Solutions

INSIGHT • INNOVATION • IMPACT®

VANDERBILT SCHOOL OF ENGINEERING
Nashville, Tennessee

JUNE 2022

IN THIS ISSUE:

RECYCLING bottles to bricks

CREATING music and academic research

SHOWCASING over 100 design projects

THE DESIGN ISSUE 2022

Front cover design by Tim Kovick/Finn Partners Southeast

Inside front cover photo by John Russell/Vanderbilt

Back cover photo by John Russell/Vanderbilt

Solutions

VANDERBILT SCHOOL OF ENGINEERING
Nashville, Tennessee

INSIGHT • INNOVATION • IMPACT

JUNE 2022

Bottles to Bricks:

Engineering team looks at recycled glass to improve building materials, protect environment

Researchers may have a solution for all the waste glass building up in landfill sites.

A Vanderbilt University professor and two undergraduate students in the School of Engineering are participating in an innovative research project that aims to use recycled glass to enhance building materials and infrastructure as well as reduce waste.

Juniors **Emily Zeller** and **Nicole Witherell**, both civil engineering majors, and research adviser **Ravindra Duddu**, associate professor of civil and environmental engineering, are collaborating with the University of Alabama on the "Bottles to Bricks" project.

In 2018, the U.S. Environmental Protection Agency estimated that a total of 12.3 million tons of glass, roughly four percent of all municipal solid waste, was generated in the United States. Of that amount, only about 31% was recycled. Moreover, the amount of waste glass has gradually increased since 2018, due to an ever-growing use of glass products, and more waste glass being dumped in landfill sites.

"This is undesirable towards reaching a sustainable or environment-friendly consumer practice, as waste glass is not biodegradable and perhaps a safety hazard," says Duddu. "Therefore, there is a need for developing solutions to use waste-glass materials and reduce their proliferation in landfills without resorting to expensive recycling."

As a possible solution, the project seeks to use waste glass in construction, which researchers say can address the global need for advanced, multifunctional building materials, either as load bearing units or as cladding. Additionally, waste glass could be incorporated into building materials for either new high-performance construction or to repair and enhance the performance of existing structures.

The project goal is to develop a versatile building product, known as concrete masonry unit or simply concrete block/brick, which can incorporate waste glass at large weight fractions without significantly impacting its overall strength or performance. Thus, waste glass can be repurposed into a usable ingredient for typical concrete mixes by crushing or grinding unrecycled glass. Previously, glass has been successfully used in asphalt concrete mixtures as a partial aggregate replacement, as well as a fine aggregate in pipe bedding, landfill-gas venting systems, and gravel backfill for drains.

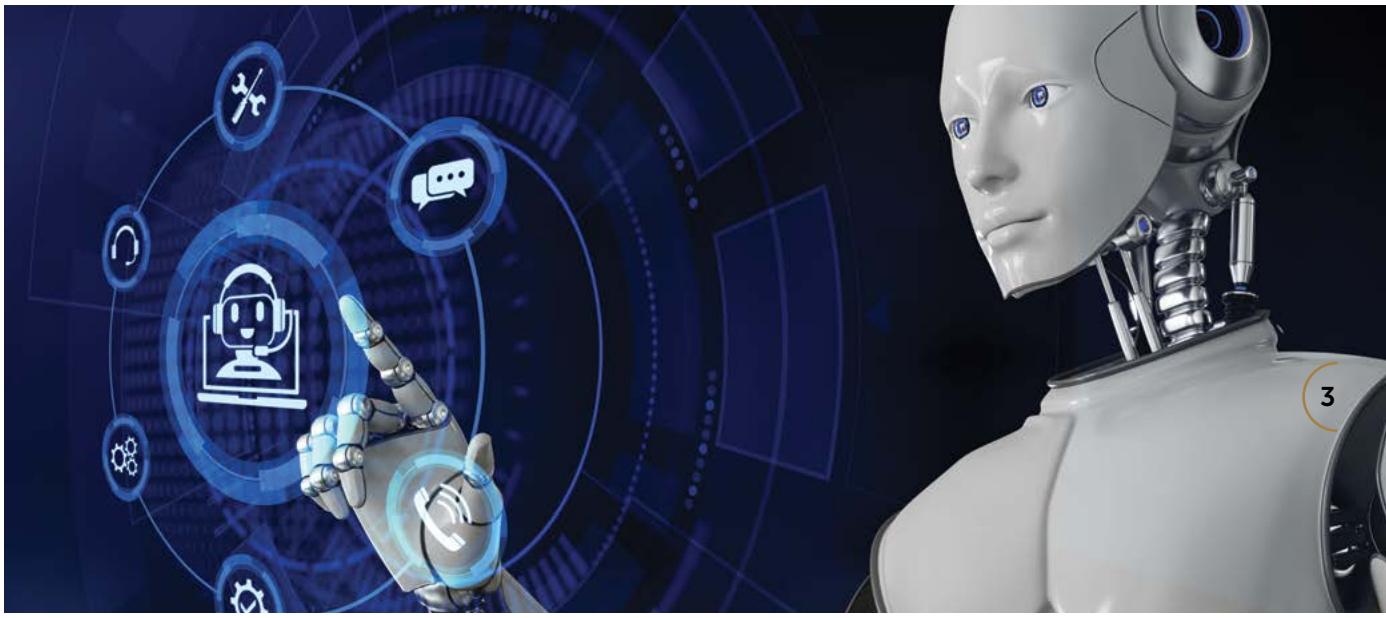
The University of Alabama team, led by Professors Sriram Aaleti and Armen Amirkhanian at the Center for Sustainable Infrastructure, is focused on mix design and strength/durability testing of the concrete bricks, while the Vanderbilt team is engaged in social and economic impact analytics, particularly how glass is recycled in Nashville and other major metro areas in the South. For instance, it costs about $40 per ton of glass to recycle it in Nashville, compared to $38.50 to put it in a landfill, which is frequently the destination because of the cheaper cost. However, these cost estimates do not include the externalities related to pollution and other negative environmental impacts.

Funding support for the project is provided by Good Molecules, LLC.

Engineering students' computer program wins Mental Health Innovation challenge

A chatbot — a computer program that simulates and processes human conversation — was the winning entrant in the Mental Health Innovation Challenge and Hackathon at the Wond'ry, Vanderbilt University's innovation and design center.

Sponsored by the Vanderbilt Clinical Informatics Center in partnership with Health IT at Vanderbilt University Medical Center, the event in February drew engineering students, nurses, medical students, Medical Center project managers and biomedical informatics graduate students.



Serving as judges were Cheryl Cobb, MD, associate professor of clinical psychiatry and behavioral sciences; Neal Patel, MD, MPH, professor of pediatrics and chief informatics officer with Health IT, and **Charleson Bell**, PhD, research assistant professor of biomedical engineering.

Designed to engage with behavioral health patients before and after outpatient visits, the chatbot is intended as a patient portal feature. It would triage patients and generate symptom scores and other summary information for provider review via an electronic health record dashboard. The chatbot was designed by **Dennis Zhou**, **Daniel Kang**, **Ricki Calbert** and **Kelli Stewart**.

Second place went to a mobile app that would use machine learning to identify people with high suicide risk based on data from their mobile phone and other smart devices, electronic health record and optional patient-reported outcomes. The app was designed by **Pragnya Adapa**, associate professor of biomedical engineering, and students **Seth Smith** and **Hannah Slater**.

Third place went to an online platform that would use quizzes and other mental challenges to monitor cognitive decline and provide engaging activities to stimulate brain health. The platform could be used by health care teams to track memory scores. The platform, dubbed AxonBlast, was designed by first-year engineering students **Neelesh Raj**, chemical engineering; **Siddharth Shah** and **Tahsinul Abir**, computer science.

Winning teams received online shopping gift certificates.

Self-powered wildfire detection plan earns CEE team national runner-up

A team of Vanderbilt undergraduate engineering students took the second spot in a national Jump into STEM challenge to develop holistic solutions that improve the resilience of the built environment.

The students proposed a self-powered system to detect wildfires, especially in rural communities that do not have access to the networks and resources available in more populated areas. Their idea was a self-sustaining, triboelectric generator, which uses contact electrification that takes place when certain materials become electrically charged after separation from a different material with which they were in contact. Everyday static electricity is one example of the triboelectric effect.

Finding a way to power temperature and carbon monoxide sensors without using lithium-ion batteries was a top priority to make the system more resilient as well as affordable, said ***Alex Holzke****. He and team member* ***Jillian Flynn*** *are rising seniors in civil engineering.* ***Francisco Diaz-Rodriguez****, a rising junior in civil engineering, and* **Ethan Rand***, a rising junior in engineering science, rounded out the team. They competed in the "Resilience for All in the Wake of Disaster" challenge. The Jump into STEM Challenge is a national online building science competition designed to attract undergraduate and graduate students to the field.*

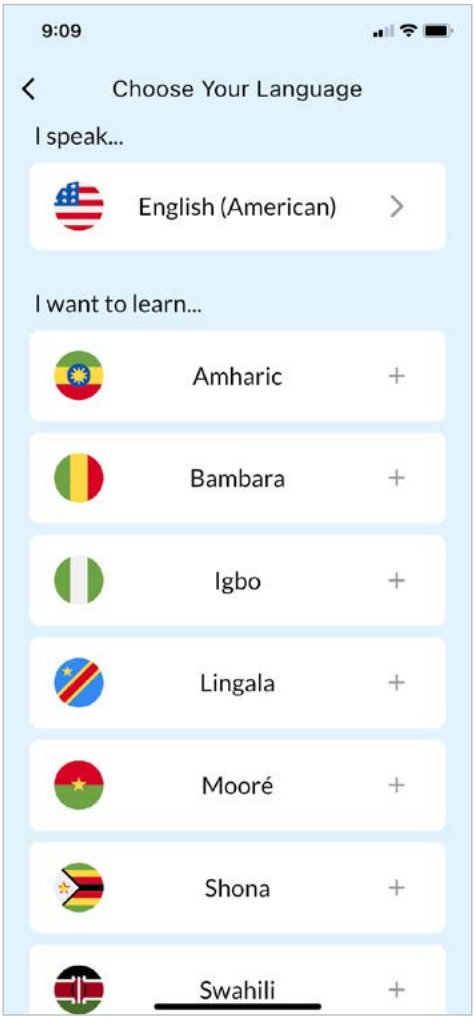
EE student spearheads design of African language app to connect with native roots

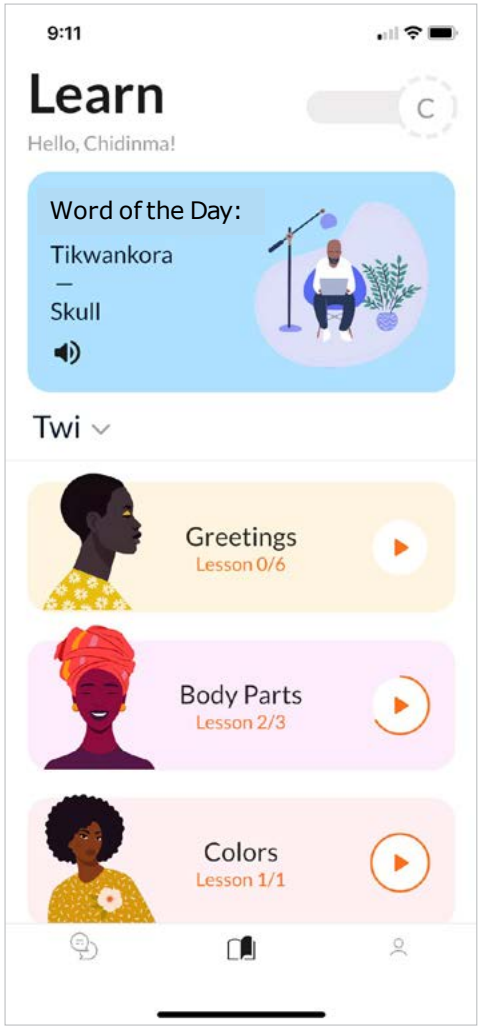
In Burkina Faso, West Africa, where **Wenitte Apiou** grew up, the official language is French. After moving to the U.S., Apiou realized he hadn't had the opportunity to learn his family's native languages, like Mooré and Kassem.

"This is something that always bothered me," said Apiou, a rising junior pursuing a double major in electrical engineering and math. "It makes it difficult to communicate with some of my family members who might not speak French."

Unable to find tools to help him learn those native tongues, he decided to develop an accessible learning program for African languages that often are left out of mainstream platforms. Apiou turned to the Wond'ry and joined its 2021 Builder Program, which provides a step-by-step launch guide for aspiring entrepreneurs with early-stage ideas. He built a team that included another Vanderbilt undergraduate, two students from Harvard University and one from MIT.

They named the app Mandla, which derives from the word "Amandla" or "power" in Zulu and Xhosa, a rallying cry in the face of apartheid-era oppression. Mandla includes a "Word of the Day," a translation tool and interactive lessons for 10 languages so far. He also plans to introduce a social feature that will consist of a chat room with individuals conversing in the language the user is learning. The free Mandla App is available in the Google and Apple stores.





Mandla includes a "Word of the Day," a translation tool and interactive lessons for 10 languages so far. Apiou also plans to introduce a social feature that will consist of a chat room with individuals conversing in the language the user is learning.

Grad student combines study and music in dazzling display

Mayna Nguyen, a biomedical engineering graduate student, wanted to combine her love of music with her academic research in biomedical optics.

Searching for ideas, Nguyen found references to harps that use lasers to produce sounds, which tapped into her experience playing a traditional harp in middle and high school orchestra. She mentioned it to her faculty mentors, biomedical engineering professors **Anita Mahadevan-Jansen** and **E. Duco Jansen**.

"I had heard of it, and so I jokingly said, 'You should build one,'" said Jansen, an avid amateur musician. "Next thing you know she was at home for a weekend and did just that, with her dad building the frame and her incorporating the lasers, the sensors, putting the control systems together and programming."

In the laser harp, beams of light replace strings and building one from scratch is not an easy task. Nor is playing it, though Nguyen succeeded and hopes to use this project to bring awareness and convey excitement for science and engineering to young students pursuing STEM fields.

She is involved with the Biomedical Engineering Graduate Student Association and the SPIE Student Chapter assisting with STEM outreach in the Nashville area.

In the lab, Nguyen explores the stimulation and inhibition of neurons using light, including lasers. Neuromodulation is being studied as a minimally invasive, drug-free treatment for cardiac arrhythmia, high blood pressure, asthma, sleep apnea, and diarrhea, as well as an alternate method to treat chronic pain.

"Vanderbilt provided the opportunity to combine so much of my background into one project," Nguyen said. "My harp background, my engineering degree and my current research focus all came together to accomplish this fun build."

Engineering grad student co-leads effort to help pregnant women and infants worldwide

A chemical engineering Ph.D. student co-leads a team of researchers and patient advocates to identify areas across the world in need of health care for pregnant women and infants.

Anup Challa chairs the Special Populations Coordinating Committee for a project organized by the Critical Path Institute, an independent nonprofit, public-private partnership with the FDA. The committee comprises representatives from the United States and the Republic of South Africa, as well as from the World Health Organization. They identify and advise CDRC partners on how to combat health disparities.

Drug repurposing, also known as drug repositioning, aims to identify new uses for medical treatments that have already received regulatory approval. Benefits include shorter development times, lower costs and increased governmental support. This appointment also aligns with Challa's research in drug repurposing and applying real-world data to enhance the regulation of drug use in pregnant women.

"There are very few safe and effective therapies for diseases related to pregnancy, women's health and early childhood," said Challa, BE'21, MS'21. "This makes drug repurposing particularly important for special populations." He also is drawing on relationships with academic mentors to develop interdisciplinary programs that can improve the quality and efficiency of consumer drug development practices.

Mobile IoT app developed by grad student wins IEEE award

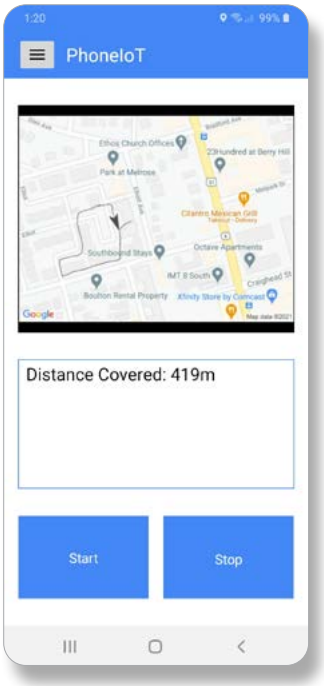
In thinking about developing an app for NetsBlox, a block-based programming language that introduces distributed computing to young learners, **Devin Jean** asked himself a simple question: Would he, as a middle school or early high school student, be interested in the data sets NetsBlox could access?

The answer was no. "I would not be interested in this as a kid," said Devin Jean, a second-year computer science graduate student. "You can pull all this data, but you cannot interact with it."

His answer: PhoneIoT, a mobile app that connects to NetsBlox and introduces the Internet of Things in the classroom, giving users access to all the sensors on an iOS or Android mobile device. Jean wanted to address barriers that have made it difficult to include some of the most ubiquitous contemporary computing concepts—IoT, cyber-physical systems, networked sensing, and actuation—in K-12 computer science and engineering education.

PhoneIoT won Best Showcase Award from the 2021 IEEE Symposium on Visual Languages and Human-Centric Computing.

With the app, students use NetsBlox to communicate with the device and retrieve live sensor data. What that means is the ability to create tilting controls for a game with the phone's accelerometer or device tracking capability with the phone's location data, as two examples. They can add labels, buttons, joysticks, and image displays as controls on the customizable screen and write the code that responds to user interface actions.



