Madison Engineering

A Year of Good through Innovation, Research, & Design

XCHANGE '14

JAMES MADISON UNIVERSITY
Department of Engineering

Engineering Capstone

Through an engineering curriculum grounded in effective instructional practices, we foster an engaged educational community of conscientious & adaptable learners who develop solutions for the betterment of society.

Welcome to the 2014 Madison Engineering xChange! If you were given four years to make a difference in the world, personalize your learning through engineering projects, and collaborate with people around the world, what would you do?

This book demonstrates what happens when students take the opportunities offered by our engineering program to do something that matters. The mostly visual chronicles herein reflect many hours of work through Madison Engineering's first-year projects, year-long sophomore community engagement project, and undergraduate research, as well as the nation's only two-year long capstone project experience.

Many of these works are the products of late night innovations, unexpected research discoveries, and countless design iterations; engineering excellence emerging from a unique mix of collaboration, learning, respect and generosity. Interestingly, these are the values promoted by Madison Engineering, embodied in a world-class undergraduate engineering education, and celebrated through our annual xChange.

Throughout the xChange I invite you to reflect on our students' journeys, interact with their works, and appreciate the learning gained through a student-customizable, project-based education. You may find yourself inspired to join our students'efforts for meaningful contributions to the world; in the end, it is up to you to define what "x"to Change.

Change well,

Kurt Paterson, Ph.D.
Head, Department of Engineering
James Madison University

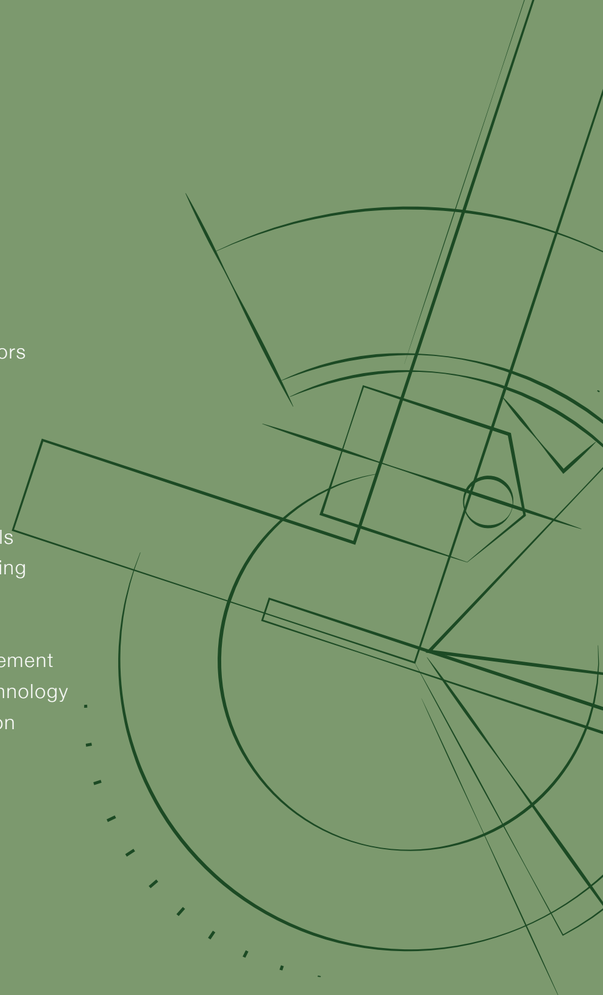
April, 2014

Seniors

Juniors

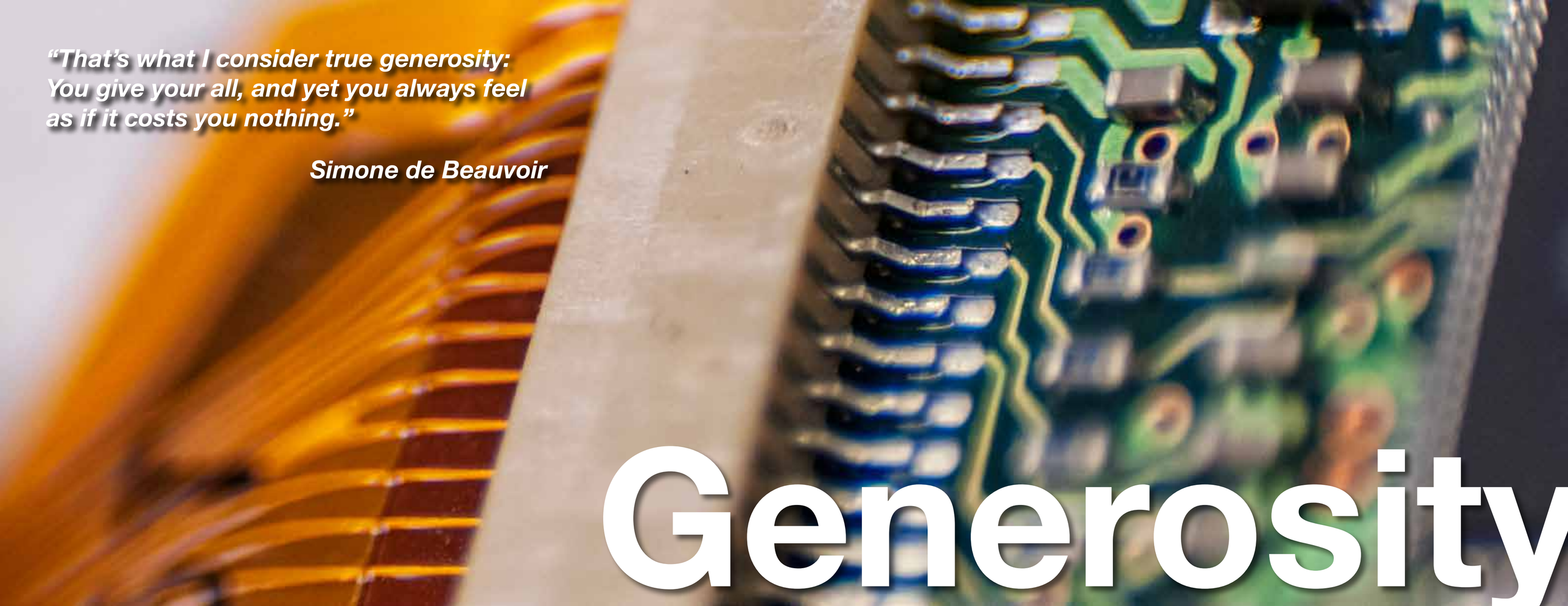
Booklet design credit:

Rachael Winfrey
Joshua See
Joshua Diaz
The staff of Creative Services



“That’s what I consider true generosity: You give your all, and yet you always feel as if it costs you nothing.”

Simone de Beauvoir



Generosity

Seniors

Seniors

"The capstone Experience here is two years long & provides a unique work experience for what I hope to do."

- Michael Hinton

Biodiesel

"We were interested in this project because we find it important to find an alternative to fossil fuels so that later generations have the same opportunities as we have."

Biodiesel can be produced from vegetable oils using a trans-esterification reaction promoted by an alkaline catalyst. While the mechanisms of the conversion of triglycerides to biodiesel are well understood and developed, the process of viable and sustainable commercial production still poses challenges. We propose the design and development of a continuous flow biodiesel reactor utilizing waste cooking oil collected from local restaurants as primary feedstock. A continuous flow reactor offers the advantage of reduced volume footprint compared to current batch reaction systems and consequently, increased reactor portability and scalability for multiple on-site implementation. We hope by this to minimize the cumulative impacts associated with the production, use and disposal of cooking oil as well as offset some of the impacts due to the use of fossil fuels. Amongst other challenges, we have identified reactant mixing as a primary challenge to be addressed in order to significantly improve product yields and residence time. A static mixer, diffuser plate and irregular shaped packing material were investigated with consideration to trade-offs such as pressure drop, flow requirements and reactor residence time. We hope to produce a biodiesel product that meets ASTM standards for the use in off road vehicles which closes the life cycle loop of oil.

Senior Project Team

Lauren Chapman
Geoffrey Hull
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Nicole Weikert

Advisors

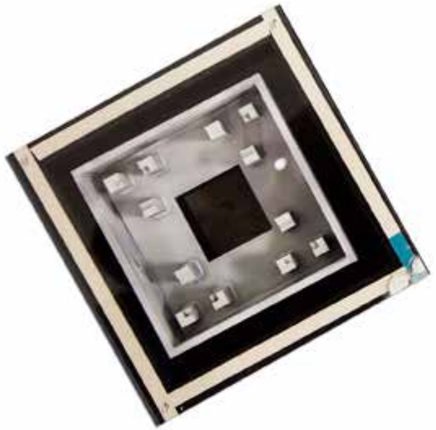
Dr. Adebayo Ogundipe

External Sponsors

Acid Piping

Packed Bed Column

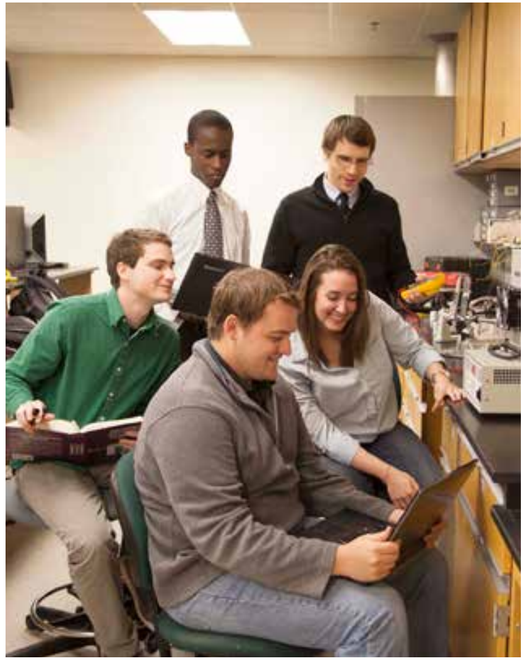
The team used several different components, including the large packed bed column and several rashing rings, among other materials.



Alpha Prototype

Made using 3D printed parts, it stores an array of four dye-synthesized solar cells that will maintain experimentally derived optimal conditions, which include temperature and humidity.

Climate Adaptable Solar Energy System



"We had great advisors. They were the perfect amount of tough on us and helpful."

