

DESIGNING the FUTURE

Student Projects
at Vanderbilt University
School of Engineering

2014

Insight • Innovation • Impact®

Summer 2014

We all know how important design is to the engineering profession. At Vanderbilt, we are taking design instruction to the next level by creating a truly unique collaborative space for students and researchers. This space will exist in the new Engineering and



Science Building recently announced and under construction on our campus. Strategically located for easy access by students, visitors, innovators-in-residence, and mentors, the facility will be adjacent to engineering and studio art buildings and foster true trans-institutional collaborations.

The Innovation Center, as it is currently dubbed, will advance the

student experience by facilitating exploration for the purpose of innovation. It will provide flexible, reservable space for design activities. Educational programming will emphasize the innovation process, concept testing, product development, intellectual property strategy, and entrepreneurship while also providing a place for mentors to share their hard-won experiences and knowledge. Machining and other visualization equipment will allow for rapid prototyping and 3-D printing. Technology transfer staff will have an outpost there as well.

Over the past several years, the School of Engineering has experienced enormous growth in entrepreneurial activity as well as interest in student design. Students, faculty, and staff are bringing their innovations to market, and the university community has taken notice. By working carefully with innovators, architects, and administrators on campus, I believe we have designed a facility we could have only imagined years ago.

Innovation is an ever-increasing part of the culture of the School of Engineering. *Designing the Future* is a sampling of how diverse it is for us. The front section of this publication highlights activity by alumni, students, and faculty. Included are curricular innovations as well as design project work. The back section contains our senior design projects presented during Design Day this past April. I hope you enjoy reading and seeing these projects and take as much pride in them as I do.

Best regards,

Philippe Fauchet
Dean

Design at Vanderbilt University School of Engineering

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Intentional Design

It all starts with an idea or a problem and the willingness to apply thought, knowledge, skills and resourcefulness to solving it. At Vanderbilt University School of Engineering, four years of undergraduate education culminates in capstone courses, Design Day projects or applying project management to implementing an idea. Brilliant faculty and graduate researchers spend long hours in the lab working on breakthroughs for society. Out in the workforce, engineers with Vanderbilt degrees improve the world in arenas such as manufacturing, health care, infrastructure, space exploration and the environment.

The following pages spotlight just a few Vanderbilt students, faculty and alumni who saw a problem and solved it with design.



Relax—Chill Pill cures forgetfulness

Student design project



The students' working prototype of the Chill Pill

Don't worry, baby boomers. Forgetting to take your medicine is a thing of the past with a new automatic pill dispenser prototype.

Current automatic pill dispensers on the market are expensive and not always user-friendly. An interdisciplinary team of six electrical, computer and mechanical engineering seniors were determined that their Chill Pill dispenser would be different.

"Our machine can dispense individual pills," said electrical engineering student Kasey Hill. "There are other dispensers on the market that can

dispense small containers or compartments of pills, but ours dispenses pills individually from larger containers."

Their \$200 prototype, about the size of a standard coffee maker, performed flawlessly at Vanderbilt School of Engineering's Design Day 2014, dropping pieces of pill-shaped candy into a small cup at two different preset times. Chill Pill can dispense two types of pills from two different containers, allowing for different sizes and shapes.

The students' prototype is controlled by an inexpensive Arduino microcontroller, which programs inter-

activity between the various objects. Its two-line, six-button LED display allows a user to set pill times and check pill information. The machine alerts users when pills are ready to be taken, and alerts again if the cup of pills has not been removed.

"If we had more time for improvements, we would expand the capacity to five different types of pills and add Wi-Fi capability to allow for the inclusion of an online portal that would display pill types, quantities and dispense times, plus permit easy pill reordering," Hill said.

Blue light special

Designing for the poorest

Sometimes all that stands between life and death for a jaundiced baby is a burnt-out light bulb. D-Rev CEO Krista M. Donaldson, BE'95, vowed to change that.

Every year, over 6 million newborns with severe jaundice don't receive the simple treatment that can save their lives—several days under intense blue light.

When Donaldson traveled to some of the world's poorest regions, she saw phototherapy systems sidelined because replacement light bulbs weren't available or because their design wasn't appropriate for rugged use.

Donaldson and her D-Rev team then created Brilliance, a device that uses long-life LED bulbs. They turned to computer modeling and developed a unit that optimizes light intensity and coverage with fewer diodes. They also designed it to rely on passive cooling—exposure to air—to keep temperatures under control and maximize LED life.

