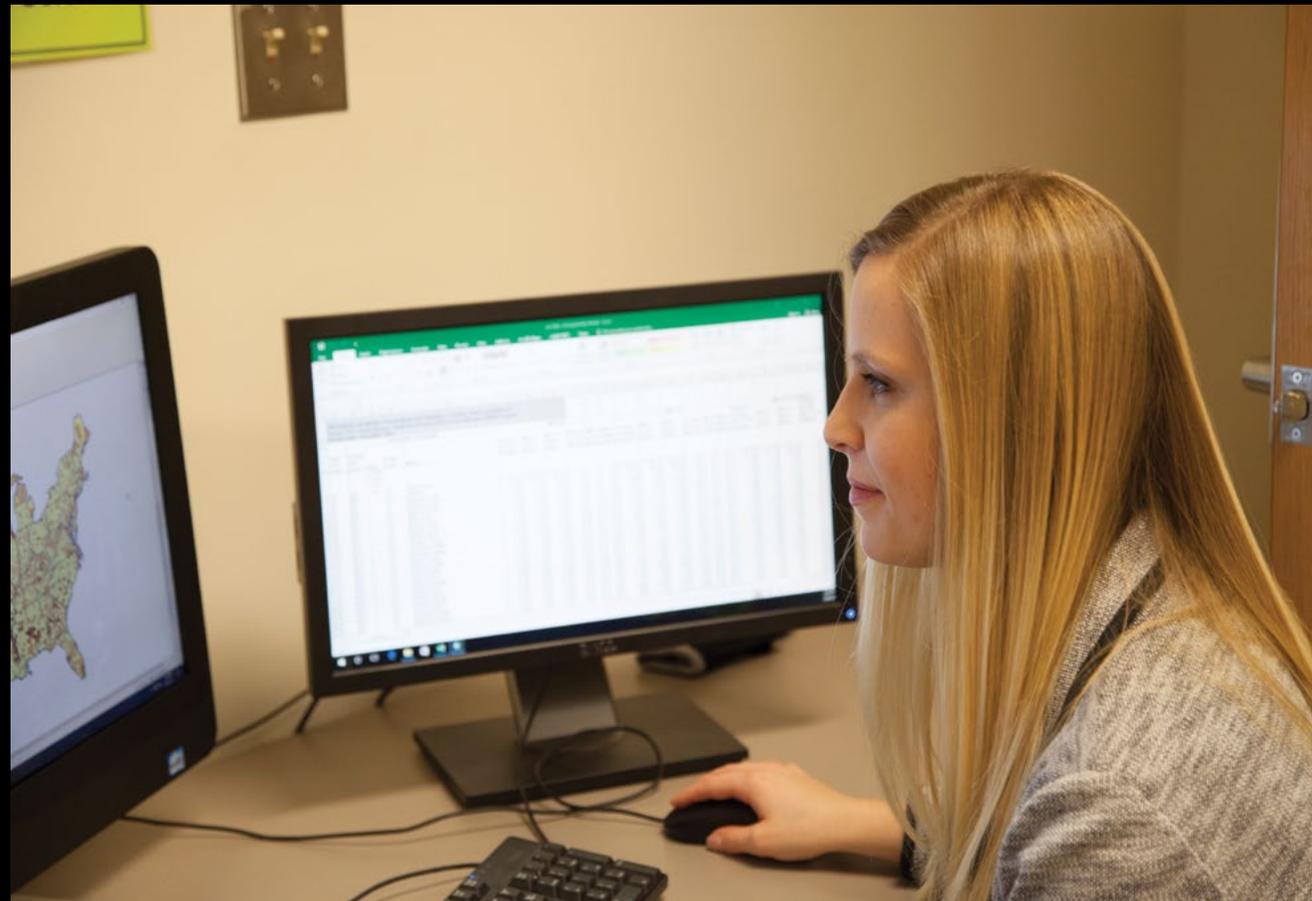
Environmental
Conservation,
Sustainability and
Development
(ECSD)