Designing energy systems that are adaptable and provide undisturbed service in different climate conditions is an essential challenge for sustainable design. Current photovoltaic solar energy cells can convert up to 26 percent of solar energy into electrical energy when under laboratory conditions. Dye-sensitized solar cells (DSSCs), which currently only convert up to 15 percent of solar energy into electrical energy are cheaper to manufacture than traditional photovoltaic systems, offer greater mechanical durability, and are a rising competitor for the current solar energy system market. This project involves the design and construction of a Climate Adaptable Solar Energy (CASE) system that uses DSSCs and aims to address the performance reduction due to changing environmental conditions. Symbiotic organisms of fungus and algae within lichen exhibit environmental adaptability through close integration, thus living as a single organism. The CASE system is a biomimetic design, inspired by lichen, and applies biological concepts of protection and energy conversion to achieve adaptability. DSSCs were implemented as the driving mechanisms for harnessing energy for the system from the sun, just as algae performs in lichen. Since the DSSCs were commercially unavailable, the DSSCs were assembled from core components contained in a kit. The DSSCs were tested in laboratory conditions and outdoors in the Shenandoah Valley area. Life cycle and cost/benefit analyses were performed to ensure the system meets environmental and economic needs. Design iterations for the alpha and beta prototypes occurred after analyzing testing results, thermal gradient analysis, life cycle assessment, and cost/benefit analysis.

Senior Project Team

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Nicolas Acton

Jonathan Hill

Melissa Bernazani

Michael Hinton

Advisors

Jacquelyn Nagel, Ph.D.

Kyle Gipson, Ph.D.

Cooling Apparel for Motorcyclists

The students test the cooling apparel through simulating a hot summer day with insulated hot water flow.

Motorcyclists who wear protective gear, including jackets, long pants, boots, gloves, and full-face helmets are sensitive to the heat of summer. Heated clothing is currently commercially available for riding during the colder months of the year, but the only cooling apparel available for riding during the summer months is mesh clothing or water saturated clothing, reliant on evaporation. In addition to the 25 million Americans who ride motorcycles annually, there are potential cooling apparel applications for the military, police, border patrol and multiple sclerosis patients, who have difficulty maintaining thermoregulation, and others. The basic research question of this project is: can a system be designed to provide portable cooling power in the form of a shirt or jacket? Throughout the two year capstone journey, students developed a light-weight, flexible, washable, non-toxic, shirt or jacket that would be safe in the event of a crash or fall. The shirt is currently comprised of 10 Peliter Devices which are wired in a combination of parallel and series and attached to the bikes power supply. These Peltier devices allow for heat to transfer away from the skin allowing the skin to maintain a cooler, more comfortable temperature of about 37 °C. The Peltier Devices are attached to heat sinks allowing for the heat to transfer away from the body at a rate of about 5W each. The combination of Peltier Devices and heat sinks are sewn between two layers of under armor material, resulting in comfortable cooling apparel.

Senior Project Team
Christopher Doyle
Mallory Middleton
Jordan Owens
Thomas Price

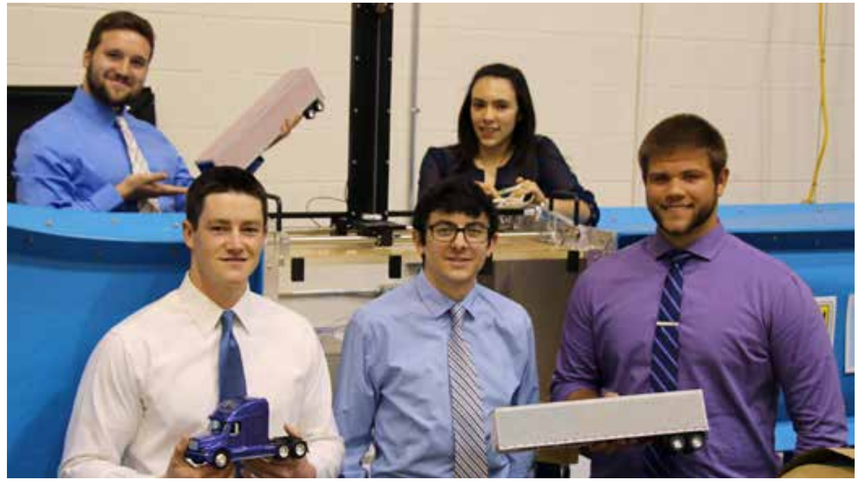
Advisor
Dr. Steven Harper

External Sponsor
Dr. Andrew Klein

Cooling the Ride

The product will be used to help cool down riders on a hot summer day.

Drag Reduction



The team designed an add-on device to reduce drag on Class 8 tractor-trailers.

The aerodynamic phenomena is not yet fully understood, but studies suggest that surface protrusions and gap coverage can lead to the reduction of aerodynamic drag on Class 8 tractor-trailers. Surface protrusions, as in the case of shark skin riblets, deal with skin friction, whereas gap coverage concepts deal with pressure drag. Total drag is the sum of pressure and skin friction drag. Reducing total drag increases fuel savings and reduce CO2 emissions. A 10% reduction of drag results in 6% fuel savings that equate to a decrease of 10764 pounds of CO2 emissions by tractor trailer per year. The widely commercialized drag reducing products are side skirts and trailer tails. This research focuses on the development of surface protrusion and gap coverage with expected 10% reduction and ease of manufacture and commercialization having a ROI similar to the existing technologies. Herein, the systematic and rigorous design process and the results from scaled-down wind tunnel tests and preliminary computational fluid dynamics (CFD) simulations using ANSYS CFX. The surface protrusions designs interact with the energy-bearing eddies and influence the energy dissipation rate having a positive effect in the reduction of the turbulent boundary layer and wake region; hence, skin friction drag and pressure drag. Gap coverage concepts help streamline the body of the tractor-trailer and eliminate the region of recirculating air between the two blunt bodies (tractor and trailer), thus also reducing pressure drag. Metrics of concept evaluation are also based on environmental impacts, manufacturability, maintainability, reliability, usage and disposal, cost effectiveness, etc.

Senior Project Team

Ziza Machado

Case VanWingerden

Jordan Pappas

Bryan McAlexander

John LeMaire

Advisor

Dr. Olga Pierrakos

Dr. Heather Watson

Increase Fuel Savings, Reduce CO2 Emissions

A 10% reduction of drag results in 6% fuel savings that equate to a decrease of 10764 pounds of CO2 emissions by tractor trailer per year.

Respect

"When you are content to be simply yourself and don't compare or compete, everyone will respect you."

Laozi

Testing 1 2 3

A laptop, speakers, microphone, webcam, and custom designed hearing test software were used for this teams hearing test platform.

Hearing Test Platforms

"I chose this project because it has personal significance and could increase my own hearing abilities."

The distributable hearing test platform is a novel advancement for research in audiology. With this system, scientists will be able to collect longitudinal data on patients before and after they have undergone various interventions to ameliorate hearing loss. The testing system is deployable to patients' homes where they can take the hearing tests at their convenience. The hearing tests we administer are more realistic and they will provide data useful for understanding how the brain learns to use a 'new' ear. Receiving the hearing test system is significantly cheaper and more convenient for the patient than traveling to take the existing, less informative test. The system currently includes two hearing tests - one that tests the ability to localize sound and another that tests the ability to distinguish speech from noise. This team has focused on the development of the speech-in-noise test. The portable hearing test platform includes a laptop and mouse, eight speakers arranged in an array, a microphone, and a webcam. The alpha prototype for the speech in noise hearing test has been validated and deployed to our first testing site: UVA's Department of Otolaryngology, where it will acquire initial data on sound localization and speech in noise abilities. The final beta prototype, which will be delivered to our client in May 2014, will be sent to patients' homes to allow for long-term data collection.

Senior Project Team

Tanvir Battu

Brittany Harwell

Advisors

Dr. Robert Nagel

Co-Advisor

Dr. Lincoln Gray, Dept. of Communications Sciences and Disorders

External Sponsors

Dr. Bradley Kesser, Dept. Otolaryngology Head & Neck Surgery, UVA

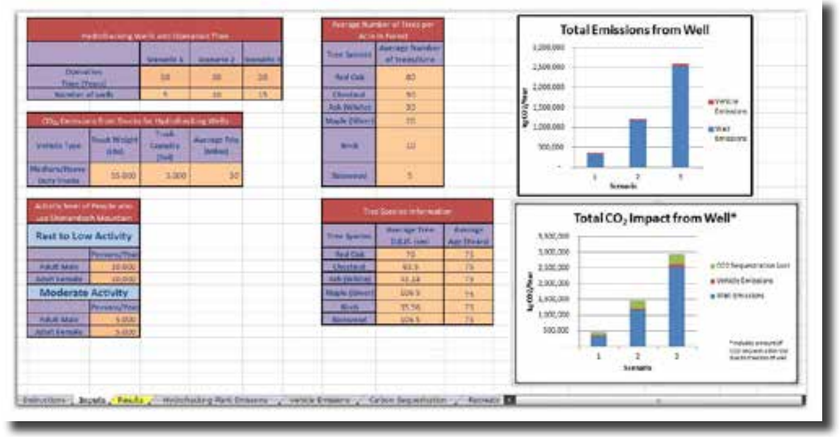


Chart it Out
The input tab of the assessment tool shows the impact of adding hydraulic fracturing wells.

Hydraulic Fracturing Assessment Tool Team

The team discusses the format of the assessment team

The purpose of this project is to develop an assessment tool to analyze the carbon dioxide impact of hydraulic fracturing in the Shenandoah Mountain region. Shenandoah Mountain is located in the George Washington National Forrest in Virginia between Route 33 and Route 250. The assessment tool is used to determine carbon dioxide equivalent emissions from the operation of hydrofracking wells. The tool was created for Friends of Shenandoah Mountain to analyze their land use proposal for the United States Department of Agriculture. Friends of Shenandoah Mountain hopes to designate the land as a wilderness area. The assessment tool analyzes four areas of carbon dioxide balance for the region. These include the operation of the hydrofracking facility, vehicle transport, recreational use, and carbon sequestration. Research was conducted to determine how to calculate the emissions from all four areas. A common metric was chosen to combine the emissions and sequestration to obtain a carbon dioxide balance. Different hydrofracking facility developments can be compared using the assessment tool. The result of the project is the assessment tool and the ability to easily compare and contrast the various hydrofracking facility developments. The project has created a useful tool that Friends of Shenandoah Mountain can use to determine carbon dioxide balance in their land use proposal.