The result: a rugged and dependable device that costs only about \$400, in contrast to an industry standard of \$3,500 or more. Brilliance can treat more than 500 babies in the bulbs' 15-year lifetime.

It's only one of the transformative products that D-Rev is designing to improve life for the world's 4 billion people who live on less than \$4 per



A baby receives life-saving treatment under D-Rev's Brilliance phototherapy system.

day. One of D-Rev's other innovations is the ReMotion prosthetic knee, which is helping amputees in the developing world for a low retail cost of \$80 vs. a comparable prosthetic knee that costs upwards of \$1,400.

Donaldson took over D-Rev in 2009. In addition to radical and effective design, the nonprofit product development company works with a global network of partners in India and other target nations for manufacturing and distribution of its devices. One of the reasons that it is able to produce high

quality yet radically affordable products is that D-Rev raises philanthropic funding for research and development, but the manufacturing, distribution, quality control, and every other cost is covered by the price of the product.

In addition to her Vanderbilt degree, Donaldson holds two master's degrees and a Ph.D. from Stanford. Named one of *Fast Company's* "50 People Shaping the Future of Design," she was inducted into Vanderbilt Engineering's Academy of Distinguished Alumni in April.

Hitting the right note

Global Solar Decathlon



It was music to their ears when Team Music City, an interdisciplinary group from Vanderbilt University, Middle Tennessee State University and Habitat for Humanity of Greater Nashville, was chosen as one of 20 collegiate teams to compete in U.S. Department of Energy's 2015 Solar Decathlon.



The team submitted a conceptual design called Harmony House, which forges a connection between Southern living and modern green technologies.

They have begun the nearly two-year process to design, build and operate a solar-powered house that's affordable, energy-efficient and attractive. The Decathlon winner will be the team that best blends cost-effectiveness, consumer appeal and design excellence with optimal energy produc-



Left and above, initial rendering and design schematics for Harmony House.

tion and maximum efficiency.

Team Music City participants include undergraduate and graduate students and faculty in the School of Engineering at Vanderbilt; the College of Basic and Applied Sciences and the College of Behavioral and Health Sciences at MTSU; and partners from nonprofit Habitat-Nashville.

Students in construction management, interior design, and electrical, mechanical and civil engineering will

work on the planning, designing and building processes, and then construct a home between 600 square feet and 1,000 square feet in size.

The house will be built on the Vanderbilt campus, then disassembled after completion and sent to the Orange County Great Park in Irvine, California, for the Solar Decathlon competition Oct. 8-18, 2015. A Middle Tennessee family will receive the Harmony House through Habitat for Humanity.



Project management students Farhana Harun and Mary Young designed a virtual environment scooter.

No crazy ideas

Project Management class makes it real

Within the first hour of Ken Pence's Project Management class, students gain the sense that no idea is a crazy idea.

The undergraduates soon discover that an idea becomes a project with tight deadlines and many questions, and, while the professor can guide them, ultimately they're responsible for turning the idea into reality.

Those realities are revealed at the culmination of the spring semester. Students unveiled such marvels as an outdoor grill light that powers itself on and off, an air-powered scooter, and a reverse microwave (it turns warm things cold). This year, one of the not-

crazy ideas was for a magnetic levitation prototype that uses rapidly rotating magnets to lift a flat sheet of metal strong enough to support a person.

Devices like those are born in the second half of Pence's semester-long class. In the first half, students learn the background behind ideas. They learn how to run a project conceptually and weigh costs, risks, needs, audience, tools, equipment, employees and other components before putting together a business plan. A scenario-based midterm exam requires them to individually develop project proposals. They then use all that new knowledge to make prototypes.

Pence is no stranger to big ideas. The associate professor of the practice of engineering management spent 31 years as a police officer and SWAT member. As part of Nashville's Metro Police Department, he secured \$28 million in technology grants to help fund wireless laptops, facial recognition software and an auto theft reduction program that cut car thefts in half.

The Project Management class is required for engineering science majors and engineering management minors. Students with other majors can also take the course or a similar one in their own department as part of their degree requirements.



(Clean) power arranger

Wedding diplomacy and design



Labruto gets hands-on with solar panels.

Less than two years out of Vanderbilt, Leslie Labruto, BE'11, found herself in South Africa helping design a system that could transform that country's coal-heavy energy program.