NetsBlox already allowed users to create simple multiplayer games like trivia contests and turn-based games like Tic Tac Toe. Users can play with each other or access publicly available data sets for science projects on earthquakes, astronomy, weather, or air pollution.

Enabling access to phone sensor data was a natural extension, Jean said.

PhD student mentors undergrads on week-long STEMSEAS expedition

As a Vanderbilt undergraduate, **Miguel Moravec** took part in a research cruise that used multibeam sonar to map areas of the Queen Charlotte Fault off the Southeast Alaskan coast. He and other students also visited Exit Glacier Park and saw first-hand how fast glacier ice had receded over the past 50 years.

"It was really impactful," said Moravec, now a Ph.D. student in civil and environmental engineering. "I really wanted to get involved in climate change."

Moravec also wanted to stay involved with the STEMSEAS program that gave him the onboard experience. He recently took his first expedition as a STEMSEAS mentor, helping introduce a group of community college students from Washington to the wide range of NSF-funded research at sea. The cruise aboard R/V Thomas G. Thompson spanned seven days and 1,000 nautical miles, from Seattle to San Diego.

Miguel Moravec (top right)

While onboard, the students worked in teams to complete research projects employing the ship's scientific instruments, ranging from fluorescence sensors to microplastic tow nets. They did everything from measuring cyanobacteria activity to documenting changes in ocean acidity and temperature and salinity using probes that fell to the sea floor.

The program is open to all undergraduates, regardless of major, and participants must comply with enhanced maritime industry COVID precautions.

alumni wisdom

Portfolio of alumnus-led green roof company includes top NYC projects

The Javits Center, the United Nations, and the Chrysler Building share more than status as New York City landmarks. They all have, or will have, green roofs designed by a company co-founded by a Vanderbilt engineering alumnus.

Sulman Usman, BS '12, is the CEO and a co-founder of Adaptive Green, a leading startup in sustainable roof technology. He also is a Vanderbilt Posse Foundation Scholar alumnus and recently joined the program's Advisory Board.

"We design and build systems to help cities adapt to climate change, and help architects, civil engineers, and developers meet new building code requirements and create value from a previously underutilized asset—roof spaces," Usman said.

Adaptive Green, which launched in 2016, has designed and installed more than half a million square feet of green roofs in New York, Washington, D.C., and California for clients including Toll Brothers, Lendlease, Lennar, and Skidmore Owings & Merrill.

The UN project is known as the Gandhi Peace Garden and features more than 20,000 square feet of green roof that combine solar panels and plantings.

Vanderbilt-developed gunshot detection technology leads to arrest in Las Vegas shooting

Gunshot detection technology developed by Vanderbilt engineers and commercialized by a longtime research partner recently led to an arrest in a fatal shooting in Las Vegas.

Within seconds of the first shot in late August 2021, 16 sensors located along the Fremont Street Experience pedestrian mall provided the precise location and video—captured immediately before and after the shooting. The data led to the identification and eventual arrest of the suspect.

*Such a success story is gratifying to **Janos Sallai**, PhD '08, an early developer of the technology and now chief technology officer at Databuoy, the company that licensed and commercialized it. Databuoy began working with Vanderbilt on the technology, which began as a DoD-funded project in 2006.*

"It was a great time to be at the Institute for Software Integrated Systems," said Sallai, who was a research scientist and research assistant professor in computer science before joining Databuoy full-time in 2017.

Databuoy, which is based in McLean, Virginia, has installed gunshot detection systems inside schools and courthouses and outside in high crime areas and busy places such as the Fremont Street Experience. The company spent years validating the sensor array technology at indoor ranges, tunnels, and real-world environments. The technology accurately identifies gunshots while classifying and segregating other loud noises such as fireworks, vehicle backfires, popping balloons, or heavy machinery.

*"This is a great example of how technology originally developed for the military finds its way into the civilian world," said **Akos Ledeczi**, professor computer science and electrical and computer engineering. "Originally, we were working on locating enemy snipers quickly to protect our soldiers and now the technology helps law enforcement."*

Cybersecurity startup wins new accolades—and funding

A blend of technical, military, and governmental expertise has proved a winning combination for the three Vanderbilt alumni who founded ARMS Cyber.

The cybersecurity startup earned a $750,000 Phase II Small Business Technology Transfer grant from the U.S. Air Force and the $25,000 grand prize in a tech startup competition hosted by VetsInTech and JPMorgan Chase.

Founders **Brad Potteiger**, MS'16, PhD'19, **Tim Potteiger**, MS'17, and **Michael Bryant**, MBA'12, have combined experience with the NSA, NASA, the White House, Amazon and Techstars. Tim Potteiger has built safety-assurance modules for operational NASA missions, while Brad Potteiger developed geo-spatial analytics and cyber exploitation technology for supporting warfighters overseas. Bryant, former director at the Center for Entrepreneurship at Owen Graduate School of Management, served in the U.S. Marines as a field artillery officer from 2006 to 2010.

"Many don't realize that an entrepreneurial spirit is implicit in military service," said Mark Elliott, a retired U.S. Army colonel who is head of military and veterans affairs at JPMorgan Chase. "Military life involves constant flexibility and organization and gaining trust in new settings, which are all critical skills for building a business."

ARMS Cyber targets software security vulnerabilities before developers have had the chance to patch them, aiming to proactively eliminate zero-day attacks.

The SBTT grant and VetsInTech award follow several wins in 2020. After working with the Wond'ry, Vanderbilt's innovation center, ARMS Cyber in 2020 took first place in the Southeastern Entrepreneurship Conference's student pitch competition and the 36|86 pitch competition. They also were selected for the National Science Foundation's Innovation Corps and the Catalyst Accelerator the same year.

"Watching students transfer what they learned at Vanderbilt and the Wond'ry into a company that is solving a serious and emerging global threat is an accomplishment the entire Vanderbilt community can be proud of," said **Deanna Meador**, the Wond'ry's director of entrepreneurship.

7 Questions with Bob Higgins

President and CEO of Barge Design Solutions

As a child, **Bob Higgins,** BE'97, says he constantly asked his father the question: Why? While an intern with Barge Design Solutions, Higgins thought about the possibility of one day leading the design firm and pondered: Why not? Today, he is the president and CEO of Barge going on 13 years. He is also a member of the Vanderbilt School of Engineering's Board of Visitors and has been named one of the Nashville Business Journal's Most Admired CEOs three times in a row. Higgins has helped establish a scholarship in the name of Barge Design Solutions for the School of Engineering. Barge employees also mentor students, visit classes, provide internship opportunities and oversee student design projects. Higgins, personally, is a strong believer in mentorship and helping others achieve success. Why, you might ask? His answers to the following questions may shed some light.

1 Do you have a favorite book, one you'd recommend to others?

Yes. *The First 90 Days*, by Michael Watkins. As I have grown in my career, it's about managing those leadership transitions and having a formula, or a process, to manage those. Where you go from a young engineering intern to a project engineer, to a professional engineer, to a project manager, to a business segment leader. That book captures the very essence of a good formula for a solid leadership transition. We give it to every leader we promote at Barge.

2 You're in a public-facing, high profile engineering leadership position with significant responsibilities to the public and to your business both day-to-day and long-term. What drives you?

It's two things that get me fired up every Monday morning. It is the people who come together, collaborate to bring projects to life. And it truly is the good that the projects do. As a young engineer at Vanderbilt, I remember reading about how water quality and treatment did more to extend the human life expectancy than any other advances ever in human history. It was then I started to realize the good that comes from all of this problem-solving talent we have. Then I come to work for Barge. There's a ribbon cutting in a big field, and 27 months later there's a fully functioning treatment plant with 200 jobs that increases people's quality of life. You're at the plant, and you're helping that community deliver affordably and efficiently, water quality. And then, just watching the team come together and make that project happen, that fires me up!

3 Public safety and welfare are paramount in the engineering profession. Inevitably there are going to be tensions between business decisions and responsibilities to the public. How do you approach those tensions, especially as the leader of the business with many young engineers looking to you for direction?

We have an orientation class, and I go to every one of them. We talk about our values, and who we are as a company. What I tell people is sometimes folks are going to challenge you, maybe do things unethical. And it's a slippery slope to take that first step toward something unethical, something that doesn't align with our values. You will get fired. Don't do that! Don't start down that road because it's too important; our brand, our reputation. When you begin to compromise your values or ethics, you start losing touch with who you really are. And it's too important to violate those for money or business. So, we stress that in the hiring process; we stress it in orientation. Don't let somebody else drag you into something that's going to change who you are.

4 You've been on the record about influences in your life and the value of hard work and how you enjoy problem solving. Have you ever questioned your choice of major in college?

My father said I wore him out during my entire childhood asking why something did what it did. He was a self-taught electrician and a maintenance man at a factory. He said I drove him nuts asking, *why dad, why are you doing that?* My mother has a picture of me in our carport where I had sawed my wooden tractor in half with my new tool kit to find out how it worked. I never challenged the thought of being an engineer, it was just what kind. Summer employment helped me decide. I worked for

utilities where I'd see waste-water systems. I had a knack for that. I fell in love with it. When I came to Barge as an intern, I realized I would get to do it for a hundred utilities. And that was it. I always had the curiosity, that problem-solving nature. I wanted to be an engineer from an early age. And then through summer employment I really honed-in on what type of engineer I wanted to be. Vanderbilt's program helped me focus even more.

5 What would you tell your 21-year-old self in the thick of your engineering education?

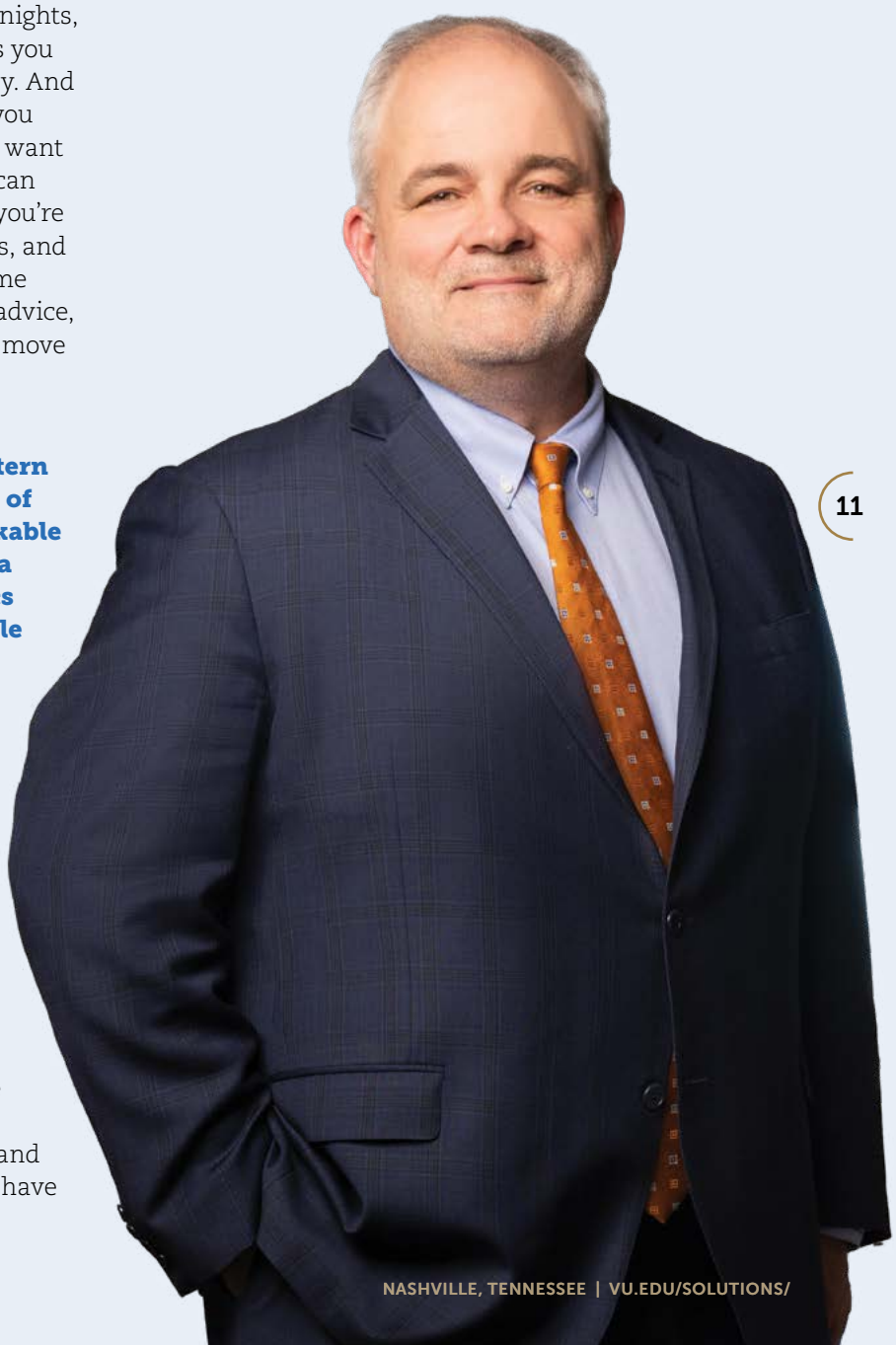
I was so intensely focused on the work and the studies. I didn't do a lot of the group activities. I would tell that young person now, and I do when I mentor, to get involved more in the university. Get involved in the professional societies. Get involved in the industry nights, things like that help you. Because networking helps you understand more about your options in the industry. And I would say engage in summer employment when you can, because that can really help clarify where you want to plug-in in your field of study. That network, you can carry it through the rest of your career. And when you're all sitting around and you're in your forties or fifties, and you're running different companies, you'll have some friends out there. And you never know when their advice, their counsel, their business relationship, will help move you forward even more.

6 You started at Barge as a student intern and are now the president and CEO of the company. That's a pretty remarkable rise in the corporate ranks not being a co-founder. With the Bureau of Labor Statistics suggesting average job tenure for young people is about two years and the average number of jobs over one's working life is about 17, do you think it is still possible to go from the entry level to the board room?

I do. It may not be your first stint with the company. You might leave and come back, with as much change that's going on right now. But growing up at Barge, and being an intern, and being a project engineer, project manager, I think companies can realize where people are in their careers. When you come out of college, you're wanting to learn technically as much as you can. So, mentoring, connection to peers, connection to the industry are so important. If we can meet the commitment of those folks early on, and make sure as a company we're meeting that, and get them excited about it, they don't feel like they have to go somewhere else.

7 What do you look for in a new hire?

Values. Values. Values. We can train you to do anything, practically. But I cannot teach a new set of values to somebody. The source of most confrontation, or most challenges in the workplace, usually is a values misalignment. One technique we use in interviews is to tell our Barge story and then ask the person, what did you hear in that story? Because people hear their own values in your story. And if they come back with something that's close, then OK. If it's something that's way off, it's an indicator to move on. I would take somebody with a little less on the technical side who has a better alignment with our values any day.



Vanderbilt engineering researchers use artificial intelligence to help basketball players improve their shots

To shoot a basketball with precision requires countless hours of practice. Usually, this happens under the watchful eye of a coach, who can provide guidance on the right mechanics of each shot. Now, though, thanks to new research from Vanderbilt University, players may soon be able to use artificial intelligence technology to work on those same principles on their own.

Jules White, associate dean for strategic learning programs and associate professor of computer science and computer engineering, and **Carlos Olea**, a Ph.D. student in the Department of Computer Science, analyzed machine learning to perfect basketball shot types in their award-winning conference paper, "Analysis of Deep Learning Action Recognition for Basketball Shot Type Identification."

"There's a role for artificial intelligence to play in sports," White said, "because there are numerous opportunities to take data and provide that data to individuals to help them improve their game."

White and Olea worked with NOAH Basketball, an organization that uses cameras and cutting-edge software technology to calculate shooting statistics for NBA and NCAA players during practice. Through facial recognition and computer vision, NOAH software can identify who is shooting and provide athletes with unique interactive shot charts and data, including arc, depth, shooting percentages and consistency. In total, NOAH provided more than 50,000 hours of video footage, which White and Olea then used to classify different shot types.

Basketball, however, doesn't always offer clean lines of sight for actions taken while playing, so creating the framework to understand what differentiated one shot from another presented a challenge for the researchers.

"The next level NOAH wanted to see is this idea that you get more than just where you were and whether or not you made it in the directory of the shots," White said. "But also, under what conditions—like whether you just received a pass from the left or right."

"We had to create a dichotomy of shot types we were looking at due to having so many variations within the sport," Olea added. "No one shot is the same."

Employing AI software called a temporal relational network, the researchers were able to optimize shot type recognition, achieving an accuracy of 96.8 percent on 1,500 novel shots. In the future, White and Olea hope that this study will assist in the enhancement of solo practices. This research has the potential to be executed through the use of their proposed five shot type dichotomy as a functional tool within an app or website with the ability to show athletes the "correct" or a "better way" to take it to the hoop.

"I can think back to times where I'd be in my backyard, and I'd record myself doing something particular, making a throw or throwing a pitch or something like that and try to look back at that video feedback to try and see what I was doing wrong," Olea said. "So having technology available to provide feedback, like a surrogate coach, is compelling not only for professionals but also for amateurs—whoever wants to try and improve at the sport."

Preface

On behalf of the School of Engineering, we would like to share some more details about the over 100 engineering design projects for 2021-2022. During this academic year, we will have three design expositions to highlight our many projects across the VUSE disciplines. At the end of fall term, 25 computer science projects were presented in an Immersion Showcase. Computer science will again hold an Immersion Showcase at the end of this spring term—they will show off 30 of more than 50 students projects from this spring in Featheringill Hall. You can see the list of the 2021-2022 CS projects and student teams on pages 42-43.