Senior Project Team

Robert Edmonds

Tyler Fagg

Hunter Knopp

Marissa McDonald

Advisors

Dr. Brad Striebig

Dr. Elise Barrella

External Sponsors

Lynn Cameron – Friends of Shenandoah Mountain

Microbial Fuel Cell

Senior Project Team

Dorrie Matthews

Amanda Shapiro

Advisors

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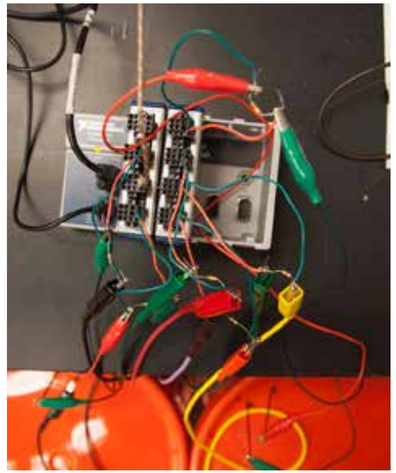
Bradley Striebig, PhD.

External Sponsor

Songhai Center

"As a small team, we knew it would be challenging, but we were excited to work on a project that could positively impact developing communities."

Developing nations have limited or non-existent access to reliable electricity and clean water. Having the ability to generate any of their own electricity could be useful, even if it just powers an LED to provide a light source. In addition, finding a way to remove harmful pathogens from their wastewater is vital to the residents' health. The capstone project focuses on the development of a microbial fuel cell (MFC) system for a developing community at the Songhai Center in Benin, Africa. MFCs capture electrons produced by bacteria while they break down waste in water. The MFC system will use a waste stream resulting from existing food processing activities at the Center and potentially provide both a modest amount of stable electricity for use in a local health clinic and a treated water supply on site. The team constructed and tested a MFC design in the lab to find an affordable design that both efficiently generates power and effectively treats the water. In the testing, sugar water simulated the food processing waste that the Center would generate. Power outputs and chemical oxygen demand efficiencies measured the MFC's performance, which the team tested at various influent concentrations and electrode spacing. The MFC design still needs further development to better meet the Center's needs, which can be continued by a Junior Capstone Team. Eventually, the end goal is implementing a MFC at the Center, who can share the technology with other developing nations through its connections with the UN and the ECOWAS countries.



COD Level Check

The team uses these products checks their voltage outputs and COD levels of MFC prototypes.

From House to Home

This is the half-scale prototype of the structure. The left side of the back wall shows how modifications can be made using natural materials and the right hald shows how the temporary structure would look upon assembly

Modular Living Structure

This is the team at work in the lab building a half-scale prototype of the structure. Prototyping has been the team's main method of exploring various structure designs.

This adaptable housing project was developed in response to refugee camps and natural disaster relief encampments that become long-term or even permanent homes and cities to their residents. Issues such as improper sanitation, limited food and clean water supply, poor infrastructure planning and a general lack of inhabitants' control over their own resources arise because these living situations were not originally designed for permanent domicile. This project explored the development of a modular structure that can be constructed quickly and simply, and that will provide for the immediate shelter needs of those in a disaster situation (similar to traditional relief systems). In contrast to traditional systems, the modularity of the design allows for later additions of housing units to expand on a single dwelling or for the connection of several individual units for the purpose of sharing resources. Over time, this adaptability serves long-term human needs such as further infrastructural development, establishment of communal space, and a sense of security, thereby empowering the population in the community where the structures are built. The project was approached by decomposing the Modular Living Structure into its components: the wall frame, roof, floor, wall covering and anchoring system. Concept generation, concept evaluation and concept selection were performed separately for each of these components. Prototyping, both analytical and physical, has been the method most used by the team to experiment with various concepts during the evaluation phase. Currently, a prototype of the temporary structure is almost complete.

Senior Project Team

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Sojin Kim
Anase N'Gadi
Maile Wood

Advisors

Dr. Stephen Harper
Dr. Jacquelyn Nagel
Dr. Kurt Paterson

Alpha Prototype of Photography Robot

The teams goal was to enable photographers to obtain close-up, high quality photographs of wildlife while maintaining the safety of the photographer and the equipment as well as eliminating the need for expensive high powered lenses.

Photography Robot

The Photography Robot team pictured on campus with their project.

In order for a wildlife photographer to capture quality photos from a safe distance, an expensive, long zoom lens is typically used. Without the use of a high magnification lens, the photographer must approach the wildlife, potentially creating an unsafe situation. Additionally, close proximity to wildlife can compromise an authentic, natural photograph. The goal of this project is to enable photographers to obtain close-up, high quality photographs of wildlife while maintaining the safety of the photographer and the equipment as well as eliminating the need for expensive high powered lenses. To accomplish this goal, a remote controlled robotic vehicle capable of moving the camera closer to the intended subject using a standard lens will be designed and built; this will provide the desired zoom at a lower cost. The robotic photography vehicle must be capable of navigating dry terrain typical of the Shenandoah area which includes dirt, grass, loose gravel, and pavement. The vehicle must be able to traverse slopes of ±15° and overcome obstacles up to four inches tall. The robot must safely support the weight of a digital single-lens reflex (DSLR) camera, position the camera via user input, and have a runtime of two hours. Viewing wildlife from short distances using a remote-controlled robot increases photographer safety and minimizes adverse effects of human intrusion into animals' territory.

Senior Project Team

Brian Bojarski
Evan Brown
Blake Lumpkin
John Quackenbush
Farrell Robinson

Advisors

Dr. Jacquelyn Nagel
Dr. Robert Nagel

External Sponsor

Bradley Striebig of Striebig Photography and Design

Shrapnel Resistant Product

"This project was really intriguing because of its real life applications and how it could potentially save lives."

The original intent of the project was to identify a current type of military technology and re-engineer it. The project direction began with protecting U.S. military soldiers, equipment, and vehicles from enemy firepower. Through research, it was determined that a major threat to the military in the Middle East was Improvised Explosive Devices (IEDs). These are homemade explosive devices made from household items with the intent to harm or kill and are prevalent in Afghanistan and Iraq. While lacking the proper protection, there is an increasing amount of civilian casualties from IEDs. Civilian protection against the effects of IEDs is a critical need and became the main focus of the project. The scope of the project was narrowed to protecting civilians outside the area of the initial pressure blast and focusing primarily on preventing lethal injury from shrapnel. The team is creating a product that can be worn at all times that is resistant to shrapnel, lightweight, and affordable. The process used has included identifying the design requirements including the force upon impact that a piece of shrapnel will apply as well as vital body parts that need to be protected. By gathering existing technology from outside companies, a prototype has been created consisting of a layered, composite material. The utilization of analytical testing and blast impact calculations allowed the different layers of the product to be determined. Physical testing was conducted to verify the product resists the penetration of a piece of shrapnel and meets the set design requirements.

Senior Project Team

Bryce Dillon
Colin McShane
Jared Eastman
Brandon Drury
Jack Vance

Advisors

Dr. Steven Harper
Dr. Samuel Morton
Dr. Robert Nagel

External Sponsors

Dr. Gwen Thomas,
Auburn University

Defense

The group created three variations of a bullet proof vest using donated materials.

South Main Makeover: Multimodal Street Design

The team used Streetmix, a street design and remixing website, to create a visualization of their project.

South Main Makeover

"Our team had a great dynamic and it moved the project along seamlessly."

Since the year 2000, James Madison University (JMU) has seen an increase in student enrollment from 15,965 to 19,927 total students; a rise in nearly 25%. Along with this, the city of Harrisonburg has seen an increase in its population from 40,453 in 2000, to 48,914; a rise in 17%. Many roads that directly service the JMU and Harrisonburg communities have not been altered in order to accommodate the new traffic demands they face from both motorized and non-motorized users. To address this, a corridor of South Main Street - spanning from Grattan Street to South Avenue - will be evaluated based upon the current conditions of the corridor and its ability to handle the traffic demand. The objective of this project is to redesign the corridor into a multimodal corridor that will feasibly and safely integrate motor vehicular, bicyclist, and pedestrian traffic in order to meet the needs of a growing and changing community. Using collected data and traffic simulator Synchro 7.0, as well as the guidance and oversight of both Dr. Elise Barrella and project advisors from the Harrisonburg Department of Public Works (HDPW), various traffic simulation network models of the corridor are designed, created and evaluated. Throughout the process, environmental, societal, technical, and economic impacts are kept in focus. The project culminates with a functional, redesigned South Main Street Corridor that addresses the present and future needs of ever-changing traffic demands.

Senior Project Team

Mallory Draeger
Nick Ferguson
Brit McMahon
Haley Moberg

Advisor

Dr. Elise Barrella

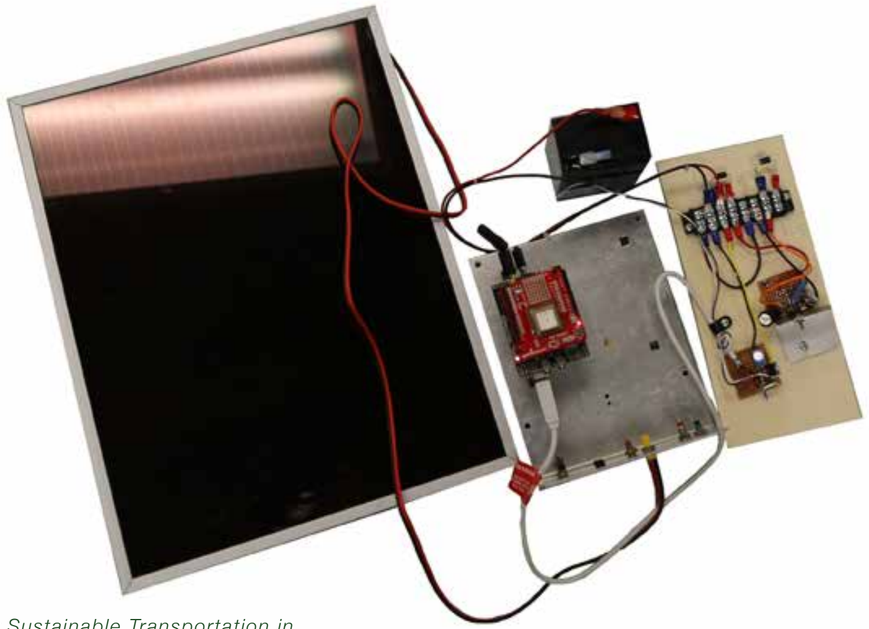
External Sponsors

Brad Reed
Thahn Dang

“Excellence is never an accident. It is always the result of high intention, sincere effort, and intelligent execution; it represents the wise choice of many alternatives - choice, not chance, determines your destiny.”