As an engineer with the Clinton Foundation's Climate Change Initiative, Labruto worked on the largest-yet deployment of concentrated solar power. The Northern Cape province of South Africa has some of the world's strongest solar resources, perfect for constructing the South Africa Solar Park, a 5-gigawatt photovoltaic and

solar power development supported by CCI.

Labruto's work on the Solar Park spanned design and policy development, although she says the need for cooperation among the many groups involved was the most challenging aspect of her job. She found that she had to forge collaborative partnerships to make change happen.

She used both her engineering and team-building skills on her other CCI projects, which involved more than 20 small island nations. She worked with CCI's Diesel Replacement Program, which seeks to reduce fossil fuel emissions with a flexible and scalable toolkit of renewable energy strategies, including solar, wind, biomass, waste, hydro, geothermal and ocean energy. Labruto assisted in the planning of a 5-megawatt waste-to-energy facility in the Maldives and aided with the kick-start of rooftop solar power systems deployments in the Seychelles.

Clean energy and global issues are not new interests for Labruto. Before she graduated from the School of Engineering in 2011, her studies and service work had taken her to Argentina, Peru and Guatemala. For her senior design project, she created a solar/bike hybrid system that brought power for the first time to the rural community of Ulpan, Guatemala. In lieu of gifts for her 21st birthday, Labruto asked for contributions to provide clean water for a community in Central Africa.

After employing her clean-fuel engineering skills for CCI, Labruto recently returned to the U.S. and joined Boston's Summit Partners. The civil engineering graduate sits on the Vanderbilt Board of Trust as young alumni trustee and earned her master's in sustainable energy futures at London's Imperial College in 2012.

Best coffee break ever

Malaria testing made easy

Spilled your coffee? The ring that an evaporating drop of coffee leaves on the counter might be the solution to saving hundreds of thousands of lives.

Researchers at Vanderbilt and around the globe are fighting malaria, which kills more than half a million people every year, the vast majority young children in sub-Saharan Africa.

An interdisciplinary team led by Professor of Biomedical Engineering Rick Haselton and Stevenson Professor of Chemistry David Wright is designing a simple blood test to determine if someone is infected with the malaria-causing *Plasmodium* parasites.

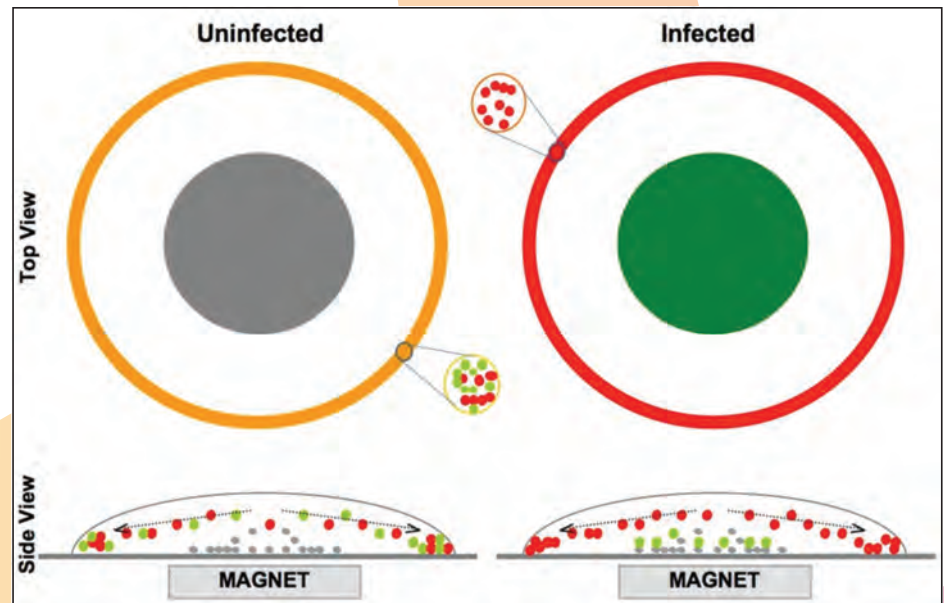
The goal is to create point-of-care diagnostics that can be used in developing areas. Swift and accurate diagnosis would allow for faster treatment and save more lives.

The microscopic characteristics of malaria in a blood sample are telltale, which should enable relatively fast and accurate diagnosis. Unfortunately, conventional tests require refrigeration, electricity and an experienced medical technician—all often in short supply in developing countries where malaria rages most furiously.