Presenter

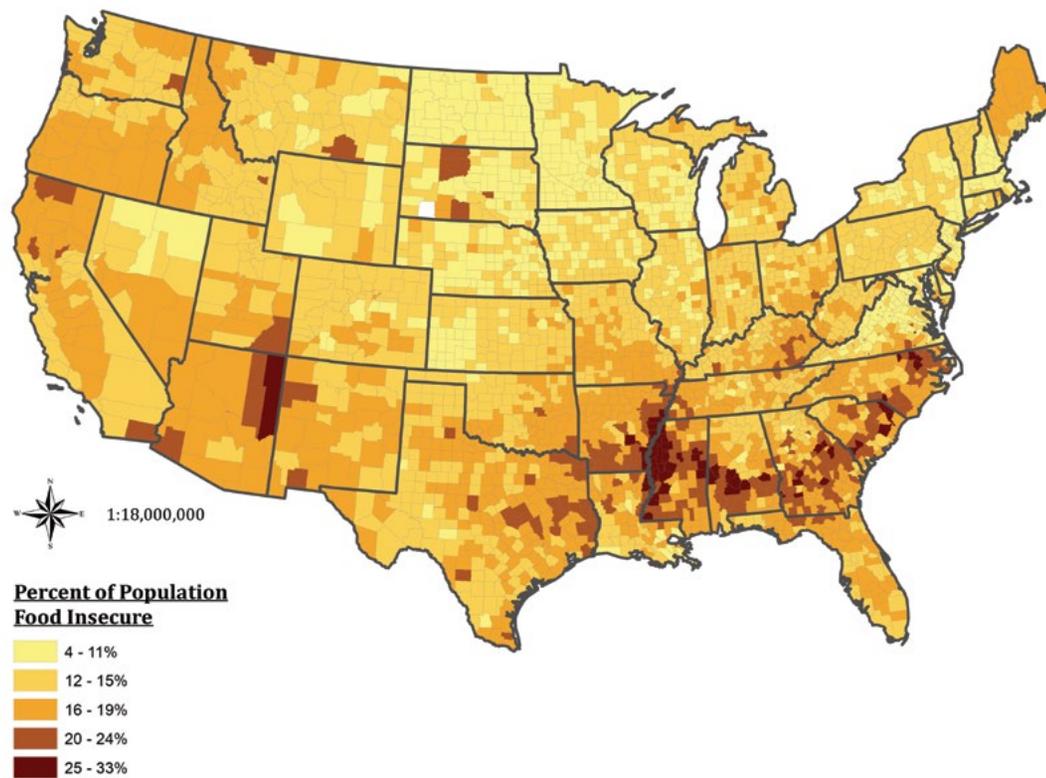
Lauren Wheeler

Advisor

Dr. Henry Way



Lauren works on mapping the data that create a compelling argument for development initiatives in the United States.



Many world organizations rank countries according to development, but rarely are those scales transposed onto smaller geographic regions of a single country in order to more fully understand the contributing factors to that country's rank. This comparative analysis at the country level does not take into account regions that are statistical outliers within a country. The United States ranked 8th in 2015 according to the UN's Human Development Index, but empirical evidence shows, through

qualitative and quantitative data, that there are regions within the U.S. that would not classify as having "very high human development." This study used multivariate quantitative data (health statistics, education levels, and income) to replicate development indices like that of United Nations for counties in the United States. Development thresholds were based on standards of highly reputable and widely recognized organizations such as the UN and World Bank. The data was then cartographically

displayed using ESRP's ArcGIS software to show the spatial distribution of development across the U.S. if counties were held to the same standards of international development. The result is a compelling analysis that the areas within the United States could benefit from domestic development initiatives.