Aristotle

Excellence



Sensors for Sustainable Transportation in Developing Countries

Prototype of the sensor and power assembly that will be installed on the Matatu.

Sustainable Transportation Sensor

"Our goal is to help developing countries keep public transportation safe and efficient."

In Nairobi, Kenya, privately owned Matatu mini-buses contribute to traffic congestion and negatively impact pedestrian safety. Matatu's are an important part of the transportation landscape in Nairobi. However, Matatus are largely unregulated and drivers may change their routes if they see a chance to increase their profit, leading to high concentrations of idling Matatus. This poses inconveniences and health risks for pedestrians and the environment. One hour of idling releases about 4 pounds of CO_2 into the atmosphere. The purpose of this project is to prototype a device that can relay real-time location information of Matatus, via wireless transmission, to a database accessible by Nairobi city planners. From this database, city planners can analyze frequency and intensity of routes that Matatus use. This information will give planners the information needed to form specified routes for the Matatus as well as the ability to provide potential customers with information on where a Matatu will be at a given time. The project team has broken the problem into four main systems: the power supply, microcontroller-sensor assembly, housing, and data storage. The team has assembled and programmed the microcontroller to collect GPS data and transmit it via GSM capability, which utilizes the cellular networks. This microcontroller will be powered by solar energy and a rechargeable battery, making the device more autonomous. This system will be versatile enough to be implemented in megacities in other developing countries. This project allows for the techniques used in this project to be built upon.

Senior Project Team

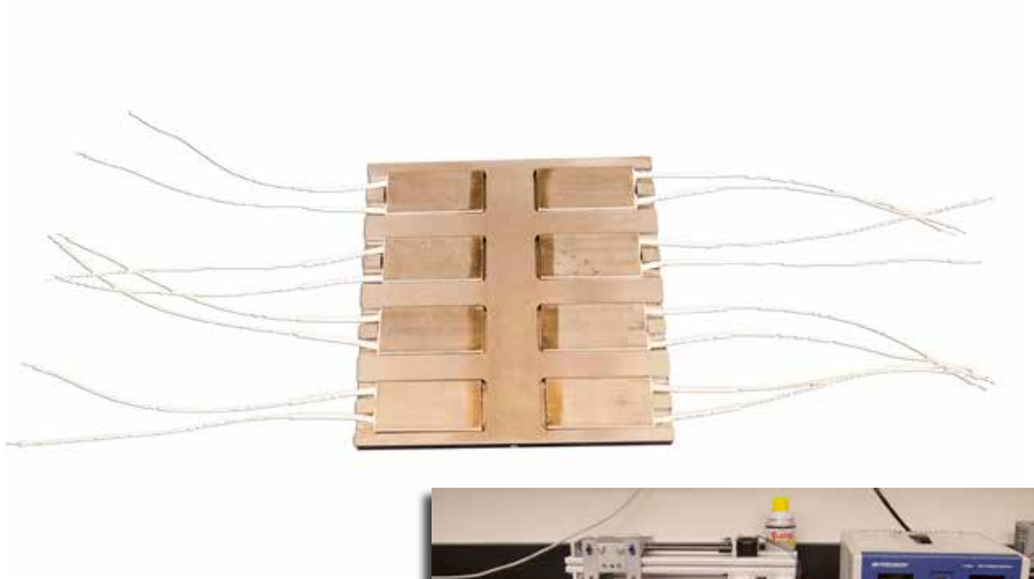
Matt Boyer

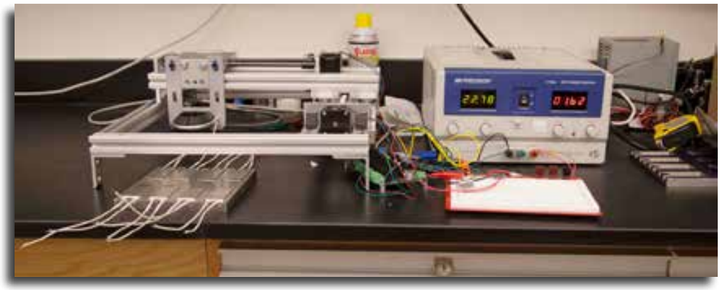
Ethan Thompson

Joshua Yeager

Advisor

Dr. Justin Henriques





Thin-Film Deposition Apparatus for Solar Applications

From left to right: Underside of Hot Plate for Heating System, X-Y frame of the Motion System with electronics.

Thin-Film Deposition Apparatus

Robert Spelman, Kyle Davis, Melissa Dutter, Keith Hutchison, and Joel Greotsem(Pictured from left to right)

Widespread adoption of solar energy technologies, such as solar photovoltaics (PV) and/or photoelectrochemical (PEC) hydrogen fuel production cells, requires low-cost fabrication methods to produce large area devices for solar energy harvesting. Novel thin-film semiconductor materials produced from chemical solution deposition have significant potential to reduce production and manufacturing costs. Thin-film semiconductors, such as BiVO4 and Cu2ZnSnS4, are fabricated by depositing a liquid precursor solution onto a heated substrate using ultrasonic spray pyrolysis, pneumatic spraying, or liquid drop casting. To enable thin-film depositions over larger sample areas, an automated deposition system is being developed. This coating system is comprised of two primary and interacting subsystems: motion and heating control. The motion system controls the path and travel speed of the precursor deposition device, such as the ultrasonic spray nozzle, during the deposition process. During the deposition procedure, the substrates rest on a heated surface, which provides the energy necessary to induce the desired chemical reactions on the substrate and remove unwanted compounds. This surface has a uniform spatial temperature distribution and must be controlled to a constant temperature ranging from 40 °C to 500 °C with a variability of ±4 °C. A specially designed heating plate was designed to meet these requirements. The focus of this work is to design an integrated system that allows a deposition area of 16 in 2.

Senior Project Team

Kyle Davis
Melissa Dutter
Joel Groetsema
Keith Hutchison
Robert Spelman

Advisors

Dr. S. Keith Holland
Dr. David Lawrence

Two Phase Energy System

The team uses a fluid reservoir and pump to simulate full-scale conditions.

This project explores the technical challenge of sustainability as it relates to solar energy production, storage, and consumption. The challenge is addressed through the design of a two-phase renewable energy system that can provide electrical energy during both day and night without the use of chemical batteries. “Phase One” is the conversion of solar energy into electrical energy using photovoltaic panels for both immediate supply to the household load and for storage in a fluid based system. “Phase Two” is the conversion of the stored potential energy back into electrical energy. Methods of energy storage evaluated include pumped-hydroelectric energy storage (PHES) and compressed-air energy storage (CAES). Mathematical models using typical energy efficiency values are first used to estimate system parameters such as reservoir volume and height or pressure requirements. Based on the results, components and the methods of energy storage for further evaluation are selected. A dynamic systems-level model is then used to estimate energy output and efficiency as a function of changing system parameters. This model is validated by simulating full-scale conditions using a fluid reservoir and a pump. Results indicate that PHES is a much more feasible option than CAES for a residential-scale system. Overall efficiency was experimentally found to be as high as about 32% but was shown to increase with increasing hydraulic head. This demonstrates that the system could be a viable replacement for conventional batteries in poor or remote locations, especially if local topography allows for low-cost installation of a raised water reservoir.

Senior Project Team
Jack Cochran
Eric Leaman

Advisors
Jacquelyn Nagel, Ph.D.

Pieces of the Fluid Bench Set Up

Cochran and Leaman used a large set up for their project that included several smaller components including the two shown.

“Alone we can do so little;
together we can do so much”

Helen Keller

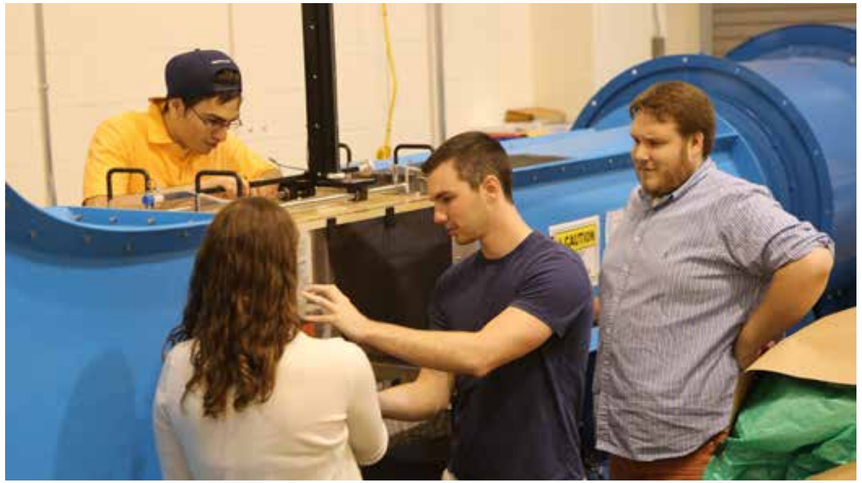
Collaboration

Juniors

Juniors

“It’s cool to see how much of a team
Effort it is to get through this program
- Mackenzie Peterson”

Aerodynamics & Rotors



"We have accomplished a lot in a short period of time and we are grateful to be a part of the first National Collegiate Wind Competition."