The final engineering exposition will host 47 engineering design projects from the departments of Biomedical Engineering, Chemical Engineering, Civil and Environmental Engineering, Electrical and Computer Engineering, Engineering Science, and Mechanical Engineering will be featured in Featheringill Hall. These projects were completed in partnership with a multitude of sponsors including Nissan North America, NASA Marshall Space Flight Center, Vanderbilt University Medical Center, Permobil, Mars Petcare, Sterling Ranch Development Company, Booz Allen Hamilton, Gresham Smith, Tennessee Department of Environment and Conservation, NeXTMed, and many more.

For all the projects, we thank our project sponsors, advisers, mentors, staff and faculty for their support of our design teams and the entire program.

Design courses provide students with experience working on real-world projects that involve design constraints, budgets, reviews and deadlines. Students learned about professionalism, teamwork, entrepreneurship, and resilience. As their projects take form, student teams interact with their industry and faculty advisers, hold meetings (perhaps more remotely), write formal documentation and present their work. By the end of the academic year, the teams produce design processes, systems, prototypes, simulations, or virtual demonstrations.

This catalog is one of the tangible representations of these Design Days, which has always been a celebration of all the lessons learned during their engineering educations. As you read this catalog, know that those lessons were learned and demonstrated throughout all these projects.

We recognize the value of projects mentored and supported by external advisers—industry representatives, entrepreneurs, nonprofit mentors, as well as research and clinical faculty. This experience allows you to work with Vanderbilt engineering seniors and discover what makes our students stand out among other applicants when it comes to employment and postgraduate study. If you or your colleagues are interested in mentoring or sponsoring a project or to learn more, please contact me.

Be resilient, persevere, and work hard to make each other's world a little better each day. We are grateful for your support and guidance of our next generation of engineers and scientists.

With gratitude,

Thomas J. Withrow
Assistant Dean for Design
Associate Professor of the Practice of Mechanical Engineering
514 Olin Hall
615.322.3594
thomas.j.withrow@vanderbilt.edu

Contents

Departments and Programs

APRIL 29

27
ELECTRICAL AND COMPUTER ENGINEERING

FACULTY ADVISERS

Ralph Bruce, Professor of the Practice of Electrical Engineering

ECE-1
Lantern dating application

ECE-2
Nissan market research digitization and analytics

ECE-3
Free Parking application

ECE-4
Autonomous features for Permobil power wheelchairs

ECE-5
Motion planning of a 7 degrees of freedom arm

ECE-6
Modular payload system for autonomous vehicle location tracking

30
ENGINEERING SCIENCE

FACULTY ADVISER

Courtney Johnson, Assistant Professor of the Practice of Technical Communications

ES-1
TDEC plant optimization program

ES-2
Mergers & acquisitions model

ES-3
Vanderbilt campus lighting

ES-4
Mars Petcare supply chain optimization

ES-5
Marketing and expansion of the Notewardy EdTech application

ES-6
Smart pill bottle for tracking patient adherence

ES-7
Electronic conversion of MyTDEC forms

ES-8
Data management dashboard

ES-9
NASA Technology2University Portfolio start-up for the ammonia wastewater recovery system

ES-10
Subscription mobile app development

35
MECHANICAL ENGINEERING

FACULTY ADVISERS

Thomas Withrow, Assistant Dean for Design and Associate Professor of the Practice of Mechanical Engineering

Jason Mitchell, Assistant Professor of the Practice of Mechanical Engineering

ME-1
Helper robot to understand fundamental controls of robotic walking

ME-2
Stream litter collector implementation and upgrades

ME-3
Modular automotive manufacturing plant design for Nissan North America

ME-4
Detecting improvised explosive devices in war torn nations

ME-5
A robotic baby elephant for the Nashville Zoo

ME-6
Nashville Zoo hoofstock animal enrichment feeder

ME-7
Autonomous interior painting robot

ME-8
Unmanned underwater vehicles docking and communications buoy

ME-9
Modular payload system for autonomous vehicle location tracking

ME-10
Automating wheel mask application for vehicle delivery

BIOMEDICAL ENGINEERING
BME-1

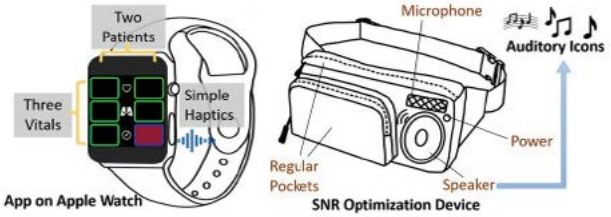
TEAM
Molly Bingham, BME
Gabriela Cestero, BME/EE
Kensington Huber, BME/EE
Fan Xue, BME/EE

ADVISER
Joseph Schlesinger, MD, Department of Anesthesiology

SPONSOR
VUMC Department of Anesthesiology

Alarmed: A novel auditory, visual, and haptic hospital alarm system

Sensory overload in the intensive care unit (ICU), or "alarm fatigue," is a serious problem affecting health care practitioners. Current alarms do not provide information about what is causing the alarm to go off nor how severe the change is. The goal is to reduce alarm fatigue in health care providers by differentiating between alarms, reducing alarm noise, and allowing mobile alarms. A novel blood pressure sound can encode information about the direction and severity in blood pressure change. Based on a previous stationary design, we created a portable signal-to-noise ratio optimization device to be worn around the waist that can modify the sound level of the alarm depending on environmental noise. An Apple watch app allows nurses to quickly see patient data without returning to the monitor, while providing haptic feedback. These three components allow alarms to provide more information to ICU staff while also reducing the total number of alarms.



Providers will receive information about their patients via visual, auditory, and tactile modalities. Vitals are displayed on an Apple Watch app that provides haptic alerts. Simultaneously, our novel alarms will play from the SNR-modulating device within the fanny pack.

VANDERBILT UNIVERSITY MEDICAL CENTER

BIOMEDICAL ENGINEERING
BME-2

TEAM
Carlos Esber, BME/CSET
John Hess, BME
Caroline Kessell, BME
Jackson Ngo, BME
Nathaniel Sifuentes, BME

ADVISERS
Professor Craig Duvall, BME
Graduate Student Josh McCune, BME

SPONSOR
Duvall Advanced Therapeutics Laboratory

16

Synthetic dermal backing for an advanced wound healing patch

To develop a removable and supportive backing for a biodegradable dermal patch, our design team developed an elastic material that can be pressed into a thin film while still retaining necessary mechanical properties that help maintain the shape of the wound bed. These properties include tensile strength to reduce tearing, flexibility to promote safe movement, and oxygen permeability to facilitate the advanced wound healing capabilities provided by the biodegradable dermal matrix. The material is biocompatible and does not degenerate throughout a three- to four-week healing process. Through research of existing solutions and discussion, our team determined that such diverse properties could be achieved by developing thermoplastic polyurethane, a highly tunable class of synthetic polymers. Trial manufacturing led the team to choose PEG, HDIt, and bismuth neodecanoate as the polyurethane components. This formulation allows the backing to have similar properties to competitors without restricting the superior healing advantages associated with the novel dermal matrix. The fabrication method used to produce the desired backing is currently being optimized for increased scalability and replicability.

The bilayer wound treatment product consists of a biodegradable matrix developed by the Duvall Advanced Therapeutics Laboratory. This layer is depicted as a yellow, spongy matrix. The transparent dermal backing is adhered to the spongy matrix. The dermal backing has a polyurethane composition and is approximately 100 microns thick, compared to two millimeters for the spongy matrix. The patch is used by suturing it into the wound bed.

TEAM
Mohamed Adan, BME
Rishi Das, BME
Ryan Habeck, BME
Connor Oltman, BME
Kirsten von Rosenvinge, BME

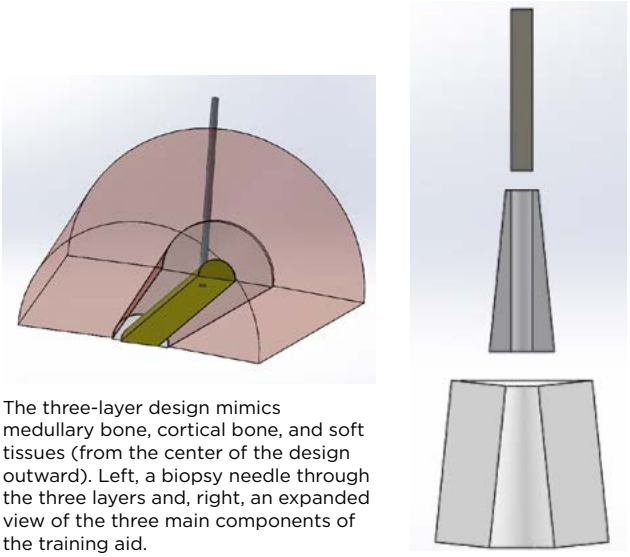
ADVISER
Nicholson Chadwick, MD, Department of Diagnostic Radiology

SPONSOR
Vanderbilt University School of Medicine

BIOMEDICAL ENGINEERING
BME-3

Bone biopsy phantom

Every year, medical students learn necessary surgical skills in the classroom through the use of training devices before they ever interact with a patient. That is, until they perform a bone biopsy. Drill in hand, many of them will approach this task for the first time on a live human patient. As the first experience of drilling into hard, smooth, slippery bone is performed on a patient, a single mistake can have disastrous results. To enable medical practitioners to learn bone biopsy skills in a low-risk environment, our team designed an easy to construct bone biopsy phantom kit. The inexpensive kit can be shipped to medical practitioners anywhere, allowing them to quickly assemble a bone biopsy phantom. The training phantom mimics some of the most complex scenarios confronted by a new radiology resident or even an experienced surgeon. It provides a life-like biopsy experience—passing through soft tissue to various thicknesses of cortical bone, including mimicking bone lesions, and even provides a removable medullary core that simulates the removal of the medullary bone sample.



The three-layer design mimics medullary bone, cortical bone, and soft tissues (from the center of the design outward). Left, a biopsy needle through the three layers and, right, an expanded view of the three main components of the training aid.

VANDERBILT UNIVERSITY MEDICAL CENTER

TEAM
John Carinato, BME
Myron Mageswaran, BME
Heng Sun, BME/Math
Mateusz Odziomek, BME
Griffin Grubbs, BME

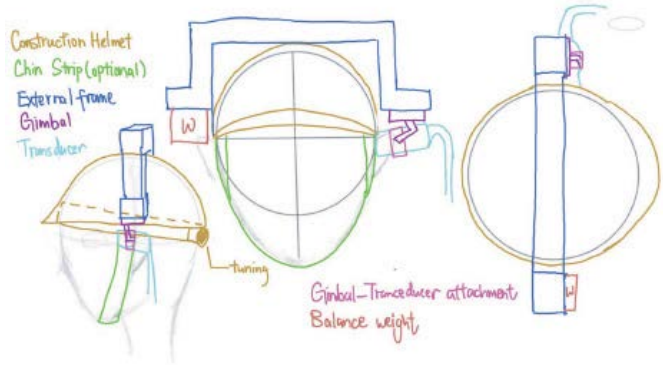
ADVISER
Professor Brett Byram, BME

SPONSOR
Vanderbilt University School of Engineering

BIOMEDICAL ENGINEERING
BME-4

Ultrasound compatible helmet system for brain imaging

Neurodegenerative diseases affect millions of Americans, resulting in a significant economic impact on health systems. Our team is assisting Professor Brett Byram, director of the Biomedical Elasticity and Acoustic Measurement Laboratory, in designing a low-cost, portable structure that can facilitate the ultrasound imaging of the brain. We are using a rigid helmet with an adjustable sizing strap, external scaffolding, and a gimbal gyroscope to house the required ultrasound transducer. We acquired all the main design components, evaluated them individually, and merged them to create the first prototype. Utilizing ultrasound imaging to image the brain requires virtually complete stability of the ultrasound sensors. This motion fixation is achieved by the gyroscope attached to the helmet scaffolding and holds the ultrasound sensor. We expect to confirm that the helmet allows Professor Byram's ultrasound system to analyze any patient's acoustic window with sufficient image clarity.



The solution is built on a construction helmet and allows a commercial transducer to be fixed in an acoustic window. A gimbal-based system with various original components is used ensure stability.

School of Engineering

BIOMEDICAL ENGINEERING
BME-5

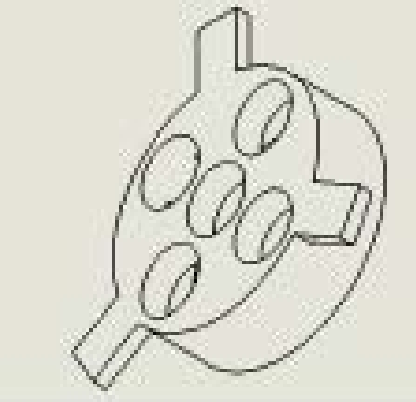
TEAM
Jason Garrett, BME
Anthony Hohn, BME
Karl Joseph, BME
Isaac Kirk-Koffi Jr, BME

ADVISERS
Lauren Woodard, PhD
Julie Bejoy, PhD

SPONSOR
Vanderbilt University Medical Center

Optimization of organoid culture process on transwell plates

Transwell plates are a fundamental part of clinical research in its many forms. These items serve as a nearly inelastic demand base for the limited manufacturing capabilities of the companies that provide them. Corning Inc., the main supplier for the specific plates that are used in the Woodard Lab for kidney organoid culture, for example, are in short supply due to the ongoing strains the COVID pandemic has placed on the domestic supply chain. Our team has designed an adapter that fits into a 24-well plate. The adapter is composed of a center piece containing five holes. The four outer holes are used to house 96-well inserts while the center hole is used to access media. Our design helps mitigate the supply bottleneck of discardable transwell plates in research labs such as the Woodard Lab by developing an adapter that is both reusable and autoclavable. This is a cost-efficient solution that would allow researchers to resume normal practices and avert the challenge of a dwindling supply of transwell plates.



Adapter to house 96-well inserts in a 24-well plate. The adapter contains four holes for placement of inserts and a fifth center hole for access to media for periodic replacement.

VANDERBILT UNIVERSITY MEDICAL CENTER

BIOMEDICAL ENGINEERING
BME-6

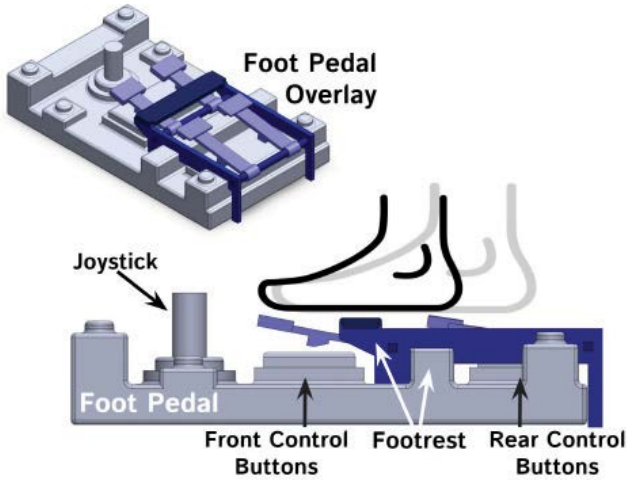
TEAM
Tanner Adams, BME
Ashley Couget, BME
Gabrielle Gramza, BME
Vishal Shah, BME
Phillip Yoon, BME

ADVISERS
Sylvia Groth, MD, Department of Ophthalmology and Visual Sciences
Professor Marc C. Moore, BME

SPONSORS
Vanderbilt University School of Engineering, Department of Biomedical Engineering
Vanderbilt University Medical Center

Ergonomic overlay for Zeiss surgical microscope foot pedal

In recent years, there has been an increase in females entering the field of surgical ophthalmology. Ophthalmologic surgery is facilitated using a freestanding microscope system with a foot pedal attachment that allows for the visualization of ocular anatomy. The foot pedal controls different functions of the microscope, such as zooming in and out and translating left and right. However, female surgeons with smaller feet have a disadvantage in navigating the buttons on the existing foot pedal. The need for constant readjustment on the pedal can cause frustration, loss of focus, and increased operation time. Using 3D printed and laser cut designs, the team aims to solve this problem with an entirely mechanical, low-profile, and removable prototype attachment for the current Zeiss Surgical Microscope foot pedal. This overlay attachment will allow surgeons with smaller feet to better navigate the original foot pedal by shifting the front and rear control buttons forward toward the joystick, reducing the need for excessive foot movement or readjustment during a procedure.



The foot pedal overlay attachment shifts the smaller foot forward on the existing foot pedal, allowing for ergonomic navigation of the front and back control buttons and joystick. The entirely mechanical system translates the force needed to depress the buttons using 3D-printed lever components rotating about bolts.

School of Engineering

VANDERBILT UNIVERSITY MEDICAL CENTER

TEAM
Danielle Klafter, BME
Leah Melancon, BME
Audrey Mello, BME

ADVISER
John Curci, MD, Department of Vascular Surgery

SPONSOR
Vanderbilt University Medical Center

BIOMEDICAL ENGINEERING

BME-7

Tourniquet for use in arterial perfusion assessment

Peripheral artery disease (PAD) is a serious condition affecting 1 in 20 Americans over of 50. The disease is typically associated with severe leg pain and weakness. When left untreated, it may lead to gangrene, heart attack and stroke. Current assessment methods of PAD are often ineffective. One issue with testing that we identified is the necessity for treadmill exercise that can be painful or dangerous for patients and may often result in the inability to perform the diagnostic test. Our goal is to eliminate the need for exercise during diagnostic testing in a reproducible manner that also could be used during trials of a novel PAD testing system led by Dr. John Curci. We propose an alternative method of inducing ischemia in the muscles using a tourniquet and a photoplethysmography (PPG) sensor to monitor blood flow. This system would allow a patient to remain seated throughout the entire test, while standardizing the amount of time the muscles are starved of oxygen to remove variability in experimental results.