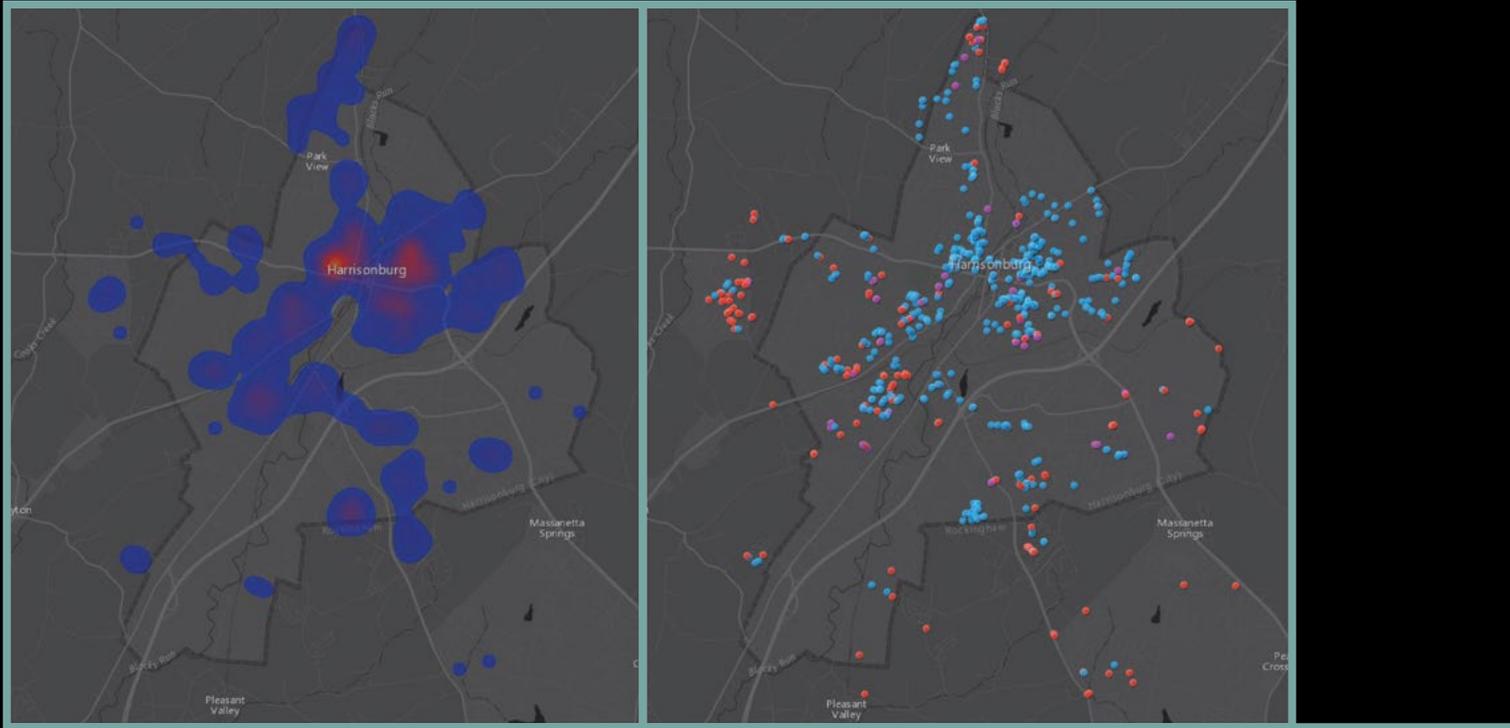
A SPATIAL ANALYSIS OF POLITICAL GEOGRAPHY IN HARRISONBURG, VA

**Geographic
Science**
Applied
Geographic
Information
Science (AGIS)

Presenter
Rebecca Schneider

Advisor
Dr. Henry Way





Due to the recent U.S. presidential election, American politics has drawn even greater attention locally, nationally, and internationally. The varied political affiliations of U.S. citizens have created a seemingly polarized public, and are drawing scrutiny and interest from researchers. The goal of this capstone research is to explore this political distribution on the local level in Virginia college towns, and explore how knowledge of this spatial distribution could be utilized in the future. By using data from political yard signs placed

around Harrisonburg and various social media posts and trends, I aim to determine whether political affiliation can be tied to stereotypically liberal college campuses and how that affiliation changes towards the outskirts of college towns. I was also motivated to visually correlate political support to other socioeconomic patterns in Virginia communities by overlaying the most recent census data for factors including median household income, family size, religion, and the highest level of education obtained. The results could be generalizable

to most small college towns throughout the United States, although there may be variance depending on the geographic location. They could potentially be used for campaign advertisements, gerrymandering, and even for predicting the outcomes of future elections.