The U.S. Department of Energy is hosting the National Collegiate Wind Competition with the purpose of assigning collegiate teams the task of designing and building micro wind turbines. The Aerodynamics and Rotors team was assigned the task of designing and building blades for a micro wind turbine that will fit within a 45 cm3 wind tunnel. Calculations were performed in order to develop concepts and analyze the turbine structure. Six different concepts were generated and then narrowed to three different airfoil blade designs which were prototyped and tested to determine the strength and performance of each blade. The concept selection process was utilized to select a final concept for the competition. This capstone project is important because it provides micro wind turbine designs for residential use, which can be used in developing countries. The target market for the final product is Kenya. The turbine should be easy to use and durable so native residents can use the turbine without any technical training.

Junior Project Team

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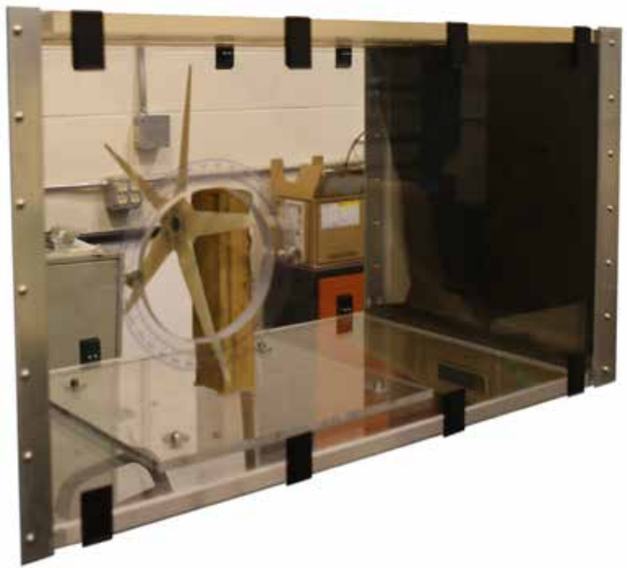
Genevieve D'Antonio
Al Donley
Dixon Drumheller

Advisors

Dr. Pierrakos
Dr. Watson

External Sponsor

Department of Energy



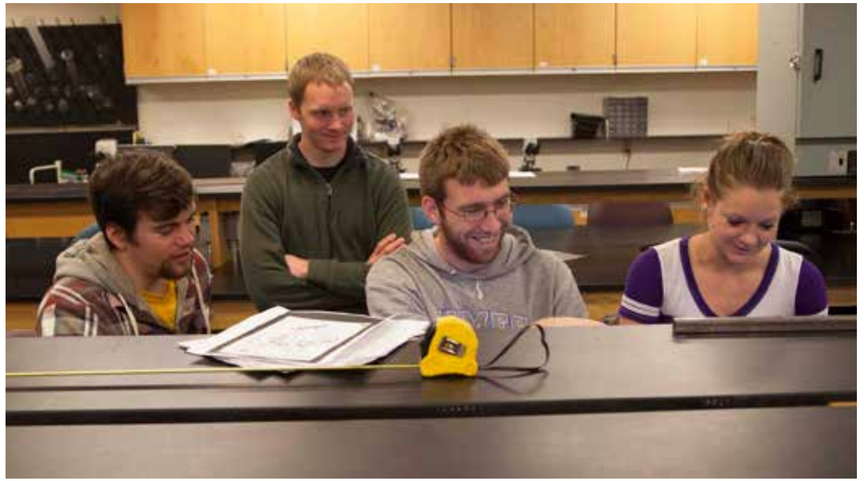
Micro Wind Turbines

Prototype turbin blade testing in a wind tunnel.

Phytoremediation of Selenium through the use of Algae-based Photo-bioreactors

The team's objective was to design a transportable, up-scalable, modular photo-bioreactor which uses algae to absorb selenium contaminants from groundwater collectors on known Superfund sites.

Algae



The team monitoring algae growth and observing the cell count and appearance.

Virginia Power is a coal company in Yorktown, Virginia that is producing fly-ash and disposing of it by dumping it into the former York County Landfill. This process has been contaminating local water sources with large amounts of selenium and has forced the nearby Chisman Creek onto the EPA's Superfund site list. Selenium is a vital nutrient for life; however, in higher concentrations it can create toxic environments for bio-life. This project's objective is to design a transportable, up-scalable, modular photo-bioreactor which uses algae to absorb selenium contaminants from groundwater collectors on known Superfund sites like Chisman Creek. The photo-bioreactor will house the Scenedesmus quadricauda during growth and removal of selenium through nutrient uptake before harvesting the biomass. The alpha prototype will consist of a photo-bioreactor containing LED's, inflow and outflow pumps, and an air pump. The purification process begins with an inflow of contaminated water that will be continuously cycled within the bioreactor using an air pump. A nutrient probe will measure the level of selenium contamination within the medium, and an algae probe will monitor algae concentration and growth over time. The full-scale photo-bioreactor system will be modular, incorporating tri-con shipping containers that are compatible with common military transportation. There is hope that once the project requirements have been achieved, this design can be expanded upon to target a diverse range of contaminants using different algae types. This design will help coal companies reduce pollution, fines, and costs associated with fly-ash disposal. Most importantly, the implementation of this solution will create a cleaner ecosystem, save animals and plants, and allow humans to safely enjoy nature.

Junior Project Team

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Mary Grimm
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Johnny Stein.

Advisors

Dr. Morton

Anaerobic Digestion for the Production of Biogas

The photo above shows an alpha prototype of an anaerobic digestor with organic waste samples.

Anaerobic Digestion

"The best aspect of this project is that it will lead to a completely sustainable system that can be used in the local community."

Large amounts of organic waste are transported from JMU dining facilities to landfills where waste anaerobically digests because of the low oxygen environment, ultimately producing biogas. The majority of biogas is composed of methane, which then enters the atmosphere. This is problematic because methane gas has a much stronger greenhouse effect than carbon dioxide. The objective of this project is to use a controlled anaerobic digestion process to dispose of food waste and capture the methane that is emitted. The by-product will be used as a fertilizer for crops, creating a completely sustainable process. Biogas will then be converted into a useable form that can be utilized in the Harrisonburg community. A multi-batch system of bio-chambers will be implemented to process the food waste generated from East Campus Dining Hall after dinner hours. Each bio-chamber will be connected to a central hub where biogas from each chamber will be collected. The amount of methane produced will be optimized and possibly filtered so that it may be used in applications such as cooking and the generation of electricity. By diverting food waste from landfills, this project will reduce the environmental impact of James Madison University.

Junior Project Team
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Artificial Wind Harvest

"Our team worked very well together with the help and input from our advisor and professors."

The Artificial Wind Characterization team consists of six members from the school of engineering at James Madison University. There are currently no models that describe the wind event that takes place as commuters travel underneath interstate overpasses. The objective of this project is to design a system which allows measurement devices to be transported along an I-beam out over the roadway in order to take measurements that allow for the modeling of the wind events that occur underneath interstate overpasses; in particular overpasses along Interstate 81. Doing this will educate those interested as to how the wind behaves in the hopes that eventually this wind will be harvested and converted to useful energy. A bridge "traveler" will be used to transport measurement devices such as anemometers, barometers, and temperature recorders over traffic to collect data. This data will then be used to create models using Microsoft Excel, ANSYS CFX, and various other thermal fluid software programs. Currently, the team is designing the bridge traveler and selecting appropriate measurement devices that will allow for the optimal characterization of the wind events. The team has divided into two sub divisions: one group designing and constructing the traveler while the other team selects the measurement devices. However, the two sub groups must continue to work together to ensure that system integration is as smooth as possible. The expected results will include the models mentioned above, guidance for future teams, a working bridge traveler, and multiple reports that track the progress of the two-year project.

Junior Project Team

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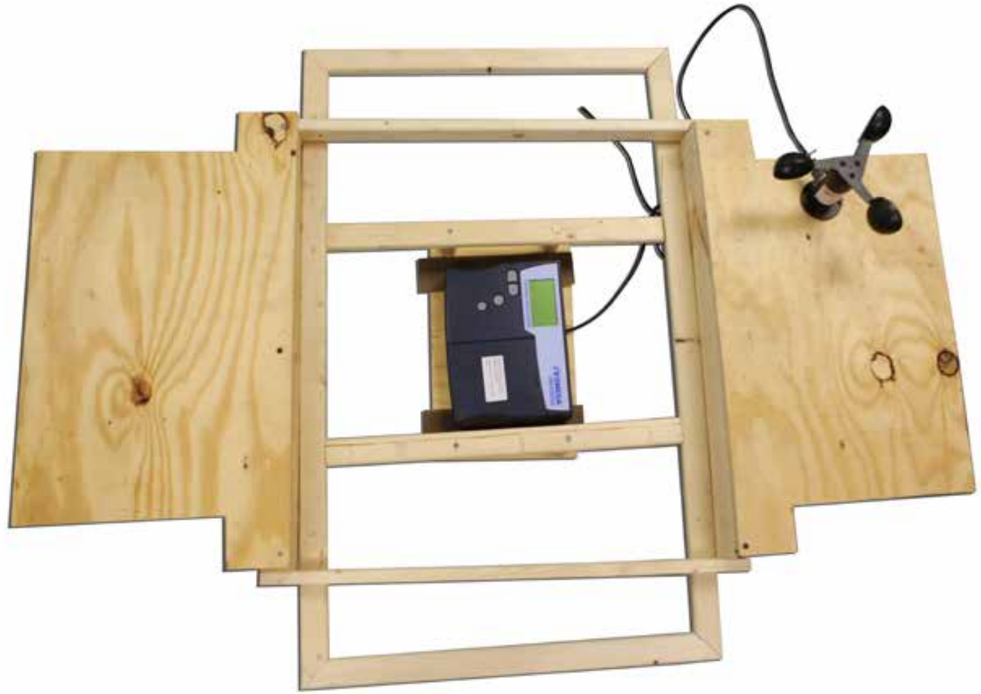
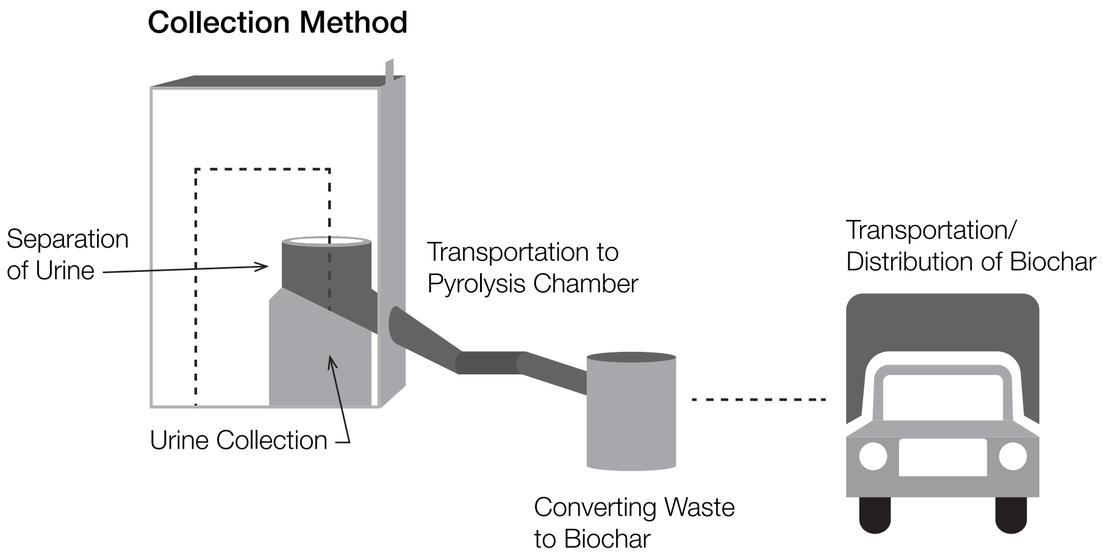