Components of the system include a blood pressure cuff used as a tourniquet, as well as the rechargeable pulse oximetry timing device.

VANDERBILT UNIVERSITY MEDICAL CENTER

TEAM
Shrey Derasari, BME
William Gao, BME
Shubham Gulati, BME
Tony Owusu, BME
Natalie Thomas, BME

ADVISERS
Andrew DeFilippis, MD, M.Sc., Department of Cardiovascular Medicine
Jessica Williams, R.N., C.C.R.N, Cardiovascular Intensive Care Unit

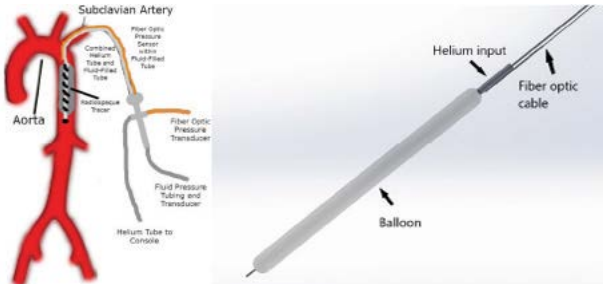
SPONSOR
Vanderbilt University Medical Center

BIOMEDICAL ENGINEERING

BME-8

Solutions for subclavian insertion of intra-aortic balloon pumps

Cardiogenic shock is a condition in which the heart is unable to pump enough blood to the rest of the body, usually occurring after some form of cardiac failure. For treatment, intra-aortic balloon pump (IABP) devices are used to mechanically augment cardiac output. However, these devices are usually placed via the femoral artery near the groin, causing a patient to be bedridden for days to weeks. The lack of mobility results in further patient complications. Our novel IABP is intended to replace existing solutions, improving on current methods of placing the IABP through an insertion point in the left subclavian artery. We have modified the existing design of IABPs to address issues that arise with pressure measurements, positioning and visualization when current models of the IABP are inserted via the subclavian artery. Our design changes the location of the fiber-optic cable sensor for accurate pressure readings, increases the length and changes the shape of the radiopaque marker to better visualize positioning of the balloon, and optimizes the device wire stiffness to reduce the risk of movement.



The IABP is modified to improve the visualization of the device, placement of the balloon, and accuracy of the pressure measurements when inserted via the subclavian artery. This device consists of a helium inflatable balloon, a radiopaque tracer and fiber optic pressure sensor.

VANDERBILT UNIVERSITY MEDICAL CENTER

BIOMEDICAL ENGINEERING
BME-9

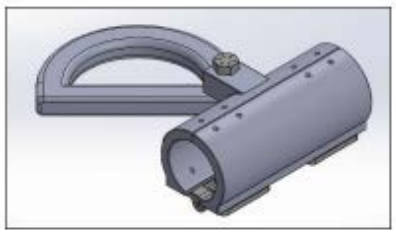
TEAM
Andrew Gnegy, BME
Kevin Oswald, BME
Isabella Richter, BME
Christina Sundt, BME

ADVISER
Gaila Fosbinder, ITF Wheelchair Tennis Tour Competitor

SPONSOR
Vanderbilt University School of Engineering

Adaptive sports racket handle

To make sports more accessible and comfortable for people with muscular degenerative diseases, particularly those with abnormal structural fixation, we have developed an adaptive sports handle that can transfer between equipment and withstand the stresses of the game. This project focuses on tennis handles but our design process should be easily replicable between sports and athletes. Our final design will incorporate an attachment piece fitted to the shape of the racket's handle, and a hinge will allow it to open and close around the handle. Connected to the attachment piece through a nut and bolt mechanism will be a handle piece. The handle piece will protrude from the handle across a range of angles, allowing a user to customize the device to match the user's joint's fixation angle. The device will be 3D-printed using ABS plastic. We hope the design allows for transfer between equipment, shows resistance to environmental conditions, and improves accessibility for athletes with muscular disorders.



Assembly of the attachment piece, handle piece, and the hinges that connect the attachment piece to the grip of the sports equipment.

School *of* Engineering

BIOMEDICAL ENGINEERING
BME-10

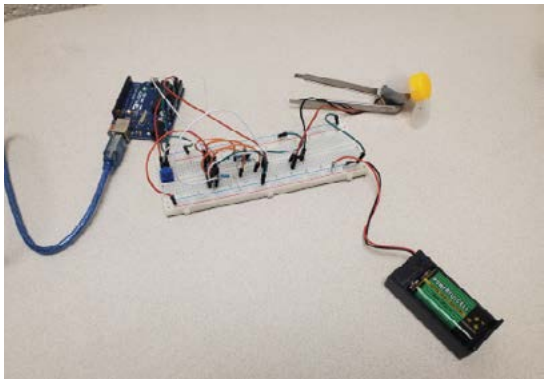
TEAM
Lucy Britto, BME
Shuyang Chai, BME
Abena Essah, BME
Thomas Hutto, BME
Rahul Regula, BME
Aire Wu, BME

ADVISERS
Matthew Bacchetta, MD, MBA, FACS, Department of Cardiac Surgery
Rei Ukita, PhD, BME

SPONSOR
Vanderbilt University Medical Center

Portable device to support extracorporeal membrane oxygenation

Extracorporeal membrane oxygenation (ECMO) is the gold standard for treating patients with pulmonary hypertension, which is effective in extending a patient's life while waiting for heart or lung transplantation. Yet, a patient's quality of life is drastically reduced as they are not able to perform basic daily activities and require continued management by intensive care staff. Therefore, there is a need to improve patient comfort and mobility for individuals receiving ECMO support. To implement a miniaturized and portable ECMO machine, the team designed a novel motor driver and controller circuit programmed with Arduino to automatically adjust blood flow through the pump to compensate for physiological changes that occur during sitting, standing up and walking. The device takes an input voltage from a variable source to stimulate venous oxygen saturation (SVO2) sensor. It compares this value to a reference SVO2 percentage and adjusts the motor speed to drive the pump accordingly.



The current motor driver design. A potentiometer is used as a stand-in for an SVO_2 sensor, while the propeller is a testing substitute for a prototype blood pump. The circuit allows for precise motor speed control by changing the position of the potentiometer.

VANDERBILT UNIVERSITY MEDICAL CENTER

TEAM
Yiting Chen, BME
Alice Ding, BME/ME
Nairah Moustafa, BME
Rainelle Nevers, BME
Jee Hyun Park, BME

ADVISERS
Joe Wiencek, Department of Pathology, Microbiology and Immunology
Professor Marc Moore, BME

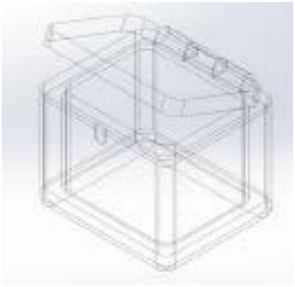
SPONSOR
Vanderbilt University Medical Center

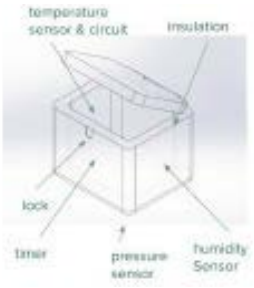
BIOMEDICAL ENGINEERING

BME-11

Temperature-controlled biosample lockbox to maintain sample viability

Current solutions of biological sample storage have high cost or low performance in maintaining a suitable environment. Degradation of sample quality results in preanalytical testing errors that can lead to incorrect diagnosis or repeated tests, additional cost and time, and puts the patient's health at risk. The goal is to design an insulated courier lockbox that prevents sample degradation from harsh outside conditions, and that can monitor temperature and sample presence in real time. High impact polystyrene was chosen for the outer casing with high-density polystyrene foam as insulation. A circuit will be implemented to monitor the temperature and humidity, control heating and cooling elements—a heater resistor and a peltier heatsink and fan module, respectively—and to alert users when the samples are no longer viable. Compared with other solutions on the market, this novel design is the first to use electronic components with effective insulating materials while maintaining affordability and durability.





The lockbox includes several elements to insulate the box from the environment, keep the samples locked safely, and alert when the samples are no longer viable.

School of Engineering

VANDERBILT UNIVERSITY MEDICAL CENTER

CHEMICAL AND BIOMOLECULAR ENGINEERING
ChBE-1

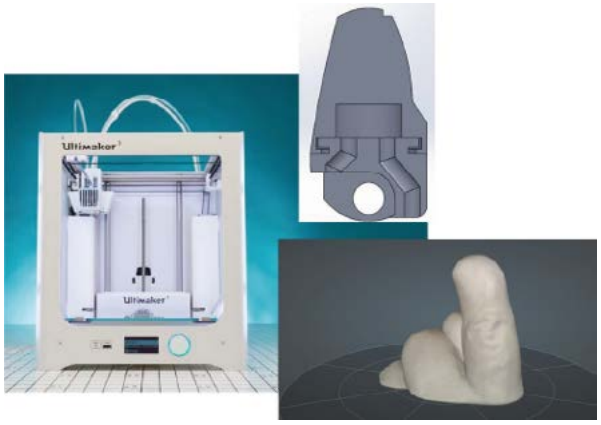
TEAM
Johannes Bachmann, ChemE
Patrick Gerber, ChemE
Kenneth Konam, ChemE
Paris Piyaket, ChemE

ADVISERS
Professor Russell Dunn, P.E., ChBE
Professor Brian Beyer, ChBE
Brian Babcock, Polymer Chemistry and Coatings, LLC

SPONSORS
Chemical Engineering Design Advisory Board
Polymer and Chemical Technologies, LLC

Articulating prosthetic finger for amputee's dominant hand using fused filament fabrication technology

Our team set out to design and produce a Fused Filament Fabrication (FFF) 3D printed prosthetic finger attachment for amputees who have lost a portion of their finger. The goal is to create an attachment with mechanisms capable of performing full finger movements, be compatible with Apple touch screens through the use of conductive materials and be comfortable for the wearer. With the guidance and testing of Professor Russell Dunn, who lost about a third of his right index finger in his youth, the team developed an appropriate prosthetic for his daily use, which includes aiding his ability to perform activities such as typing on touchscreen devices and playing the piano. Computer-aided design (CAD) software was used to design and produce multiple prototypes for testing and evaluation to identify the optimal design. In addition, we used molding techniques and 3D scanner technologies throughout the design process to ensure that the design not only was a custom fit for Prof. Dunn, but also could be adjusted to fit other patients with amputated portions of a single finger or multiple fingers.



Example of the FFF 3D printer, CAD model and 3D scanning model used for the creation of prosthetic finger portions for an amputee

CHEMICAL AND BIOMOLECULAR ENGINEERING
ChBE-2

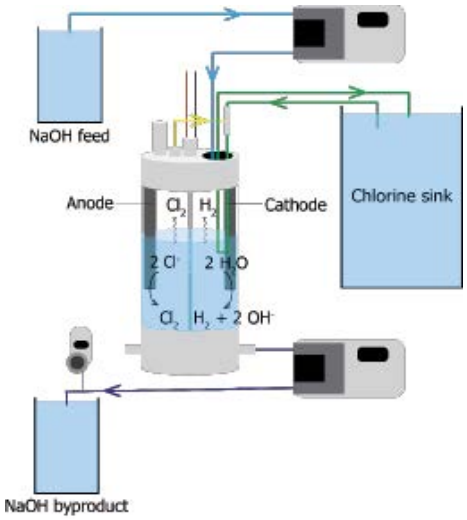
TEAM
Karan Bhardwaj, ChemE
Griffin Collins, ChemE
Long Than, ChemE/Chem
Isabelle Verret, ChemE

ADVISERS
Professor Russell Dunn, P.E., ChBE
Professor Brian Beyer, ChBE
Tony Davis, Chemical Engineering Consultant
Richard Baud, P.E., Baud Engineering, LLC

SPONSORS
Chemical Engineering Design Advisory Board
Polymer and Chemical Technologies, LLC

Design of a continuous lab-scale chlor-alkali electrolysis process

An important industrial process, chlor-alkali, involves converting a brine solution to chlorine and sodium hydroxide through an electrochemical membrane-based reaction. Due to the significant use of the chlor-alkali process in the chemical industry, there is a need for chemical engineers to be exposed to electrochemical engineering concepts during their undergraduate education. We converted a lab-scale chlor-alkali batch reactor into a continuous reactor and developed a lab module that uses the modified unit to teach chemical engineering undergraduates about fundamental concepts in electrochemistry and reaction engineering. Our team assembled a WaterStep M-100 Chlorine Generator system with a variable DC power supply, water inputs and outputs, and a pH meter to measure caustic product and provided the means for students to develop an understanding of chlor-alkali chemistry and the effects of various process parameters on unit performance. This lab module improves upon previous designs by eliminating batch operation of the unit, emphasizing the effect of ionic concentration, lessening emphasis on variable flow rates, and focusing on galvanostatic operation, allowing for exploration of voltage as a parameter.



The chlor-alkali unit is modified to be operable by undergraduate students as a continuous electrolysis membrane reactor producing chlorine, hydrogen, and sodium hydroxide.

TEAM
Jacob Legaard, ChemE
Lucas Mowery, ChemE
Riya Patel, ChemE
Jack Tsenane, ChemE

ADVISERS
Professor Russell Dunn, P.E., ChBE
Professor Ethan Lippmann, ChBE
Professor Brian Beyer, ChBE
Alan Crawford, Chemical Engineering Consultant
David Steckler, Impact Technology Development

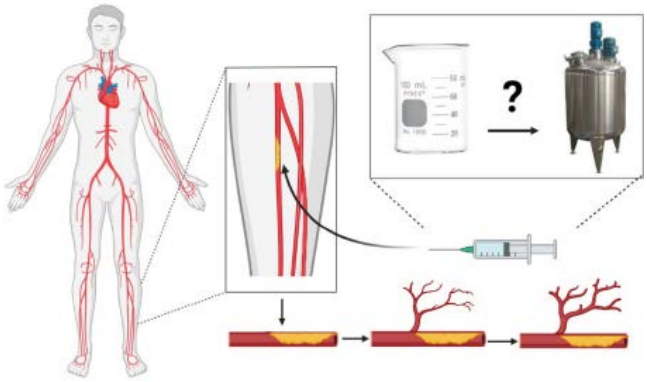
SPONSOR
Chemical Engineering Design Advisory Board

CHEMICAL AND BIOMOLECULAR ENGINEERING

ChBE-3

Design of a regenerative medicine manufacturing facility

Lower extremity peripheral arterial disease (PAD) affects approximately 10% of the American population. In severe cases, PAD can result in critical limb ischemia (CLI). Each year, nearly 12,000 people die and 150,000 people require amputation because of CLI. The Lippmann Lab created a hydrogel that has successfully promoted vascularization that can combat CLI. This project optimized the hydrogel manufacturing process, designed a manufacturing facility that met the demand for a vascularizing hydrogel, and estimated the costs of this facility. Current lab-scale production capacity is one dose every six days; thus, the desired production capacity for this facility is 300 doses per day based on an estimated annual demand of 100,000 doses. The team examined current lab scale procedures and equipment to identify areas for improvement by identifying shortcomings in the current production process, namely the use of dangerous solvents and inefficient drying methods. The team also selected new equipment to be used to meet the desired production capacity and identified the Food and Drug Administration requirements for production to allow the design a Good Manufacturing Practice (GMP) production facility.



Using the hydrogel to treat arterial blockages in the lower body requires substantial scaling of the production process to meet projected demand.

TEAM
Eric Bley, ChemE
Katie Johnson, ChemE
Ana Wallace, ChemE
Sophia Yue, ChemE

ADVISERS
Professor Russell Dunn, P.E., ChBE
Professor Brian Beyer, ChBE
Tony Davis, Chemical Engineering Consultant
Richard Baud, P.E., Baud Engineering, LLCt

SPONSORS
Chemical Engineering Design Advisory Board
Polymer and Chemical Technologies, LLC

CHEMICAL AND BIOMOLECULAR ENGINEERING

ChBE-4

Microbrewery plant design for multi-product manufacturing

Craft brewing has skyrocketed in popularity over the past decade with a total of 9000 craft brewers contributing $62.1 billion to the U.S. economy in 2021. Our team determined the profitability and feasibility of building and operating a moderately sized microbrewery in comparison to outsourced production. When running at full capacity, the microbrewery was designed to brew 5 popular year-round varieties and 7 seasonal varieties with a total target production rate of 100,000 barrels of beer per year. Capital investment, operating cost, and financial return were assessed to determine the economic feasibility of the project. The brewery maximized utilization of equipment and reduced the environmental impact of wastewater and carbon dioxide emissions associated with the brewing process and this resulted in higher overall efficiency and sustainability.