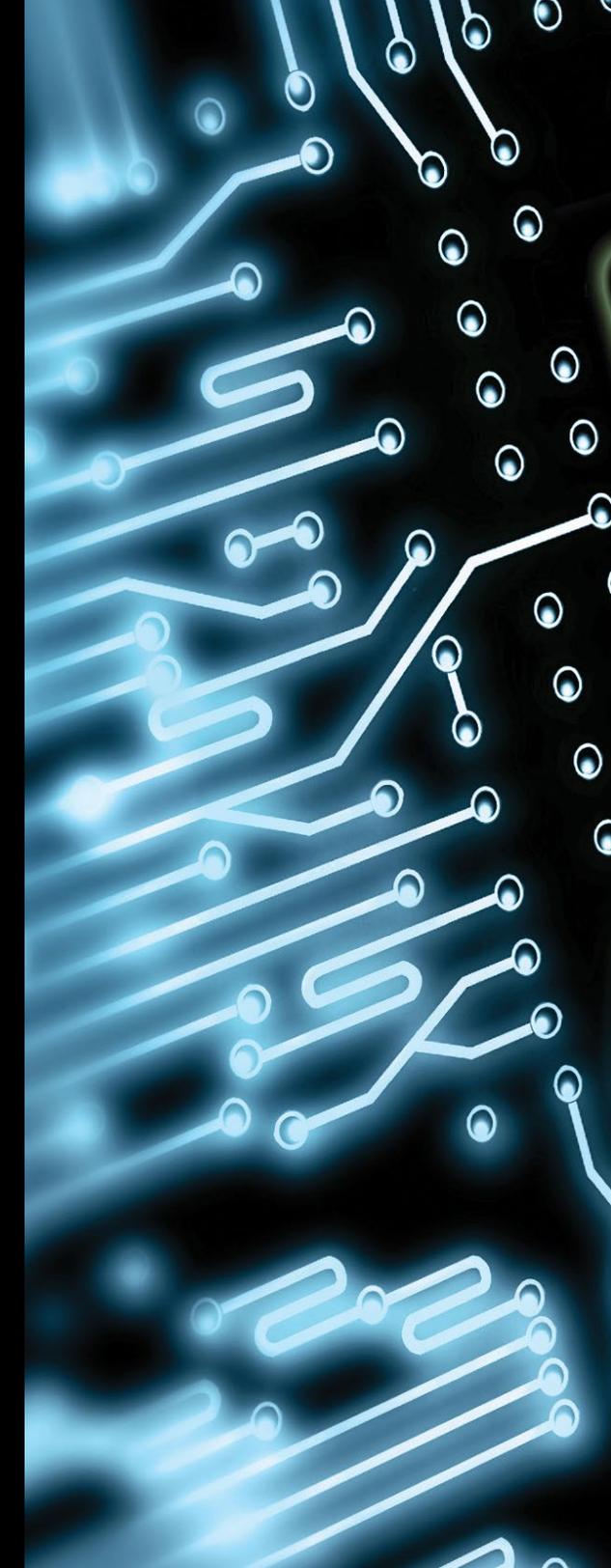
THANK YOU!

On behalf of the ISAT Department, I want to thank the students, faculty, sponsors and especially the staff whose hard work helped to make this book and our event possible.

The incredible amount of dedication, teamwork, time and effort (and occasionally some frustrations) is what makes this event possible year after year.

Dr. Jeffrey Tang

Interim Head, Department of Integrated Science and Technology



**JAMES
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UNIVERSITY®

MSC 4102
701 Carrier Drive
Harrisonburg, VA 22807

Department of
INTEGRATED SCIENCE
AND TECHNOLOGY

540.568.2790 Phone
540.568.2761 Fax
strangfx@jmu.edu
www.jmu.edu/isat

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