Capturing Wind Under Overpasses

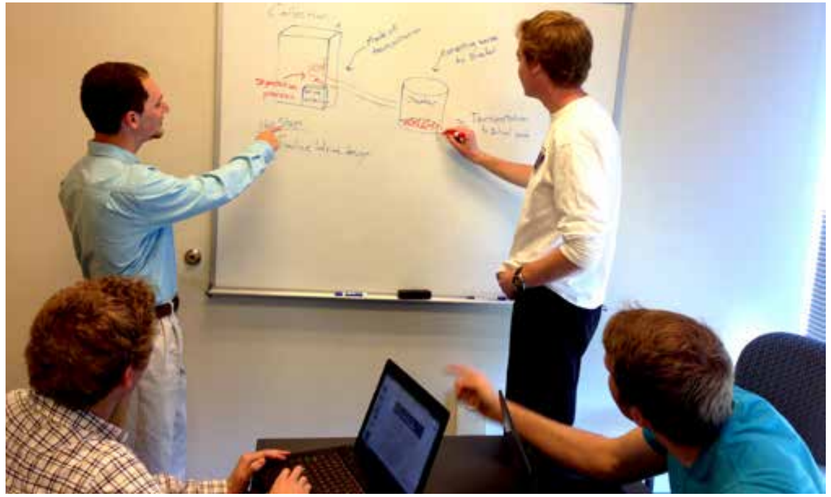
The team created a prototype to characterize the wind activity under an overpass as vehicles, specifically semi-trucks, travel underneath.



Conversion of Human Waste to Biochar Fertilizer through Pyrolysis

The team's project includes a means for the collection of human waste, the transportation of waste to the pyrolysis chamber, and a pyrolysis process producing biochar to be used as fertilizer.

Biochar Fertilizer



The purpose of the biochar system is to create a closed loop system by recycling human waste in order to reduce health risks and utilize the nutrients in a positive manner.

Throughout the world, roughly 2.6 billion people lack access to improved sanitation. This leads to water borne diseases that take the lives of 115 people each day in Africa alone. The purpose of the biochar system is to create a closed loop system by recycling human waste in order to reduce health risks and utilize the nutrients in a positive manner. The objective is to maximize the production of biochar when using human waste as a feedstock while minimizing the energy requirement of the pyrolysis process, burning in the absence of oxygen, and health risks. The project includes the means for the collection of human waste, the transportation of waste to the pyrolysis chamber, and the pyrolysis process producing the biochar to be used as fertilizer for local flower beds. The first step of the process was to research the problem, intended area of implementation, and pyrolysis. This information was used as the foundation for designing each individual subsystem. Slow pyrolysis was determined to be the best method for producing biochar. Wood was chosen as the fuel source over other options such as natural gas because of its local availability and stability/safety. Currently the designs for all subsystems are being finalized. Through the remainder of the semester each subsystem will be integrated into one final and comprehensive design. It is anticipated that the physical prototyping will begin at the start of the fall semester.

Junior Project Team

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Weather Master

The team challenged themselves to design an electric bike that can be operated in most weather conditions that is specifically tailored to the topographies of Harrisonburg and Charlottesville.

Electronic Bike

The team works on their electric bicycle prototype.

The electric bicycle is emerging as a competitive mode of personal transportation for daily commuting needs. A common problem associated with current electric bicycle technology is the inability to commute comfortably and safely in inclement weather conditions. The objective of this capstone project is to create a relatively affordable means of transportation that can be operated in most weather conditions that is specifically tailored to the topographies of Harrisonburg and Charlottesville. The methods used to address this problem include: benchmarking of current electric bicycles, modeling local commuting routes, developing concepts and testing prototypes, and refining concepts into a final design. The current status of the project is to expand on preliminary modeling and prototyping to further the development of concepts that will lead to a final design for the project.

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“The more that you read, the more things you will know. The more that you learn, the more places you’ll go.”

Dr. Suess

Learning

Electronics & Controls

The team uses a non-traditional trial and error design approach and conceived many feasible designs.

The utilization of fossil fuels creates many disbenefits for a sustainable society. As such, many innovations are created in an attempt to alleviate the burden of non-renewable energy resources. One major innovation, continuously being improved, is high performance wind turbines. Thus, the Department of Energy proposed a competition to create a small scale wind turbine. The wind turbine will be used in any energy deprived countries as a means for charging common battery powered electronic devices, i.e. laptops and cellphones. For testing purposes, the turbine must be operated in a wind tunnel only large enough to hold two 5 gallon buckets. Therefore, the parameters of components were appropriately scaled for testing. Due to the deliverable deadline of May 1, 2014, many components of the project were chosen in relation to the always present time constraint. Many scale analytical models were created for component merging studies and to acquire fabrication documents. A non-traditional trial and error design approach was implemented and many feasible designs conceived and conveyed through the aforementioned analytical models. Furthermore, testing rigs and apparatuses were constructed to obtain actual turbine performance and component efficiency. Currently, the electronics portion of the project is underway as well as the design of the turbine infrastructure. When each of the sub-deliverables for the wind turbine is fabricated, the sub-deliverables will be merged to create the final deliverable.

Junior Project Team

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David Harootyan
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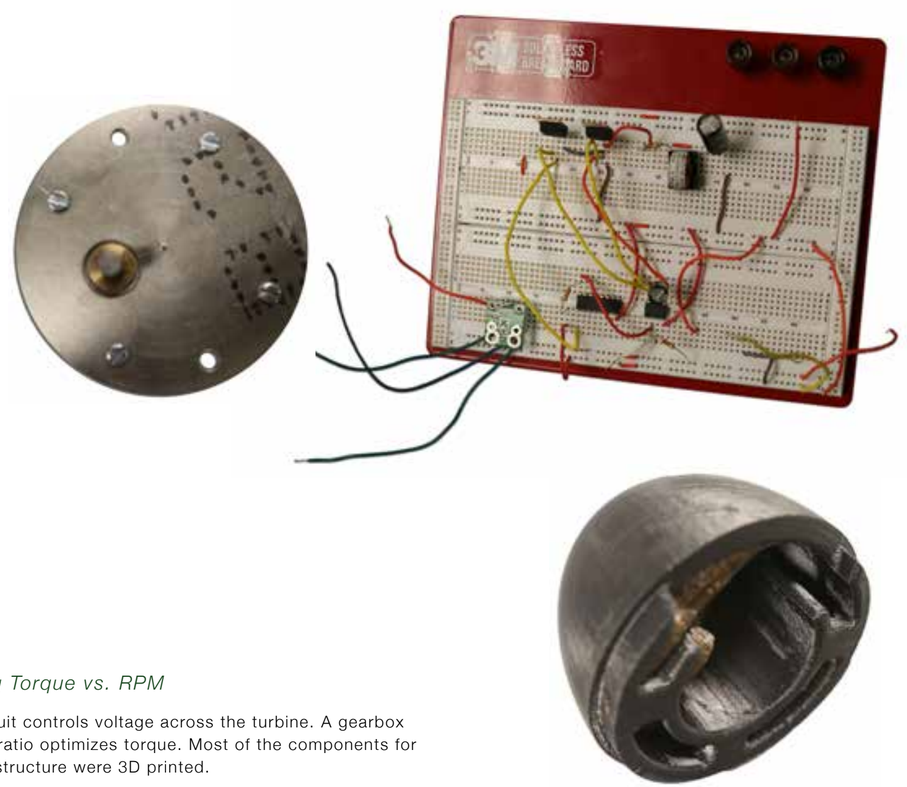
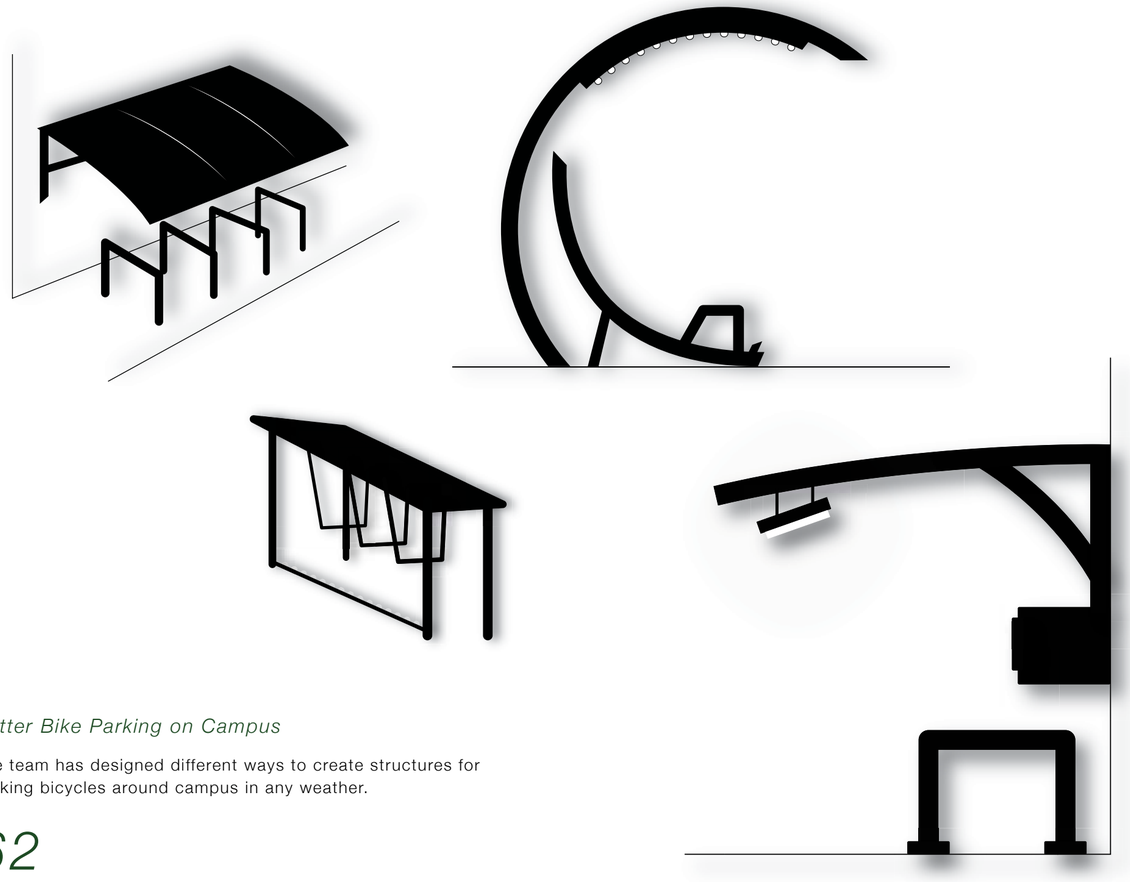
Dr. Miles, NCWC