Craft beer brewhouse fermenter tanks

CHEMICAL AND BIOMOLECULAR ENGINEERING
ChBE-5

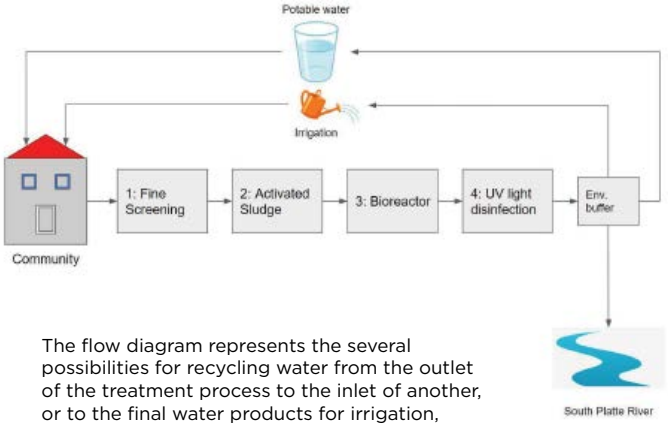
TEAM
David Carolan, ChemE
Mattigan Kelly, ChemE
Andrea Scheidt, ChemE
Carly Shafer, ChemE

ADVISERS
Professor Russell Dunn, P.E., ChBE
Professor Brian Beyer, ChBE
Alan Crawford, Chemical Engineering Consultant
David Steckler, Impact Technology Development

SPONSORS
Sterling Ranch
Dominion Water and Sanitation District

Design and optimization of a water treatment network for Sterling Ranch

Sterling Ranch is a community near Denver, Colorado developed to produce a minimal environmental impact while implementing leading edge of sustainability. To achieve their sustainability goals, innovative strategies to recycle water throughout the treatment process, reduce load on treatment technologies, and minimize ultimate water waste are necessary. As such, contaminant regulations for potable water, irrigation wate and river discharge must be considered as well as the water needs of the community. Also, the effluent contaminant concentrations from each treatment technology were estimated based on influent concentration from the community and industry standards for the treatment capabilities of each technology. Our solution reduces load of the treatment plant by implementing bypass streams. This method for designing a water treatment network is superior to industry standards that treat the entire influent stream through each step of the process as the recycling method avoids "overtreatment" of water that requires larger and more expensive and energy-intensive technologies.



The flow diagram represents the several possibilities for recycling water from the outlet of the treatment process to the inlet of another, or to the final water products for irrigation, potable water, or river discharge.

CHEMICAL AND BIOMOLECULAR ENGINEERING
ChBE-6

TEAM
Lynn Lee, ChemE
Yeabsira Mekonnen, ChemE
Justin Song, ChemE

ADVISERS
Professor Russell Dunn, P.E., ChBE
Professor Brian Beyer, ChBE
Brian Babcock, Polymer Chemistry and Coatings, LLC

SPONSORS
Chemical Engineering Design Advisory Board
Polymer and Chemical Technologies, LLC

Optimizing utility usage for chlor-alkali and vinyl chloride monomer plants

In response to the global demand for chemical materials and high costs of energy, chemical companies have pushed to reduce their plants' energy consumption. One way to achieve major energy savings is the implementation of Heat Exchanger Networks (HENs). HENs take advantage of the possible heat integration between existing hot and cold streams flowing in the plant to reduce utility costs associated with cooling and heating these streams. Our feasibility study investigated the energy savings of a chlor-alkali plant and a vinyl chloride monomer (VCM) plant using the HEN technique. The team integrated a new heat exchanger in an existing chlor-alkali plant and developed an automated Excel spreadsheet. It solves all mass and energy balances with upstream property change inputs and outputs annual utility savings for the plant. For the existing VCM plant, our strategy was to utilize streams from distillation columns, with assistance from compressors, to minimize the annual process utility usage by rerouting selected streams through reboilers. These process design changes are expected to outperform the existing plants in terms of energy conservation and plant expenses.

A heat exchanger integrated into the chemical plant heat exchanger network allows for seven figure savings annually on utility usage.

TEAM

Adetokunbo Faparusi, ChemE
Cassandra Fernandes, ChemE
Annabelle Li, ChemE
Ester Teper, ChemE/CSET

ADVISERS

Russell Dunn, P.E. Professor of the Practice of Chemical and Biomolecular Engineering
Brian Beyer, Adjunct Assistant Professor of Chemical and Biomolecular Engineering
Alan Crawford, Chemical Engineering Consultant
David Steckler, Impact Technology Development

SPONSORS

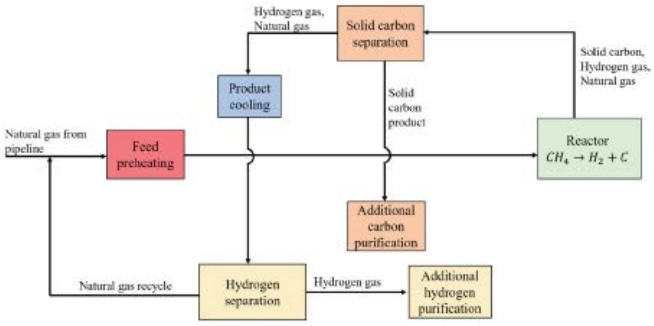
Chemical Engineering Design Advisory Board

CHEMICAL AND BIOMOLECULAR ENGINEERING

ChBE-7

Decarbonization of natural gas from flare gas

The project identified a process is to convert 3 million standard cubic feet of gas per day (MMSCFD) of flared natural gas to either carbon products or liquid petrochemicals with a product price that can provide a high internal rate of return. To design this process, the team broke down the concepts of flaring and decarbonization to conduct preliminary research on methods that could reduce flared gas, and researched the technologies of steam methane reforming, catalytic methane pyrolysis, gas to liquid, and multifunctional catalysts in depth through enthalpy balances, financial computations, and usability of byproducts, in order to optimize the decarbonization process. Catalytic methane pyrolysis was identified as the best choice, so catalyst types were explored for more finite values of temperature, pressure, and activity for a precise optimization. We created a simple scale-up for the process and began calculations to reach the desired values for conversion of natural gas. We also developed the heat exchange network for the scale-up, and then optimized the process for a high specified rate of return.



Proposed process schematic for the conversion of natural gas to carbon products and hydrogen gas via catalytic methane pyrolysis.

Polymer & Chemical Technologies, LLC

Chemical Engineering Design Advisory Board

TEAM

Owuraku Asare, CE
Courtney Howarth, CE
Nicholas Laning, CE
Summer Rucker, CE
Isabelle Russell, CE

ADVISERS

Eric Barney, P.E., Sterling Ranch Development Company
Brian Hart, P.E., Redland Consulting Group Inc

SPONSOR

Sterling Ranch Development Company

CIVIL AND ENVIRONMENTAL ENGINEERING

CEE-1

Site design of a Sterling Ranch neighborhood

Sterling Ranch, a master planned community southwest of Denver, will soon be home to 40,000 people. Our teamusedAutoCAD Civil 3D to develop detailed layout, grading, and utility site plans for a 4-acre village. The layout plan designates 17 lots for single family homes, and denotes lot dimensions and areas, road widths and radii, total sidewalk area, and tract designations. The grading plan describes elevation changes across the site through labeled contour lines and the incorporation of specific elevations of points of interest. Utility plans are separated into water, sewer, and stormwaterdrawings. Each plan depicts the location of required manholes and inlets, as well as the pipe networks designed to collect and transport the water, sewage, or stormwater from the site. Profiles of each utility system are included to illustrate the location and slopes of each underground pipe network. Other important elements include a detention pond for on-site stormwater management, ADA accessible ramps at outer road connections, and fire hydrants for adequate fire safety precautions. The results of this design are intended to help Sterling Ranch Development Company provide a safe, sustainable, and feasible village to support the continued expansion of their larger community.

Sterling Ranch site layout plan including tracts, lot dimensions, and square footage.

STERLING RANCH COLORADO

CIVIL AND ENVIRONMENTAL ENGINEERING
CEE-2

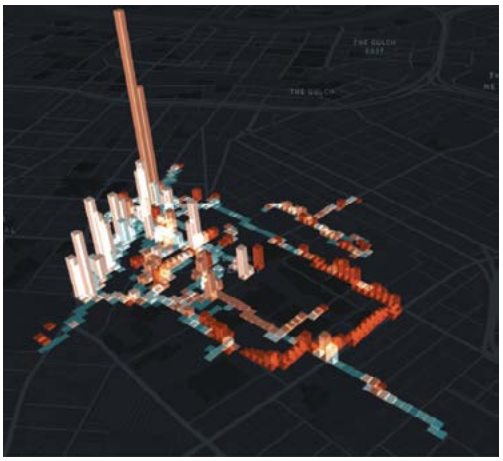
TEAM
Crystal Cheng, CE
Blythe Dewling, CE
Jake Haas, CE
Kristi Maisha, CE
Erin Olender, CE

ADVISERS
Professor Mark Abkowitz, CEE
Mike Sewell, P.E., Gresham Smith
Keith Besserud, AIA, Gresham Smith
Rachael Muscatello, Ph.D., VUMC
Will Barbour, Ph.D., Vanderbilt Institute for Software Integrated Systems

SPONSORS
Gresham Smith
Vanderbilt University Department of Civil and Environmental Engineering
Vanderbilt University Medical Center

Empathic data collection for transportation infrastructure redesign

Members of the Vanderbilt community experience hazardous road conditions as they use pedestrian infrastructure surrounding the campus. The team partnered with Gresham Smith and VUMC to pilot a new method of informing roadway redesign. Heart rate and campus location data from smart watches was collected into an aggregated, anonymized data set to determine pedestrian stress levels. Areas with high stress levels are identified as locations for pedestrian safety redesign. Current roadway safety decisions are reactive; multiple fatalities and other serious injuries can occur in a location before any mitigative action is taken. This new methodology provides a quantitative basis of perceived danger, thereby proactively addressing dangerous pedestrian infrastructure. Informed by the stress data, traditional transportation safety information (e.g., accident records), and the expertise of transportation planners and engineers, this team is redesigning high-stress locations along West End Avenue and 21st Avenue to make them safer and more comfortable for pedestrians.



Stress measurements map to help inform pedestrian redesigns for the Vanderbilt University campus.

Gresham Smith | School of Engineering | Vanderbilt University Medical Center

CIVIL AND ENVIRONMENTAL ENGINEERING
CEE-3

TEAM
Max Beavers, CE
Tobias Houghton, CE
Sofia Ramirez Starkey, CE
Michael Roman, CE

ADVISERS
Lesa Brown, Research Engineer, CE
Rich Teising, Staff Engineer, CE

SPONSORS
Vanderbilt University Civil and Environmental Engineering Department
Vanderbilt University American Society of Civil Engineers Student Chapter

ASCE Concrete Canoe Competition

The 2022 Vanderbilt Concrete Canoe team researched, designed, and constructed a canoe for the American Society of Civil Engineers® (ASCE) Concrete Canoe Competition. The team designed a buoyant, strong canoe with a streamlined shape that can be raced in the 2022 Mid-South ASCE Student Conference. The annual competition is designed to mimic the construction bid process and includes a multitude of technical requirements based on industry standards. The team designed, mixed, and tested 40 concrete test mixes. To create the mold for the canoe, a wooden replica of the canoe's outside dimensions was made to construct a female mold of Rockite and burlap covering the exterior. The female mold was then removed from the wooden replica and used to lay concrete inside and build the canoe. After curing for 28 days, the canoe was removed from the female mold, sanded to a smooth finish, and sealed to waterproof the concrete. Throughout the project, the team collected information and lessons learned to be passed on to next year's team.

Vanderbilt Concrete Canoe team applies specially colored concrete to the mold to create the concrete canoe with the aesthetic design of *Charon's Ferry.*

Vanderbilt University | ASCE Student Chapter Vanderbilt University

TEAM
Carson Fallon, CompE
Henry Goldenberg, CompE
Michael Dobson, CompE
Philip Ferreira, CompE

ADVISER
Professor Ralph Bruce, ECE

SPONSOR
Jack Cogan,
Owen School of Management

ELECTRICAL AND COMPUTER ENGINEERING
ECE-1

Lantern dating application

Millennials spend an average of 82 minutes per day on dating apps. About 45% of users report feeling frustrated with these apps. The goal of the Lantern dating application is to provide a new way to find and meet other people in a specific area by allowing users to indicate precise times they are available. The application differentiates itself from the rest of the mobile dating application landscape in that users will spend less time on the application finding dates by introducing the Lantern Candle feature. A user's lantern is visible only to other users with a lit lantern. Only when two users have illuminated their candles can they message each other. This feature is visible as the app still utilizes familiar layouts and user interfaces found in other similar apps. The project integrates mobile application design and backend software development practices to create an innovative user experience.

The app control flow starting from the boot screen and login page.

Owen Graduate School of Management

TEAM
Nafis Ahmed, CompE
Ryan Wu, CompE/Physics
Difan Yang, CompE

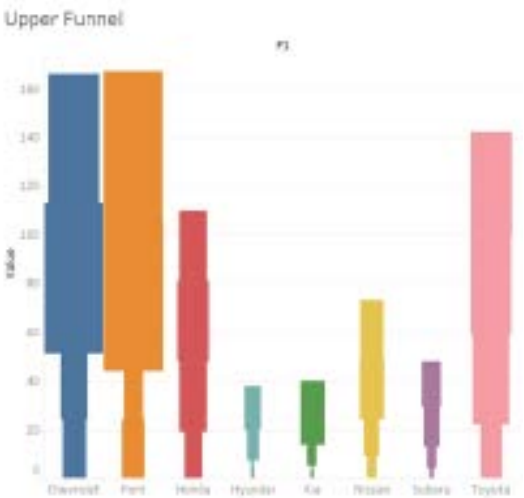
ADVISERS
Professor Ralph Bruce, ECE
Charlie Gerrity, ECE
AnnMarie Heideman, Nissan MI
David Terebessy, Nissan MI
Laura Harlin, Nissan MI
Brandon McLain, Nissan MI

SPONSOR
Nissan Market Intelligence

ELECTRICAL AND COMPUTER ENGINEERING
ECE-2

Nissan market research digitization and analytics

Nissan Market Intelligence stores and utilizes large amounts of data, often all being pulled from different locations to study their customers through quantitative and qualitative market research. There is a good deal of effort put into formatting the data into a usable and presentable format. The purpose of this project is to find efficiencies with the current data through the development of backend applications and dashboards to enable efficient analysis. The team is utilizing Tableau to create a dashboard system to convey various spreadsheets of data into a readable format. The final product has fully automated backend data sorting, color coding to distinguish between Nissan and its major competitors, and an intuitive frontend system.



Quarterly brand upper funnel visualization of Nissan and its major competitors.

NISSAN

ELECTRICAL AND COMPUTER ENGINEERING
ECE-3

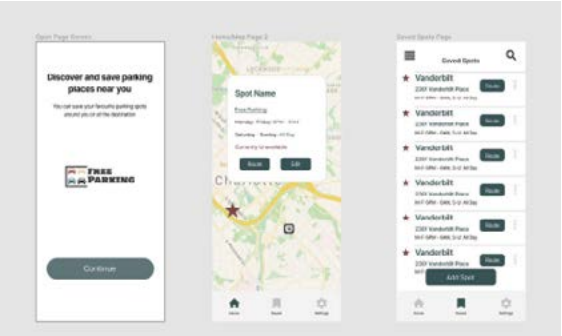
TEAM
Jaden Hicks, CompE
Bill Shi, EE
Todd McKinney, CompE
Bohan Jiang, CompE

ADVISER
Professor Ralph Bruce, ECE

SPONSOR
Twin Sun, LLC

Free Parking application

Finding parking in any city can be extremely challenging. Large cities have complex street parking systems that can be confusing to navigate on one's own. Commuters often are unaware that they've parked their cars or motorcycles in a restricted area, only to find their vehicle ticketed or towed away when they return. The Free Parking application makes the task of finding parking easier and less time consuming. The team's application allows users to document their favorite parking spots, both physical location and time availability, to fulfill future parking needs. Users also have the option to take a picture of the parking sign and the application will automatically record all pertinent information based on the GPS data and the text on the parking sign.



The welcome page, map page, and saved spots page of the application.

ELECTRICAL AND COMPUTER ENGINEERING
ECE-4

TEAM
Anandita Singh, EE
Bubby Nagarajan, EE
Chloe Champagne, CompE
Declan Fitzpatrick, CompE

ADVISERS
Professor Ralph Bruce, ECE
William Emfinger, Permobil

SPONSOR
Permobil

Autonomous features for Permobil power wheelchairs

Many users of power wheelchairs experience significant mobility issues beyond an inability to walk. Various levels of paralysis may prevent users from being able to fully observe their surroundings from the wheelchair. As a result, users have the tendency to accidentally run their wheelchairs into obstacles, resulting in damage to the wheelchair or the users. The team is working to implement autonomous features in Permobil's power wheelchair system. These features include the ability to analyze the surrounding areas, avoid obstacles, and dock into place without user intervention. Permobil's mission is to enable wheelchair users to achieve day-to-day tasks with as much ease as possible. With the addition of object detection and avoidance functionality to the wheelchairs, this design improves upon previous and current power wheelchairs by adding autonomy to docking operations. Four depth cameras on the corners of the chassis base, as well as two depth cameras on the arm rests, enable environmental awareness within a 16-meter radius, and a microprocessor on-board calculates if motion should be stopped to prevent collision. A simple switch flip enables autonomous docking, using the depth cameras to guide motion. Utilizing Unreal Engine 4 and ROS, the group intends to simulate and validate the depth camera design in preparation for hardware implementation.

Permobil simulation software within the Unreal Engine 4 framework in which the group is designing the autonomous wheelchair additions and validating their project design. Depth cameras are placed strategically on the wheelchair to enable environmental awareness, and the ROS framework is used to process the depth camera data.

TEAM
Jireh Katebe, EE
Xue Ye Lin, ME
Stefany Rodrigues, EE
Jeongwoo Seo, ME
Amy Sihn, EE

ADVISERS
Professor Ralph Bruce, ECE
Professor Tom Withrow, ME
William Emfinger, Permobil

SPONSOR
Permobil

ELECTRICAL AND COMPUTER ENGINEERING

ECE-5

Motion planning of a 7 degrees of freedom arm

Many powered wheelchair users also have limited upper-body mobility, causing them to rely on others for tasks like opening a door or pouring water. With the decreasing cost of robotic arm technologies, assistive robotic arms are a viable solution to help these users interact more comfortably with their environment. Our team has designed an assistive robotic arm attached to a wheelchair to aid users who have limited mobility. The smart assistive robotic arm ultimately will be developed to offer features such as automatic object avoidance, input rejection, and grasp assistance. Our team's goal is to design a testing platform that integrates a manipulator, sensors, and other input devices to assess the design of smart assistive robotic arm software and hardware.

Hardware additions include a 3D-printed camera mount, a Realsense 435i camera, and the UFACTORY xArm gripper.

TEAM
Sebastian Bond, CompE
Abdul-Latif Gbadamoshie, ME
Kellen Lively, EE
Kai Malcolm, ME
Ethan Mayer, CompE

ADVISER
Professor Amrutur Anilkumar, ME

SPONSOR
NASA

ELECTRICAL AND COMPUTER ENGINEERING

ECE-6

Modular payload system for autonomous vehicle location tracking

Interplanetary exploration requires operating in environments absent of existing location-tracking systems such as GPS. The Payload team of the Vanderbilt Aerospace Design Lab (VADL) aims to remove the dependency on existing terrestrial-based location systems by designing a modular and autonomous payload capable of using several redundant locating methods to track a launch vehicle's landing location. Our modular tracking system uses several different sensors, such as cameras and Inertial Measurement Units (IMUs), to allow the onboard Raspberry Pi 4Bs to interface with their surrounding environment, whether on Earth or elsewhere. The primary novelty of the payload, the inherent modularity of the design, allows for several different tracking methods to work simultaneously and redundantly. The flight path reconstruction is performed using the real-time IMU data while location tracking via image processing is based off the Scale Invariant Feature Transform algorithm. Continuously detecting key points rather than searching for pre-determined features allows the payload to overcome issues with existing tracking solutions, such as the reliance on known or prominent features in the operating environment.

The payload assembled on the full-scale VADL rocket at the launch field.

ENGINEERING SCIENCE
ES-1

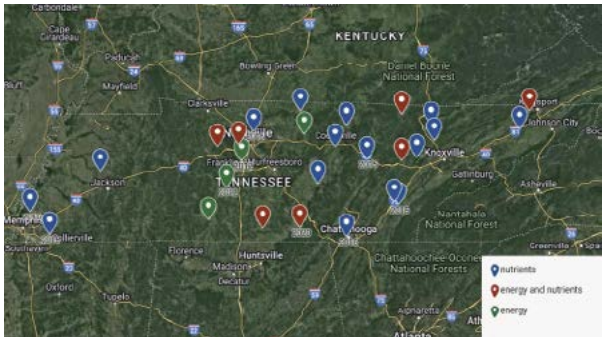
TEAM
Sophie Acosta, ES/Medicine, Health, and Society
Yunxu Cai, ES/Math
Janice Mutuku, ES
Julia Shehadi, ES/Architecture & Built Environment

ADVISERS
Vojin Janjic, Tennessee Department of Environment and Conservation
Karina Bynum, P.E., Tennessee Department of Environment and Conservation
Professor Courtney Johnson, GE

SPONSOR
Tennessee Department of Environment and Conservation, Division of Water Resources

TDEC plant optimization program

The Division of Water Resources (DWR) in the Tennessee Department of Environment and Conservation (TDEC) runs a voluntary Plant Optimization Program (POP) to assist wastewater utilities in achieving energy efficiency and nutrient optimization. Some of the benefits of the program include reduced nutrients in effluent, which eliminates the need for nutrient limits in permits and reduced expenses for operating the facility since the rate of nutrient removal would be increased. This latter benefit also will reduce the carbon footprint of these facilities by saving energy. Nevertheless, facilities are hesitant to participate in the program despite the potential benefits. Our team designed a survey to determine why facilities have been hesitant to participate in the optimization program. Our team is using the results of the survey to provide the DWR with recommendations on how to increase participation in the program. Our survey encompasses both Likert-scale and short-answer questions and is expected to accurately capture facility concerns about participation in the optimization program.



The survey is targeted to Tennessee Plant Optimization sites and non-participating Tennessee facilities.

TN Department of Environment & Conservation

ENGINEERING SCIENCE
ES-2

TEAM
Kate Christensen, ES
Brianne Gross, ES
Conner McConnell, ES
Jaden Uecker, ES/Econ

ADVISER
Professor Courtney Johnson, GE

SPONSOR
Vanderbilt University, Division of General Engineering

Mergers & acquisitions model

The project client is in the process of expanding their presence in Huntsville, Alabama. As the Defense Industrial Base Industry is highly competitive in Huntsville, the client is researching current small to mid-size players in the Huntsville market related to teaming, merging, and acquisitions strategies that strengthen their market position. The capstone team was tasked with creating a mergers and acquisitions model to quickly identify small to mid-size companies in the locale that possess unique capabilities in the cyber, digital, engineering, and analytics spaces. Their final deliverable is a top ten list of potential candidates with a one-page description on each. After narrowing the market based on the client's specifications, companies were indexed based on a weighted average of their current and historical market performance, unique capabilities relative to their competitors, and desirable characteristics regarding the business's reputation and employee benefits.

The mergers and acquisitions model uses a combination of quantitative and qualitative metrics in a weighted average grading scale to determine the top acquisition targets in the current Huntsville market. Some of these metrics include revenue per employee, existence of unique capabilities, years of relevant experience, and ownership type.

School of Engineering

TEAM
Lucas Bittof, ES
Ford Chope, ES
Brady Scanlan, ES/Econ

ADVISERS
Damon Varble, P.E, Facilities Department
Mitch Lampley, Director of Engineering and Technical Support, Plant Operations

SPONSOR
Vanderbilt University
Facilities Department

ENGINEERING SCIENCE
ES-3

Vanderbilt campus lighting

The goal of our project was to meet the lighting needs and improve the lighting experience of Vanderbilt University staff, faculty, and residents while maximizing energy savings. We implemented several lighting strategies in order to test their results against the established goals. The strategies our team chose to implement include changing the time lights remain on before automatically turning off during various times of day, establishing partial lighting in large buildings such as campus libraries, reducing nighttime lighting in hallways and shorter timers on occupancy sensors, and establishing daylight tuning in various buildings. These strategies aim to reduce energy usage while also serving to establish better living and working conditions for the campus community.

The team's strategies were implemented using the Lutron Electrics Company online database for Vanderbilt University.

VANDERBILT UNIVERSITY

TEAM
Tatiyanna Singleton, ES
Jared Stein, ES/Econ
Nathalie Wight, ES/French
Franklin Zisengwe, ES

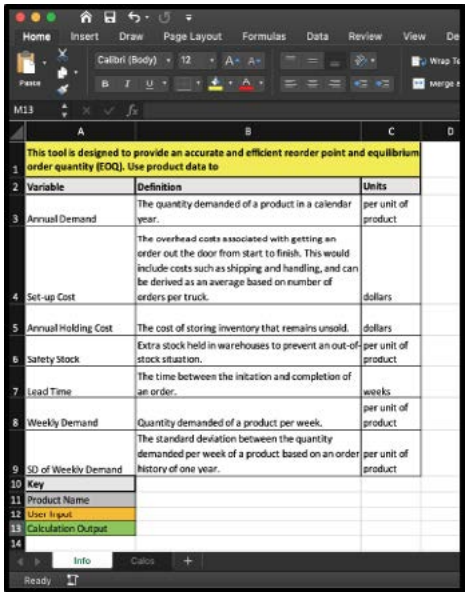
ADVISERS
Hunter Miller, Mars Petcare
Erin Phillips, Mars Petcare
Professor Courtney Johnson, GE

SPONSOR
Mars Petcare

ENGINEERING SCIENCE
ES-4

Mars Petcare supply chain optimization

The Petcare division of Mars, Incorporated, needs to optimize and automate supply chain processes surrounding plant orders and project runouts. The goal of the team is to create solutions that will minimize manual work and time involved in business analysis. The team is creating two Excel tools to accomplish this. One tool is a template to streamline EOQ and reorder point calculations, and another tool is a macro to automate runout date and write off quantity data parsing. The finished products will produce faster results, require less human involvement, and include a simpler and more standardized process for employees to use. The supply chain is expected to benefit from simpler standardized tools and processes that enable better analysis, accurate decision making, and time savings across multiple teams.



The Excel tool template calculates EOQ for a product based on variable inputs provided by the plants.

MARS Petcare

ENGINEERING SCIENCE
ES-5

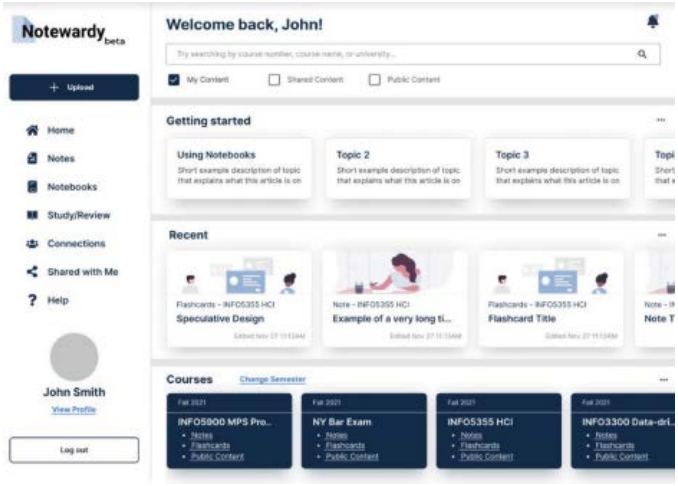
TEAM
Brian Duncan, ES
Jonathan Wieland, ES
Tara Menon, ES/Econ

ADVISERS
Andrew Ward, Notewardy
Casey Ward, Notewardy
Professor Courtney Johnson, GE

SPONSOR
Notewardy

Marketing and expansion of the Notewardy EdTech application

Notewardy is a startup working on developing an EdTech study app. The app is designed to revolutionize the way students study by increasing efficiency and improving test scores while maximizing learning backed by neuroscience and the science of learning. The company is currently facing many of the same challenges most startups face, such as product development, increasing the number of users, and identifying areas of improvement. The goal of this project is to increase the number of users in order to gather feedback for further app improvements. The feedback has already brought forward new and innovative ideas that will enhance the features of the app and improve the user experience.



The dashboard design includes proposed changes based on feedback through customer research.

ENGINEERING SCIENCE
ES-6

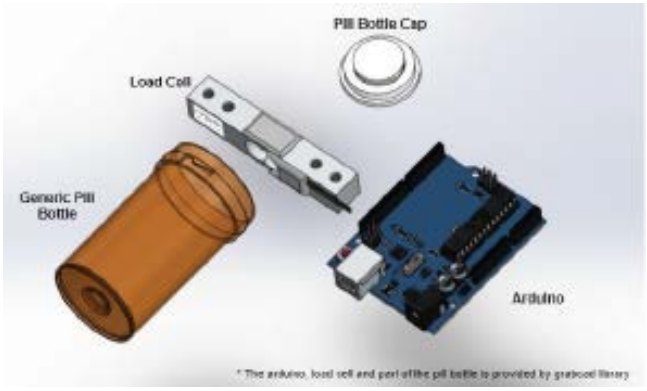
TEAM
CJ Hardnett, ES
Briahnah Streeter, ES
Sevrina Tekle, ES
Ammar Zulqarnain, ES/Econ

ADVISERS
Christopher Abiodun, NeXTMed, LLC
Professor Courtney Johnson, GE

SPONSOR
NeXTMed, LLC

Smart pill bottle for tracking patient adherence

Patient adherence to their medications is a major issue worldwide. In the U.S., the lack of patient adherence is leading to more than 100,000 deaths annually. It also is detrimental to the health care system, costing billions of dollars annually. The project's goal is to circumvent this issue by creating a proof of concept for a "smart" pill bottle that can track a patient's adherence to their medications. The design comprises of a load scale that would be able to weigh the amount of pills in the bottle, a biometric lock that controls a patient's access to their medication, and a mechanical counter. The bottle could connect to an app so a patient would be able to tell how many pills are left as well as serve as a reminder for a patient to take the medication. The design's goal is to be able to avoid some of the common non-adherence reasons such as forgetfulness and modifying the dose regimen without a doctor's approval.



The components of the bottle would include a counter, a biometric lock, and a load scale connected to an Arduino.

NeXTMed

TEAM
William Essery, ES
Marcus Ferreira, ES
Kaitlyn McVeigh, ES
Julia Waldman, ES

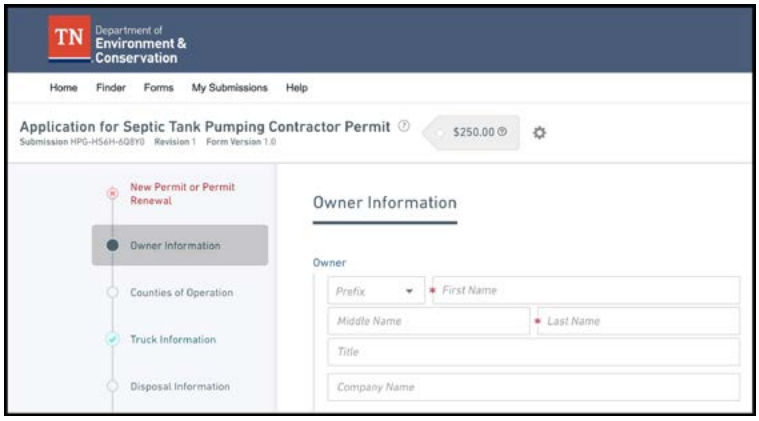
ADVISERS
Vojin Janjic, Tennessee Department of Environment and Conservation
Professor Courtney Johnson, GE

SPONSOR
Tennessee Department of Environment and Conservation—Division of Water Resources

ENGINEERING SCIENCE
ES-7

Electronic conversion of MyTDEC forms

The Tennessee Department of Environment and Conservation—Division of Water Resources (TDEC-DWR) is responsible for managing, protecting, and enhancing the quality of the state's water resources through voluntary, regulatory, and educational programs. In Tennessee, numerous properties are served by subsurface sewage disposal systems (SSDS), commonly referred to as septic systems. These systems must be installed and serviced by licensed professionals in the state. TDEC-DWR is responsible for providing these professionals with the appropriate applications to install and pump septic systems. The project objective is to convert the TDEC SSDS Installer Permit and TDEC Septic Tank Pumping Contract into electronic forms to be completed, submitted, and reviewed on the TDEC webpage. These forms will be accessible to applicants within their personal TDEC profiles. The forms allow applicants to complete the required permits online with the assistance of help text and clarification of necessary information to streamline the process of approval. The online forms will allow the TDEC internal team to request additional information or approve the permit on a faster timeline than paper forms.



The online form collects information about the form's owner, business entity, operational logistics, and legal requirements in a curated progression with text-help and requirements noted.

TN Department of Environment & Conservation

TEAM
Megan Krueger, ES/Math
Megan MacGillis, ES
Mary Ashley Mendik, ES/Psychology
Sarah Mutombo, ES

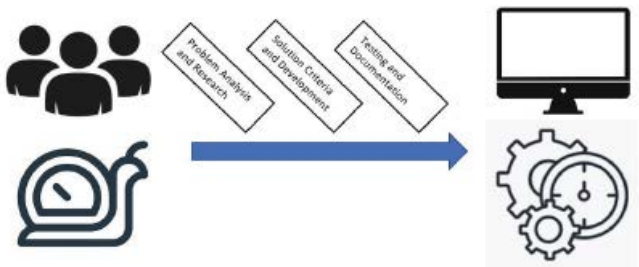
ADVISERS
Laura Young, Tennessee Department of Mental Health and Substance Abuse Services
Ty Thornton, Tennessee Department of Mental Health and Substance Abuse Services
Richard Zhu, Tennessee Department of Mental Health and Substance Abuse Services
David Phillips, Tennessee Department of Mental Health and Substance Abuse Services
Kelvin Winrow, Jr., Tennessee Department of Mental Health and Substance Abuse Services
Professor Courtney Johnson, GE

SPONSOR
Tennessee Department of Mental Health and Substance Abuse Services

ENGINEERING SCIENCE
ES-8

Data management dashboard

The Department of Mental Health and Substance Abuse Services wants to leverage data as an asset to improve services and delivery. The Data Warehouse project was initiated to serve as a repository for federal reporting, and the project was extended to produce the Commissioner's Dashboard. This system will automate the manual effort of gathering and aggregating data from multiple sources. The system will also automate the presentation of the data by creating standardized reports based on pre-existing templates. By documenting this process, this system can be replicated to produce evidence-based decisions and business needs. Students have collaborated with stakeholders to understand and map multiple business processes. The intended result is a systems engineering report that can be adopted by other agencies and organizations seeking data management support through the creation of a dashboard.



Thorough analysis of the current manual, human-dependent processes allow for the development of an automated and efficient data management system.

TN Department of Mental Health & Substance Abuse Services

ENGINEERING SCIENCE
ES-9

TEAM
Shun Ahmed, ES
Grace Koonmen, ES
Jack Pantlin, ES
Wally Vargas-Ríos, ES

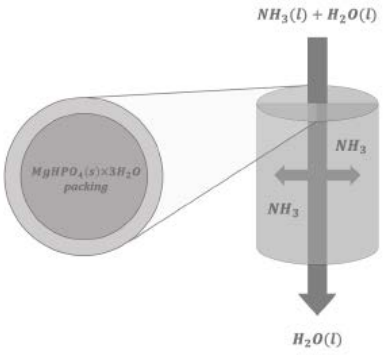
ADVISER
Professor Yiorgos Kostoulas, GE

SPONSOR
NASA Technology2University Program

NASA Technology2University Portfolio start-up for the ammonia wastewater recovery system

This project takes the Technology2University portfolio program from the National Aeronautics and Space Administration and turns one included technology into a built-out business model. The team focused on the Ammonia Wastewater Recovery System due to a spotlight on sustainability and environmental consciousness within multiple fields today. The team chose to fine tune a market and its attached scope through consumer interview and market research to then evolve into a business plan and an organizational outline for the product. The markets we considered are farming or industrial applications. We intend to determine what alterations the technology needs to go through to be able to put it onto the market—ranging from but not limited to legal considerations, physical infrastructure, application and installation for the consumer, and even smaller factors like geographical locations to address issues such as demand. Our goal is to meld this technology into one that could become a strong competitor in the field of wastewater treatment nationally.

$$MgHPO_4(s)\times 3H_2O + NH_3(l) + 3H_2O(l) \rightarrow MgNH_4PO_4(s)\times 6H_2O$$



The ammonia recovery system features columns of magnesium phosphate packing material that react with ammonia in wastewater to form crystallized magnesium ammonia phosphate that can be removed by heat or low pressure.