Optimizing Torque vs. RPM

A Buck Circuit controls voltage across the turbine. A gearbox with a 25:1 ratio optimizes torque. Most of the components for the turbine structure were 3D printed.



Better Bike Parking on Campus

The team has designed different ways to create structures for parking bicycles around campus in any weather.

Four Season Bike Parking

The lack of proper bike parking and weather conditions are two huge barriers when it comes to students, faculty, and staff biking on campus. The need for improved bike parking has been identified using several different means. The Four Seasons Bicycle Parking Solution Team is working with bicycle advocates and potential users to help improve the bicycle parking system for JMU. By looking at ways to put bicycle parking where it is most needed and helping to protect bicycles from outside influences such as the weather and theft, they plan on increasing the number of bikers on campus. Using methods such as personal and bulk surveys, the specific needs of the potential users have been identified and will be used as the team moves forward during the current concept generation phase. These concepts will lead to a large array of potential designs and prototypes that will then be evaluated, tested, and narrowed down to a final solution. Their goal is to have a final design by the end of their two-year capstone period in order to develop a presentation for the JMU Bicycle and Pedestrian Advisory Committee as well as any other stakeholders. The team is also trying to have the design accepted by JMU and implemented on campus for future classes. In hopes to continue with the study, a forthcoming capstone group could continue in-depth testing and find other ways to accommodate biker's needs.

"We chose to work on improving the bike parking system at JMU because we are all interested in civil engineering."

Junior Project Team

Garrett Cashman

Stefan Haas

Jon Nagy

Tyler Wade

Advisors

Dr. Elise Barrella

Quantum Efficiency Measurement Apparatus

The photo above shows the testing set up for calibrated photodiode and LED.

IPCE

"The project gives us the opportunity to get in a lab and prepare for graduate school."

The objective of this project is to create a low cost, accurate, and reliable Incident Photon to Charge Efficiency (IPCE) measurement system, also referred to as a Quantum Efficiency (QE) measurement system. Quantum Efficiency or Incident Photon to Charge Efficiency is a measure of the electrical current generated by a photosensitive material relative to the intensity of the light incident on the material. The efficiency is a quantifiable measurement for the spectral response of a given photonic materials electrical sensitivity for generating a measureable current; thereby effectively characterizing material performance across a range of particular wavelengths. However, these measurements are collected via the use of expensive laboratory equipment. In turn, research opportunities are limited and therefore highly selective to institutions, universities, etc. capable of providing the necessary measurement systems. Such IPCE/QE measurement systems are critical instrumentation for the research and development of novel photonic materials and systems for next generation photovoltaics, photocatalysts, biological reactors, and optical sensors. The project stakeholders have identified an opportunity to design an IPCE/QE measurement system that is less than 1/3 the benchmarked price of currently available research grade IPCE/QE systems. Reducing the design cost of currently marketed systems includes pursuing alternative solar simulation forms and light filtering methods while implementing more cost-effective components within a modular type QE system that provides comparably accurate efficiency measurements to those previously benchmarked. The resulting low-cost system is intended to reduce barriers of research of novel photonic materials and provide an alternative method for preliminary evaluation of photonic material performance.

Junior Project Team

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External Sponsors

JMU Center for Materials Science

Olive Packaging System

The team's new packaging system was designed to increase the rate of packaging and decrease the amount of manual labor input.

Olive Oil

The team tests their new packaging process.

Laconiko is an award-winning extra virgin olive oil and kalamata olive company whose olives are grown in the Southern Peloponnese, located outside of Sparta, Greece. Laconiko's sorting and distribution center is located in Gainesville, Virginia. Laconiko is known for their outstanding olive oil products and would like to begin to expand the production and distribution of their kalamata olives. Laconiko needs a packaging process/system developed to replace their current method for packaging, which is archaic and entirely manual. The stakeholders involved in this project consist of the owners of Laconiko, the retailers of their product, and the consumers purchasing their products. The scope of the project is to design and implement a new packaging process to increase the rate of packaging and decrease the amount of manual labor input. The end deliverable of this project is a new packaging system that increases Lakoniko's production and decreases the overall input of manual labor, while ensuring the olive quality/shelf-life is maintained, in order to help Laconiko increase their profitability as an olive distributor.

Junior Project Team

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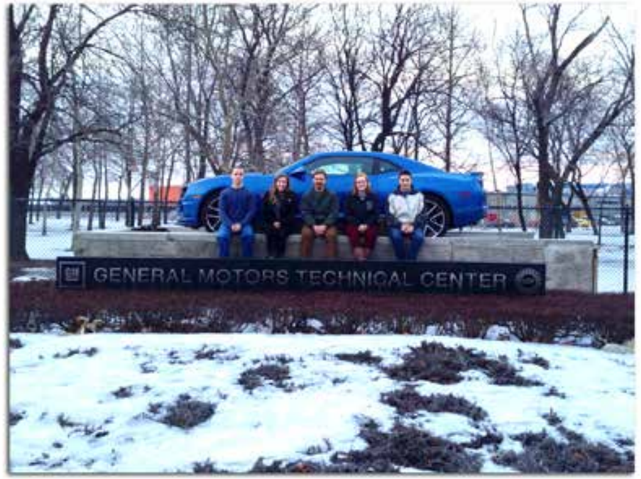
Laconiko



Implementing a Product Failure Knowledge Management System

The team along with advisor, Dr. Robert Nagel, siting outside of the General Motors Headquarters in Warren, Michigan on their trip to Detroit in March 2014.

Product Failure Management

The team of students is currently working with the Research & Development and Product Quality staff at General Motors to develop and implement a system for managing and applying product failure knowledge in the FMEA process.

Engineers conduct Failure Modes and Effects Analyses to anticipate failures throughout a product's life cycle. They are not able to anticipate all potential event failures stemming from users' interactions with the product, and environmental influences, which occur over the product lifecycle as well as failures occurring at unanticipated interfaces between various functional systems. This team of students is currently working with the Research & Development and Product Quality staff at General Motors to develop and implement a system for managing and applying product failure knowledge in the FMEA process. The project is being executed in three phases: 1) Students will perform reverse engineering on a representative sample of vehicle subsystems to develop a knowledge base of potential failure causes and effects. The completeness of this knowledge base will be verified by comparison to vehicle warranty claims for the subsystems investigated. 2) Students will encode the knowledge generated in Phase 1 in an ontology of potential failure causes and effects. Students will then develop a database and user interface to automate the process of developing ontologies for additional vehicle subsystems. 3) Students will evaluate the effectiveness of the ontology and the knowledge management tool conducted in Phases 1 and 2 by investigating a previously unstudied vehicle subsystem. In addition, the students will redesign this system to remove failure modes identified by the tool. Currently, the team has completed phase one and is in the process of generating concepts and beginning to gather data in order to begin coding the database system.

Junior Project Team

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Fletcher Grow

Mackenzie Peterson

Jeremy Rhodes

Advisor

Dr. Robert Nagel

External Sponsors

General Motors

Joe Donndelinger – Vehicle Systems Research Laboratory

Robotic Assistance

The team created prototypes of their concept using the university's CNC Machine.

Robotic Assisstive Technology

From left to right: Sean Micucci, Rachny Soun, Nicholas Henriksen and Jason Nembhard, hard at work analyzing and refining their manual prototype.

The Robotics Assistive Technology Team is tasked with designing a process for assembling a latex probe cap onto a cardboard tube for use on a Tonometer reading device. A Tonometer reading devise is used by optometrists to sanitarily test patients for glaucoma. The process requires that 8000 units are made by 4 personnel over an 8 hour work day. The team is working with an external client, Friendship Industries Inc., who is a community engaged company whose main task is to employ people living in the Rockingham, VA area who aren't otherwise readily employable. The team has used engineering methods for concept generation such as morphological matrix, SEED method and finally used the design matrix to identify the best of the proposed concepts. The selected concept was a hand tool designed to stretch the latex over the cardboard tube. A prototype of this concept was built using the university's CNC Machine and was delivered to the client in February. The team returned to the concept generation phase, taking what they've learned from the first prototype and applying that knowledge into new proposals. The team just finished a second round of concept generation and plans on delivering a second manual prototype to the client by May.