ENGINEERING SCIENCE
ES-10

TEAM
Sam Blum, ES
Jane Jang, ES
Amanda Sarubbi, ES/ Cognitive Studies
Ryan Zhou, ES

ADVISERS
Jasmine Jones, VT3 Enterprises LLC.
Tearra Vaughn, VT3 Enterprises LLC.
Professor Courtney Johnson, GE

SPONSOR
VT3 Enterprises LLC

Subscription mobile app development

VT3 Enterprises wants an app that allows its customers to create/edit profiles, select/modify/cancel subscription plans, and add/change/cancel billing methods and options. The customers currently do not have an efficient way to subscribe and manage subscriptions on their mobile devices. The team is tasked with designing an iOS application that will enable customers to create and edit a profile and manage their subscription plan. The team is using Swift and other various development tools. The goal of the app is to extend brand reach and create an easily accessible interface for existing customers. In addition to the features mentioned above, it is our goal to work towards incorporating a payment API for direct payments in-app.

Through a tab bar navigation style, the iOS application will include features for registering and logging into the user's account, subscribing, managing subscription options, and making purchases.

TEAM
Adrian Florea, ME
Jacob Gordon, ME
Joseph Reddy, ME

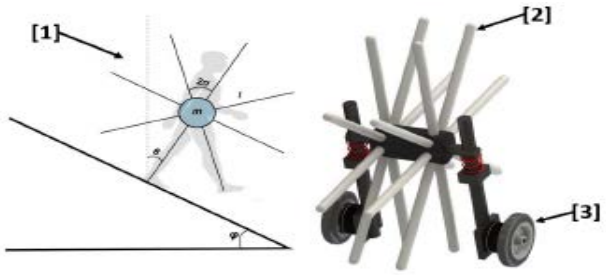
ADVISERS
Professor David Braun, ME
Ali Kilic, ME
Levent Cinar, ME

SPONSOR
Advanced Robotics & Control Lab

MECHANICAL ENGINEERING
ME-1

Helper robot to understand fundamental controls of robotic walking

Bipedal robots that mimic walking can assist humans in carrying out difficult tasks and eliminate the risk of injury or casualty. Maintaining a stable walking gait is a common point of failure since slight environmental changes can cause a robot to fall. Failure of satisfying the minimal necessary level of performance for walking results in an uncontrolled fall in which the bipedal robot is unable to recover. Our project addresses this problem by introducing a learning-helping robot model to enable the learning bipedal robot to use repetitive physical experimentation to improve its walking ability. The team designed a helping robot that acts as a set of robotic training wheel to support the bipedal robot. This system aims to support the bipedal robot as it attains a steady limit cycle and gait. The team utilized a rimless wheel approach to model human walking and to use as a testbed for the helping robot. This design will provide constant and stable locomotion in different scenarios and provide data into how learning-helping robotic systems can be improved.



(1) Comparison of human walking to a rimless wheel model. (2) Model of rimless wheel prototype attached to (3) wheeled helper robot.

TEAM
Michael Finn-Henry, ME
Christopher Shella, ME
Katherine Yohe, ME

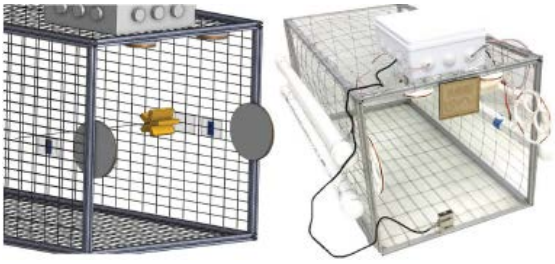
ADVISERS
Joe Chapman, Cumberland River Compact
Sarah Habeck, Department of Earth and Environmental Sciences

SPONSOR
Cumberland River Compact

MECHANICAL ENGINEERING
ME-2

Stream litter collector implementation and upgrades

Litter collection devices are used to make waterways cleaner while minimizing impact to water flow and wildlife. The Cumberland River Compact needs a sensor package for their litter collector, the Bandalong Bandit, to gain information about litter in Nashville waterways and the effects that significant rainfall events have on the presence of litter in streams. Currently, the only way to determine if litter collecting devices are full is by visual observation. The team's goal is to implement a sensor package to determine the amount of litter collected, what type of litter is collected, and to automatically notify the CRC when the collector device if full. The project design consists of three major subsystems of sensors. Flowrate and tension sensors, photocell sensors, and inductance sensors mounted on the litter collection device detect the presence and consistency of incoming litter. The goal is to provide the CRC with real-time data and insights on when a litter collection device is full, how quickly the device fills up based on the amount of rainfall the waterway receives, and the amount of organic versus inorganic material present in the collector.



Test litter collection device with prototype sensor system. CAD model (left) shows the placement of flowrate, inductance, and photocell sensors. The prototype (right) also shows the tension sensor at the entrance of the collection device and displays the upgrades made for the waterproofed system.

MECHANICAL ENGINEERING
ME-3

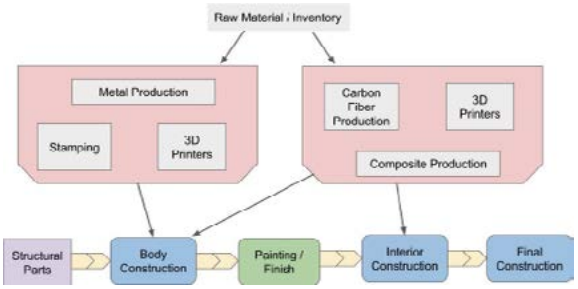
TEAM
Evan Bouck, ME
Kyle Haynes, ME
Joseph Herrera, ME
Matthew Witalec, ME

ADVISERS
Josh Westerhold, Nissan North America Mobility Group
Eric Sipe, Nissan North America Mobility Group
Matthew Overbay, Nissan North America Manufacturing Strategy
Thomas Lesieur, Nissan North America Manufacturing Strategy

SPONSOR
Nissan North America

Modular automotive manufacturing plant design for Nissan North America

As Nissan looks toward the future, the company plans to construct manufacturing facilities with higher levels of flexibility to open possibilities both internally and with exterior startups who need an experienced manufacturing partner. This design plan maps a potential plant layout that uses multiple novel and emerging technologies to increase modularity without excessive sacrifices in time and cost. The novel design implements pin molds for stamping and die casting, metal additive manufacturing technologies for unique part production, new welding technologies to update that area, and enhanced quality assurance around the entire process. Also, evaluations of more solutions accompany this project in order to eliminate or qualify the use of additional manufacturing methods that may not satisfy the requisite needs of Nissan at this time or in the near future. This solution allows Nissan to produce cars within the same space with limited tooling changes or downtime, thereby opening the door to leasing space for manufacturing as a service.



The next generation design layout features multiple raw material processing stations that feed into assembly nodes for creation of vehicle's body and interior.

MECHANICAL ENGINEERING
ME-4

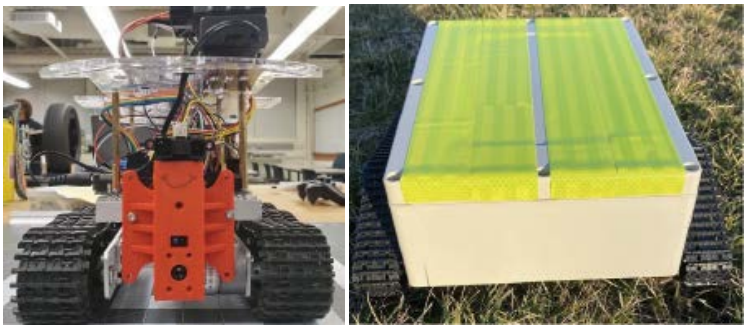
TEAM
Megan Dernberger, ME
Kaheem Gibbs, ME
Ally Stuart, ME
Jeremy Trujillo, ME/Spanish
Josh Villatuya, ME/Math

ADVISERS
Micah Deyoung, Booz Allen Hamilton
Robenson Jean, Booz Allen Hamilton
Adrian Perez, Booz Allen Hamilton
Eric Barlett, Booz Allen Hamilton

SPONSOR
Booz Allen Hamilton

IEDetected: Detecting improvised explosive devices in war torn nations

Thousands of active improvised explosive devices have been left in war torn nations as a result of guerilla warfare tactics. These IEDs continue to kill, causing a current annual death toll of around 22,000 civilians. The team designed a Go-kit to help detect the location of IEDs that is easy to understand and can be used by civilians to evacuate areas with potential IEDs. This device does not deactivate IEDs and should be used in tandem with a technical explosive ordnance disposal team to dismantle. A robot composed of an electrical box and thick treads includes a sensor payload attached to the chassis. The payload includes a metal detector, thermal camera, and infrared sensors. The sensors will be used in tandem to pick up potential IED signatures. A drone will offer a zoomed-out aerial view to allow the human controller to maintain a safe distance between a user and a potential IED. In the future, sensor data will be analyzed to help predict trends regarding IED location and types. IEDetected offers an easy-to-use, inexpensive alternative to IED detection.



Left, the first iteration of the robot carrying all electronics for motor control and IED sensor payload, including infrared sensor, metal detector, and thermal camera. Right, the updated electrical box and stronger treads used in the final iteration to increase durability and endurance.

TEAM
Tucker Ballantyne, ME
Lauren Harmon, ME
Isaac Huggins, ME
Lydia Manuel, ME
Quentin Millora-Brown, ME
Morgan White, ME

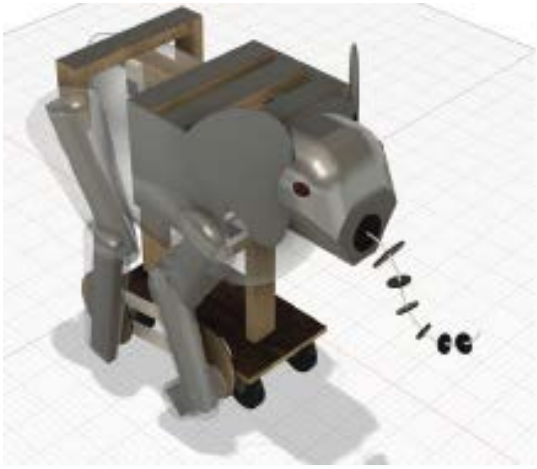
ADVISER
David Oehler, Nashville Zoo at Grassmere

SPONSOR
Nashville Zoo at Grassmere

MECHANICAL ENGINEERING
ME-5

A robotic baby elephant for the Nashville Zoo

The goal of the project is to develop a robotic baby elephant for the future African Safari experience currently underway at the Nashville Zoo. Employing the use of quadruped robots allows for educational opportunities without compromising the animal's quality of life. The team's two sub-goals are to develop an animatronic face that replicates an elephant (i.e. eyes, ears, a mouth, and a moving trunk) as well as to make the robot capable of walking with a realistic gait. The legs are kinematically linked to the wheels through a cyclical motion to show the walking pattern of the elephant. Gait research and kinetic analysis was conducted with the intention of determining the power needed for the motors for future design iterations. This project, an example of humanitarian engineering, is proceeding while the exhibit is being constructed, so we hope to produce a design that future teams can easily iterate upon.



A robotic elephant model to show the functional mobility of the legs, trunk and ears.

TEAM
Gabby Seberger, ME
Lucas McBride, ME
Nolan Van Nortwick, ME/Math
Rose Litt, ME
Tessa Kim, ME

ADVISERS
Nikole Edmunds, Nashville Zoo at Grassmere
David Oehler, Nashville Zoo at Grassmere

SPONSOR
Nashville Zoo at Grassmere

MECHANICAL ENGINEERING
ME-6

Nashville Zoo hoofstock animal enrichment feeder

The long-term under-stimulation of animals held in captivity has become an issue of increasing prevalence and severity. Unlike their natural environments where the challenging pursuit of survival ensures constant mental, physical and social enrichment, animals in captivity are stripped of these factors that help maintain their health. Our design team has developed an enrichment feeder for hoofstock animals at the Nashville Zoo that not only safely addresses the needs of a diverse group of animals, but also is easy to use for their zookeepers. Zookeepers have used off-the-shelf high-density polyethylene (HDPE) hay feeders for their giraffes, antelopes, okapi, and tapirs. Due to discontinuation, they sought a similar solution that would enable easy feeding and better stimulate the animals. The enrichment feeder, made primarily of food-safe hard plastic, features a custom tight-locking lid, a durable hanging mechanism, and holes cut to various sizes according to the animal species it serves.

The enrichment feeder, made primarily out of food-safe hard plastic, features a custom tightlocking lid, a durable hanging mechanism, and holes cut to various sizes according to the animal species it serves.

MECHANICAL ENGINEERING
ME-7

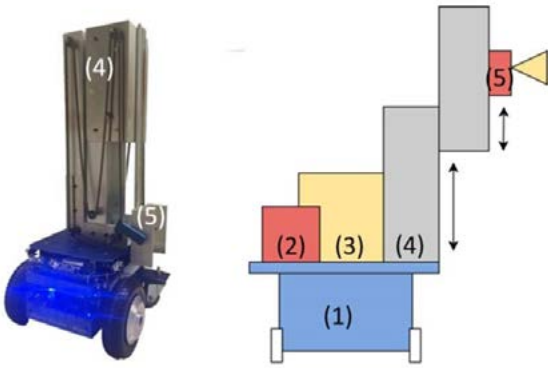
TEAM
Luis Aburto, ME
Omar Borai, ME
Coral Brockman, ME
Ben Chick, ME
Alex Feeley, CompE/Math Nikki Gloudemans, ME

ADVISERS
Nick Hegeman, PaintJet
Sonia Chacko, PaintJet

SPONSOR
PAINTJET

Autonomous interior painting robot

Rising labor prices and worker scarcity has prompted companies in the painting industry to turn to autonomous solutions to save time and money. The team designed and built an autonomous painting robot to paint commercial spaces overnight. After workers prepare a room for painting, the robot traverses the room to create a map. A worker then draws a path on the map to direct the robot around the edge of the room and loads a paint bucket onto the robot, which has a battery life of up to 8 hours. Throughout the night, the robot navigates along this path, stopping at set intervals to apply paint. The team designed a tiered lift system to raise the paint sprayer from the ground to 12 feet high while ensuring the system can collapse and pass through a standard doorway. The robotic base can carry up to 215 pounds, allowing it to carry a 5-gallon paint bucket, lift system, and paint sprayer. The autonomous painting robot is simple for one person to set up, clean, and resupply between painting jobs, making it more efficient, inexpensive, and less labor intensive than manual painting.



Left, A photo and model (right) of the autonomous painting robot with (1) robotic base, (2) paint bucket, (3) paint pump, (4) lift system and (5) paint sprayer.

PAINTJET

MECHANICAL ENGINEERING
ME-8

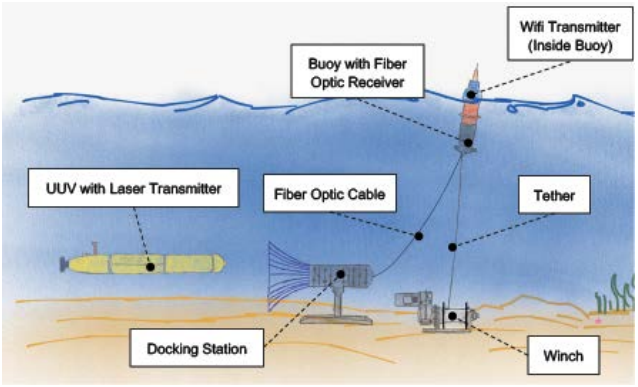
TEAM
Jacob Augelli, ME
Cole Diamond, ME
Ryan Joyce, ME
Katherine Wiesbrock, ME
Jiajun (David) Xiao, ME

ADVISERS
Timothy Daniel, NSWC Panama City Division
Matthew Bays, NSWC Panama City Division
Professor Jason Mitchell, ME

SPONSOR
Naval Surface Warfare Center, Panama City Division

Unmanned underwater vehicles docking and communications buoy

Unmanned underwater vehicles collect massive amounts of data as they complete reconnaissance missions. Accessing this data is difficult due to the physical challenges of secure wireless communication through water. Traditional methods of data transfer involve hauling the UUV onboard a surface ship, which is expensive and interrupts the mission of both the UUV and surface personnel. Our team designed a buoy to mediate remote communication between a submerged UUV and a surface ship. The system implements optical communication using visible light to eliminate the challenge of making direct electrical contact underwater. The UUV enters a docking station on the seafloor and fires a laser to transmit data as a series of light pulses. A fiber optic cable carries these light pulses from the docking station to a buoy on the surface. Signal processing electronics inside the buoy translate the pulses into electrical signals that can be sent over WiFi to a nearby ship. A winch system attached to the docking station submerges the buoy after transmission to minimize its risk of detection.



When the unmanned underwater vehicle docks, it transmits data through a fiber optic cable to the buoy. This data is processed, stored, and sent over WiFi to a passing ship when the buoy surfaces. The winch then submerges the buoy to hide it from view.

NAVSEA WARFARE CENTERS Panama City

TEAM
Joseph Aquino, ME
Thomas Colicci, ME
Zachary Friedman, ME
Brian Knapp, ME
Özgür Örün, ME
Marissa Schwarz, ME

ADVISER
Professor Amrutur Anilkumar, ME

SPONSOR
Vanderbilt Aerospace Design Laboratory
NASA

MECHANICAL ENGINEERING
ME-9

Modular payload system for autonomous vehicle location tracking

The Vanderbilt Aerospace Design Laboratory is developing a vehicle and payload system for the 2022 NASA Student Launch Initiative. The goal for this year's project is to autonomously locate the vehicle upon landing by identifying its position on an aerial image of the launch site without GPS assistance. The team has developed a novel modular payload housing system, allowing for expedited payload configuration and a more robust set of mission capabilities. The vehicle will fly to a target altitude of 4,900 feet before descending under two parachutes. Design of the payload system incorporates redundancy between two side payload and two nose cone payload systems. The side payloads take photos and videos of the launch field on both ascent and descent to provide visual data. The nose cone payloads house a pair of cameras used to capture images for a computer vision algorithm, which has been developed to track changes in vehicle position so the final landing location may be determined. The vehicle also contains inertial measurement units (IMUs), which are used for a redundant vehicle location tracking method with 3D flight path reconstruction. The landing location is then transmitted to base using LoRa radio modules.

The 7-foot long launch vehicle with a modular and redundant payload system capable of autonomously identifying its landing location without the use of external systems.

TEAM
Diana Florencio, ME
Carson Muhlada, ME
Kevin Shulman, ME
Barock Taddese, ME
Amber Terry, ME

ADVISERS
David Blaylock, Nissan North America
Mark Larson, Nissan North America
Derrick Young, Nissan North America
Bryan Meadows, Nissan North America

SPONSOR
Nissan North America

MECHANICAL ENGINEERING
ME-10

Automating wheel mask application for vehicle delivery

Nissan applies wheel masks to their wheels to protect them from damage, as well as keep the rotors from rusting due to airflow coming through the spokes during vehicle delivery. The current process for applying the wheel masks on the assembly line is manual, requiring workers to continuously bend and twist during their shift. This leads to fatigue and inconsistent application. Unreliable wheel mask application could incur large expenses on different fronts. For example, delivery costs increase sharply if the vehicle is damaged and needs to return to the factory. In addition, if the mask comes off later down the assembly line, there is an additional material and labor cost to reapply the mask. To eliminate the poor ergonomics in this process and reduce the overall expense for vehicle delivery, the team designed an automated application system using a Universal Robotics COBOT (UR10e) to select the appropriately sized wheel mask based on a signal from the assembly line. The UR10e then moves the mask to a peeler station to remove the paper backing, and finally moves the peeled mask to the wheel and applies it—all while maintaining vehicle production rate.

The UR10e robotic arm's custom end effector equipped with suction cups and vacuum generators, applying a mask to a wheel.

Design and project faculty

**Biomedical Engineering,
Chemical Engineering,
Civil and Environmental Engineering,
Electrical and Computer Engineering,
Engineering Science, and
Mechanical Engineering**

We take great pride in recognizing these faculty members who are the core of our design program in their respective departments. Their outstanding contributions and excellence as instructors, advisers and mentors have led to the work demonstrated on Design Day, April 29, 2022.

RALPH BRUCE
Professor of the Practice of Electrical Engineering

MARC MOORE
Associate Professor of the Practice of Biomedical Engineering

RUSSELL DUNN
Professor of the Practice of Chemical and Biomolecular Engineering

LORI TROXEL
Professor of the Practice of Civil and Environmental Engineering

COURTNEY JOHNSON
Assistant Professor of the Practice of Technical Communications

THOMAS WITHROW
Assistant Dean for Design
Associate Professor of the Practice of Mechanical Engineering

JASON MITCHELL
Research Assistant Professor of Mechanical Engineering

Administration

Dean
Philippe Fauchet, Bruce and Bridgitt Evans Dean
philippe.fauchet@vanderbilt.edu
(615) 322-0720

Senior Associate Dean for Graduate Education and Faculty Affairs
E. Duco Jansen
duco.jansen@vanderbilt.edu
(615) 343-3773

Senior Associate Dean for Undergraduate Education
Cynthia Paschal
cynthia.paschal@vanderbilt.edu
(615) 343-3773

Associate Dean for Research
Peter T. Cummings, John R. Hall Professor of Chemical Engineering
peter.cummings@vanderbilt.edu
(615) 343-3773

Associate Dean for Development and Alumni Relations
Teresa Rogers
teresa.rogers@vanderbilt.edu
(615) 322-4934

Associate Dean for External Relations
Christopher Rowe
chris.rowe@vanderbilt.edu
(615) 343-3773

Associate Dean for Academic Success
Julie Vernon
julie.vernon@vanderbilt.edu
(615) 322-2441

Associate Dean for Strategic Learning Program
Jules White
jules.white@vanderbilt.edu
(615) 343-7472

Assistant Dean for Academic Services
Adam McKeever-Burgett
adam.w.mckeever-burgett@vanderbilt.edu
(615) 343-8061

Assistant Dean for Professional and External Education Programs
Joanne Wang
joanne.wang@vanderbilt.edu
(615) 875-8386

Assistant Dean for Design
Thomas J. Withrow
thomas.j.withrow@vanderbilt.edu
(615) 322-3594

Departments

Department of Biomedical Engineering
Michael King, Chair, J. Lawrence Wilson Professor of Engineering
mike.king@vanderbilt.edu
(615) 322-3521

Department of Chemical and Biomolecular Engineering
Kane Jennings, Chair
kane.g.jennings@vanderbilt.edu
(615) 322-2441

Department of Civil and Environmental Engineering
Caglar Oskay, Chair,
caglar.oskay@vanderbilt.edu
(615) 322-2697

Department of Computer Science
Xenofon Koutsoukos, Chair
xenofon.koutsoukos@vanderbilt.edu
(615) 322-8283

Department of Electrical and Computer Engineering
Bennett Landman, Chair
bennett.landman@vanderbilt.edu
(615) 322-2771

Department of Mechanical Engineering
Nilanjan Sarkar, Chair,
David K. Wilson Professor of Engineering
nilanjan.sarkar@vanderbilt.edu
(615) 322-2413

Division of General Engineering
Yiorgos Kostoulas, Director
yiorgos.kostoulas@vanderbilt.edu
615-343-4965

Department of Computer Science

2021-2022 Immersion Showcases

FACULTY ADVISERS

Bobby Bodenheimer, Professor of Computer Science and Professor of Electrical Engineering and Computer Engineering

Douglas Fisher, Associate Professor of Computer Science and Associate Professor of Computer Engineering

Aniruddha Gokhale, Professor of Computer Science and Professor of Computer Engineering

Graham Hemingway, Associate Professor of the Practice of Computer Science

Gabor Karsai, Professor of Computer Science and Professor of Electrical Engineering and Computer Engineering

Forrest Laine, Assistant Professor of Computer Science

Ipek Oguz, Assistant Professor of Computer Science and Assistant Professor of Electrical and Computer Engineering

Jules White, Associate Dean for Strategic Learning Programs and Associate Professor of Computer Science and Computer Engineering

PROJECTS

Amadeus *(Yifan Wu, Xiaoliang Zhu, Zihao Wu, Wangzhe Sun)*

Analyzing the Use of Load Balancers through HAProxy, YCSB *(Katie Cella, Hannah Schrager)**

Arcade VR *(Sam Bianco, Joe Mathis, Bo Peng, Miquéla Thornton, Kielan Watson)**

An Automatic Ukulele Tuner *(Melissa Wang, Anthony Huang)*

AR Project Cloudification *(Elle Summerfield, Alan Xu, Logan Powell)**

Big Five Personality Test Comparison using a Distributed Web Application *(Charlie Overton, Matthew Tremblay, Angelica Zverovich)**

Bank Shot: A Fully Automated Environment for NBA Gambling Data Collection, Analysis *(Chris Hoogenboom, Jerry Li, Kyle Gendreau)**

Building AIs to Play a Simulated-World Sustainability Game *(Hermela Gebremariam, Kevin Gomez, Anvitha Kosaraju, Erin McConnell, Blaine Mitchell, Joshua Newman, Sithara Samudrala, Hadley Shapland)*

Camera-Based Object Tracking *(Tianxiang Zhang, Yihao Yan, Alex Korman, Katie Helman, Emily Hugan, Jatin Krishna, Daniel Chu, Prakyath Bujimalla, Emma Willey, Jessica Lee, Yousef Abu-Salah, Jane Jung, Reena Zhang, Tina Guo)*

Class Attendance System using AWS-Based Facial Recognition *(Evelyn Mulyono, Sarah Wan, Siqi 'Christine' Zhou)**

Classifying Public Sentiment About Climate Change *(Nam Dau, Emma Willey, Rohan Nakra, Anjay Friedman)*

Cloud-Based Deep Learning: End-To-End Full-Stack Handwritten Digit Recognition *(Aadarsh Jha, Ashwin Kumar, Terry Luo, Ruida Zheng)**

Cloud Based Facial Recognition Multi-Factor Authentication *(Sean Tuttle, Bao Pham, Michael Knight)**

Cloud-Based Ray Tracing Animation Generator *(Daniel Shu, Xinyu Niu, Yueqi Li)**

Cyclops *(Jeongwoo Seo, Leila Leblanc)*

APRIL 28

Deathris *(Alicia Yang, Ashley Suh, Abby Cohen, Jaehyuk Yu, Kelly Chang, Nishan Shehadeh)**

Deploying Mutational Biases Analysis on the Cloud *(Qianhui Zheng, Xinyu Shen, Shiliang Tian)**

Don't Get Run Over *(Karl Schreiner, Dylan Gaines, Christine Zhou, Craigh McLaughlin, Angus Black)**

Drinking-Water Quality Monitoring System: A Raspberry Pi (cyber), MATLAB (physical) Approach *(Surya Sunil, Eduard Tataru)*

Droopy Dodo *(Justin Condren, Grant Bowlds, Alexa Madsen, Claire Whetstone, Jessica Wu, Victoria McMillen)**

Dynamic Modalities *(Aadarsh Jha, Raahul Natarrajan)*

Escape From the Lost Tomb *(Brandon Groothuis, David Tamburri, Jennifer Jiang, Rachel Yang, Shannon Yan, Xinyu Niu)**

Experience Orchestra! *(Kristine Choi, Raahul Natarrajan, Garrett Crumb, Richard Li, Patrick Tong)**

Experimenting with Microservice Scheduling, Performance in the Cloud *(T. Dawson Lee, Jeerthi Kannan, Jingyuan Gao)**

Hanabi *(Yuanhao Lyu, Sarah Fishbein, Marlee Silverman, Ignatius Liu, Sydney Horn)**

Handle: An Open Source Tool For Accurate Gesture Recognition In Real-Time Systems Across Static, Lantern Party *(Zhangyi Shen, Tianyu Han, Yuanhan Tian, Qibang Zhu)*

High Speed Autonomous Driving *(Xi 'Iris' Sun Karman Nagra, Matthew Daniel, Henrik De Jounge, Andrew Huang, Jason Kim, Ricardo Sandoval, Sam Welch, Jason He, Nicholas Ma, Rashmi Ja, Nibraas Khan, Zinnie Zhang, Maya Warren, Ao Qu, Ziyang Li, Luke Hewitt, Ioannis Dimotsis)*

Kubernetes vs Marathon via Phoronix Suite *(Hao Fu, Jianqiang Hao, Yuheng Shi)**

Lidar-Based Localization and Mapping *(Erskine Nyoike, Robi Abera)*

Light Piano *(Karina Rovey, Leen Madiah, Damian Ho, Jacky Zhang, Katelyn Itano, Rhiannon Moilanen)**

The Making of Fake Twitter *(Johnny Ou)**

Neural Implant *(Noah Knox, Marco Georgaklis)*

Rage Room *(Chenhao Ma, Akshay Doobay, Antonio Dominguez, Toni Mecklenburger, Ancher Li, Xue Ye Lin)**

Resilient Weather Interpolation *(Baxter Hunter, Meghan Callandriello, Jaden Hicks, Martin Pena)**

Reuse Vandy Marketplace *(Tabitha See Ya Lee, Alice Qiao, Kyle Gendreau, Kaleab Gebremichael)*

RL Skillshot Dodger *(Rong Wang, Jerry Qin, Terry Luo, Nitish Nimma)*

Robot Collision Avoidance Controller *(Yuanhao Lyu, Changzhe Liu)*

Semantic Segmentation for Autonomous Vehicles *(Peize Li, Xinxuan Lu, Amanda Sun, Yihang Zhang)*

Spark Streaming with Twitter for Finance *(Camren Hall, Safet Hoxha, Luke Garrett)**

SpikeBall *(Anshul Joshi, Grace Schillewaert, Grace Sullivan, Jai Bansal, Rebecca Sun)*

Surf-Safe Flag Switching System *(Jack Walton, Ryan Edelstein)*

Sybil Attack Detection on Edge Computing Servers *(Baiting Luo)**

synthEsiziNG realistic fmrI coNnectivity matrices for Enhancing dEep leaRnING in data poor domains *(Lucas Remedios, Alireza Abbasi)*

Towards using Twitter, Deep Learning to Predict Potential COVID Cases *(Joshua Berger, Kabindra Shrestha, Hannah Yoon, Juyoung Kim)*

Traffic Control System Model *(Todd McKinney, Donovan 'Donny' Carr)*

**These projects were presented at the fall 2021 CS Immersion Showcase.*

Thank you to our sponsors

Our sponsors generously support the Vanderbilt School of Engineering's design program. Thank you for providing your time, experience and financial support, which help make our program a success.

American Society of Civil Engineers, Vanderbilt Student Chapter

Booz | Allen | Hamilton

Chemical Engineering Design Advisory Board

Cumberland River Compact

Gresham Smith

Dominion Water and Sanitation District, Colorado

Mars Petcare

Nashville Zoo at Grassmere

NASA

Naval Surface Warfare Center, Panama City Division

NeXTMed, LLC

Nissan North America

Notewardy

PaintJet

Permobil

Polymer and Chemical Technologies, LLC

Sterling Ranch

Tennessee Department of Environment and Conservation Division of Water Resources

Twin|Sun

Vanderbilt Institute for Software Integrated Systems

Vanderbilt University
- Facilities Department
- Plant Operations

Vanderbilt University Medical Center
- Department of Cardiovascular Medicine
- Cardiovascular Intensive Care Unit
- Department of Anesthesiology
- Department of Cardiac Surgery
- Department of Pathology, Microbiology and Immunology
- Department of Vascular Surgery

Vanderbilt University School of Medicine
- Department of Pathology, Microbiology and Immunology
- Department of Diagnostic Radiology
- Vanderbilt University School of Engineering
- Advanced Robotics and Control Laboratory
- Biomedical Elasticity and Acoustic
- Measurement Laboratory
- Duvall Advanced Therapeutics Laboratory
- Department of Biomedical Engineering
- Department of Civil and Environmental Engineering
- Vanderbilt Aerospace Design Laboratory

Sponsorship in no way implies endorsement, guarantee, warranty, or recommendation of the ideas or designs presented in this book or at Design Day.

2022 Design Awards

The **Thomas G. Arnold Prizes for Biomedical Engineering Systems Design and Research** is shared by Lucy Sammis Britto, for research; and by Andrew David Gnegy, Kevin Michael Oswald, Isabella Richter and Christina Elizabeth Sundt, for design.

The **C. F. Chen Best Design Award** for the best design project in the Department of Electrical Engineering and Computer Science is shared by Sebastian Alexander Bond, Ethan Hunter Mayer, Kellen McKenzie Lively, Abdul-Latif Gbadamoshie, and Kai Devon Malcolm for the project: Modular payload system for autonomous vehicle location tracking.

The **Civil and Environmental Engineering Design Award** goes to the project: Empathic data collection for transportation infrastructure redesign, and is shared by teammates Crystal Cheng, Blythe Dewling, Jake Haas, Kristi Maisha and Erin Olender.

Kenneth A. Debelak Award for Excellence in Design is given for the best design project in chemical engineering in honor of a former faculty member. The winning project is: Design of a regenerative medicine manufacturing facility, and it is shared by teammates Jacob Legaard, Lucas Mowery, Riya Patel and Jack Tsenane.

The **Arthur J. Dyer Jr. Memorial Prize** is awarded to a senior who has done the best work in the study and/or design in use of structural steel, and who is a member of the American Society for Civil Engineers. The recipient is Crystal Cheng.

The **Computer Science Design Prize presented by FortyAU** is given by software development company FortyAU for outstanding achievement in originality, robustness and impactfulness of software design. The award is shared by Marco Georgaklis and Noah Knox.

The **Mechanical Engineering Design Award** is shared by two teams. They are Automating wheel mask application for vehicle delivery (Nissan North America) with teammates Diana Florencio, Carson Muhlada, Kevin Shulman, Barock Taddese and Amber Terry; and Unmanned underwater vehicles docking and communications buoy (Naval Surface Warfare Center, Panama City Division) with teammates Jacob Augelli, Cole Diamond, Ryan Joyce, Katherine Wiesbrock and Jiajun (David) Xiao.

EDITOR
Lucas Johnson II

WRITERS
Brenda Ellis, Celeste Malone, Pamela Coyle, Lucas Johnson II, and Paul Govern

DESIGN
Mary Alice Bernal, Finn Partners Southeast

Solutions is published biannually by the Vanderbilt University School of Engineering Office of Communications.

engineering.vanderbilt.edu

@VUEngineering

vanderbiltengineering

vanderbiltengineering

http://vanderbi.lt/vusevideos

https://linkedin.com/company/vanderbiltengineering

Subscribe to Dean Fauchet's weekly newsletter

School *of* Engineering

PMB 351826
2301 Vanderbilt Place
Nashville, TN 37240-1826