Junior Project Team

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Jason Nembhard
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Dr. Robert Nagel

External Sponsors

Friendship Industries

Stormwater Remediation

Junior Project Team

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Lauren Distler
Sameer Saini
Richard Schommer

Advisors

Dr. Elise Barrella
Dr. Joy Ferenbaugh
Dr. Kyle Gipson

External Sponsor

Thanh Dang, Harrisonburg Department of Public Works

Abe Kauffman & Dale Chestnut, JMU Facilities Management

The Stormwater Remediation capstone team works together on research and test result analyses.

Black's Run is a polluted stream over eight miles in length flowing through downtown Harrisonburg, Virginia. The Grace Street corridor, located on James Madison University campus, is an outlet for many nonpoint source pollutants flowing into Black's Run. These pollutant streams are a result of stormwater runoff and leaching from surrounding rural areas, roofs, and streets. Specifically, pollutants include solid sediments resulting from erosion; oils, gas, and heavy metal particles coming from cars and exhaust; and organic contaminants including Nitrogen and Phosphorous which are the result of agricultural activity. Additionally, the majority of the land cover on Grace Street is impervious surfaces and materials. The presence of these non-absorbent surfaces lead to excess stormwater flow and pooling in empty lots on the street. In order to determine a specific subsystem or location of focus within the Grace Street Corridor, the quantity of water flowing from each outlet to Black's Run must be analyzed. Using this information, a design plan for the management of incoming stormwater to Black's Run can be developed, modeled, and implemented. This plan will aim to increase the overall aesthetics of the system location and surrounding environment, and more broadly, improve Grace Street as a place for the community. The proposed management technologies will minimally impact existing ecosystems and raise awareness of pollution in the Harrisonburg community. This project will take place within a four-semester time frame, and the end result will be designed to help the stakeholders meet city and state stormwater remediation codes and standards.

A Better Place for the Community

The team's plan aims to increase the overall aesthetics of the system location and surrounding environment, and more broadly, improve Grace Street as a place for the community.

Waste to Water

The team working in lab optimizing prototype system for capstone symposium.

In 2001 a major outbreak of Cholera occurred in Benin, Africa. This is located in western sub-Saharan Africa where there were 3,943 cases and 71 deaths due to Cholera in the water supply. The goal of this project is to create a point of use chlorine water treatment system to be implemented for cholera outbreaks in Benin, Africa. The system must be portable, easy to use, and be able to treat large volumes of water at a rapid rate for use in disaster relief efforts. The system chosen by the customer must be a chlorine treatment system. The reason chlorine is the right choice is that it is a proven inhibitor of Cholera bacteria replication. The chosen method is an electrolysis chlorine-producing system. This system will be able to be brought to the Songhai Center in Porto Novo, Benin for use in preventing Cholera outbreaks. Currently the team is beginning to test a proof of concept in the lab, in preparation for testing in Benin this coming summer.

Junior Project Team

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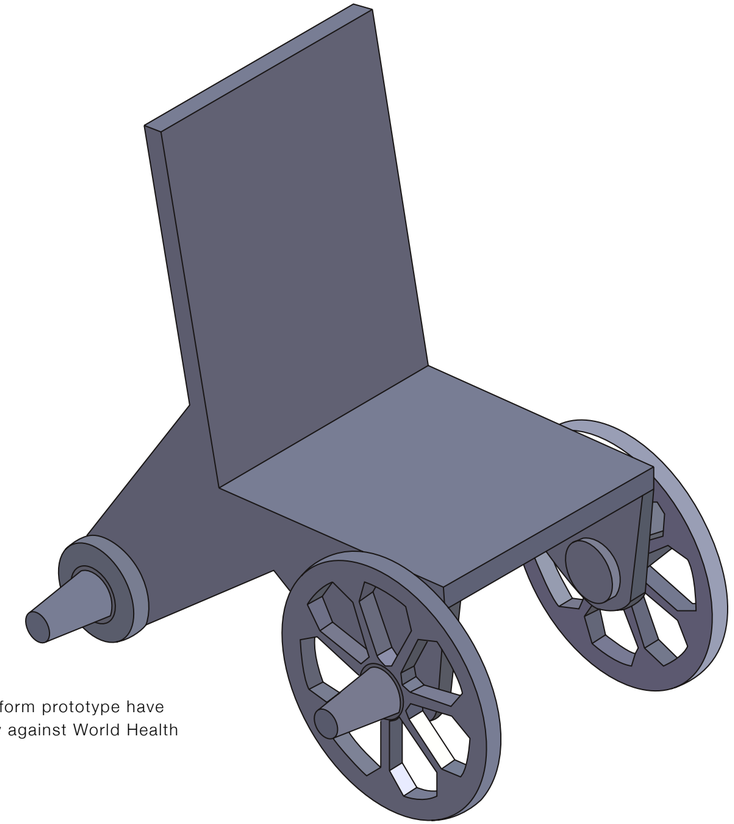
Joseph Gossen
Tim Wilson
Xun Sun

Advisors

Dr. Bradley Striebig
Dr. Samuel Morton

Water Treatment System for Disaster Relief

The team's goal is to design a system that is portable, easy to use, and able to treat large volumes of water at a rapid rate for use in disaster relief efforts.



CAD drawing prototype

Three CAD drawing prototypes and one form prototype have been created and vetted for functionality against World Health Organization standards.

Wheelchairs for Haiti

The team works together to design and produce a wheelchair to be used by Haitian children.

Handicapped children in rural Haiti affected by polio or cerebral palsy typically do not have wheelchairs suitable for their environment and cannot afford a wheelchair designed for the local conditions. It is more difficult for children who are not mobile to participate in village life. The Wheelchairs for Haiti team aims to design and produce a wheelchair to be used by Haitian children to increase their mobility so they can engage in village life and attend school. Stakeholders include handicapped Haitian children and the point of contact in Haiti who has provided necessary information to the process. Three CAD drawing prototypes and one form prototype have been created and vetted for functionality against World Health Organization standards. Frame, center of mass, and tip-slip analysis calculations are performed to assist with evaluating materials available in Haiti, as well as how the wheelchair design will function on the diverse terrain of Haiti. The end deliverables of the project are a complete and working prototype that has been rigorously tested and refined, and a comprehensive sustainability analysis that ensures the product can be owned, produced, and operated in Haiti.

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Terence McKeever

Advisors
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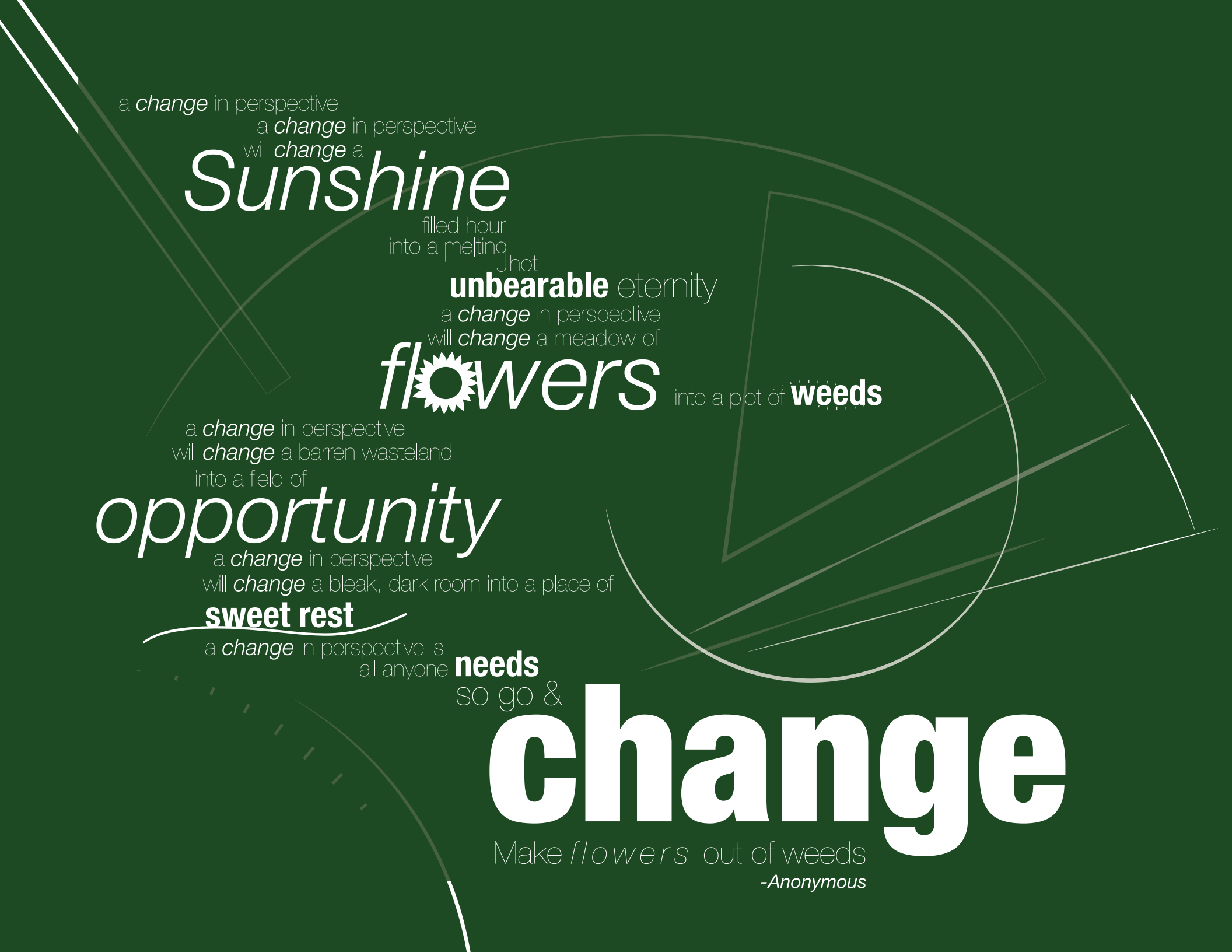
Dr. Mary Tacy


a change in perspective
a change in perspective
will change a
Sunshine
filled hour
into a melting hot
unbearable eternity
a change in perspective
will change a meadow of
flowers
into a plot of weeds
a change in perspective
will change a barren wasteland
into a field of
opportunity
a change in perspective
will change a bleak, dark room into a place of
sweet rest
a change in perspective is
all anyone needs
so go &
change
Make flowers out of weeds
-Anonymous