The idea for the Vanderbilt team's "coffee ring" biomarker detection process came when they sought naturally occurring phenomena that could be engaged to detect malaria. The researchers considered how coffee evaporating on a flat surface leaves behind particles visible with the naked eye and wondered if malaria indicators in a blood sample could be induced to do the same.

Their proposed malaria test consists of a specially developed liquid

and a glass slide containing a small magnet. The liquid is mixed with the blood sample and a drop of that mixture is placed on the glass slide. Once it has dried, the color pattern of the resulting ring indicates a positive or negative test. If the ring is yellow, the person is not infected. If the ring



An illustration of how test results might differ. An actual diagnostic test using this approach could be interpreted visually in less than 10 minutes.

is red with a green center, the person has malaria. The test does not require refrigeration or a lot of training to administer, making it viable even in the remotest areas, says team member Josh Trantum, BE'95, MS'10, PhD'13, whose Ph.D. focused exclusively on the research.

The project has been supported by the Vanderbilt Discovery Grant Program and a Grand Challenges Exploration grant from the Bill & Melinda Gates Foundation.

That's how we roll

Sweet success with The Hershey Company

You probably don't think much about the wrapper when opening gum or candy unless you're hooked on Science Channel's *How It's Made* or work in manufacturing.

Three mechanical engineering seniors thought about it a lot, spending nearly two semesters designing a testing apparatus for plastic film packaging used on nonchocolate confectionary products produced by The Hershey Company's facility in Memphis, Tennessee.

"Hershey doesn't outsource any phase in its product lifecycle. They package seven different products on 14 assembly lines using film packaging materials from 21 different vendors," student William Yates said. "They also don't have the instruments, lab or time to test for film defects."

The team worked specifically on film packaging for the cylinder-shaped container of Ice Breakers gum—a sticky issue when it comes to wrapping.

Hershey was having two issues with the process. Slight variations in the width of the wrapping film, which is sourced from several vendors, and the coefficient of friction created when

the film passed through the machinery caused downtime and material losses.

"Snags and jams in the film process meant that they had to stop the line and literally cut out the material, and then set up the machinery again," team member Nicholas Souder said.

Khairul Kamarulzaman applied his expertise as an award-winning student videographer to help solve the problem. The team's testing unit uses an inexpensive webcam to measure the width of the film and the coefficient of friction as the film travels through the unit.

Measurement data is output to a monitor for real-time inspection while a spreadsheet with the raw data for the entire film roll is produced. This results in a numerical value used to characterize the roll. An alarm triggers if the tested film has a numerical value in the defective range, alerting the operator to check before it's used on the line.

Measuring the defects quickly and accurately wasn't possible before. End result? "We proved that it works and it does everything Hershey wanted," Kamarulzaman said.

You might say the students have the problem all wrapped up.



The team's working prototype at Design Day







Don't use the D word

Interest in unmanned aerial vehicles soars

UAVs—unmanned aerial vehicles—draw plenty of public attention as well as student interest. When Julie A. Adams, associate professor of computer science and computer engineering, wanted to offer a course in designing UAVs, her department gave the green light. After all, Adams has a decade of research into issues of security, robotics, navigation and emergency response. Her first lesson for the class: Don't call them drones.

Adams says that the media has oversensationalized the word—and it's an improper term for most unmanned aerial vehicle work. A drone is a vehicle that can fly forever by itself and make decisions on its own. In contrast, the UAV system Adams and her students are developing cannot be flown completely by itself and has sensors intended to aid first responders in large-scale disasters, where it might provide maps of buildings or find victims. Their system uses remote control aircraft parts the same as those used by RC airplane enthusiasts.

Adams' senior level class is hands-on, not lecture, with students leading the way in designing and constructing the UAV. Students from seven different majors form localization and navigation, structural, electrical and human detection subteams, whose team leaders have weekly meetings with Adams.

The team of 22 students is working on a four-rotor design about the size of a large pizza box. Four rotors are optimal for decreasing complexity and adding stability to the UAV.

Outdoor testing is banned by the FAA, but indoors, where the UAV would do much of its work, the subteams build and test with relative ease.

In addition to parts they've purchased at hobby and hardware stores and others they made with 3-D printers, the team also augmented software they gleaned from Xbox Kinect for Windows. They combined the Kinect with thermal sensors to detect human body temperatures and skeletons so that the UAV can locate humans during search and rescue missions.

The UAV class conducts a test flight in the Adams Atrium in Featheringill Hall.

To infinity and beyond

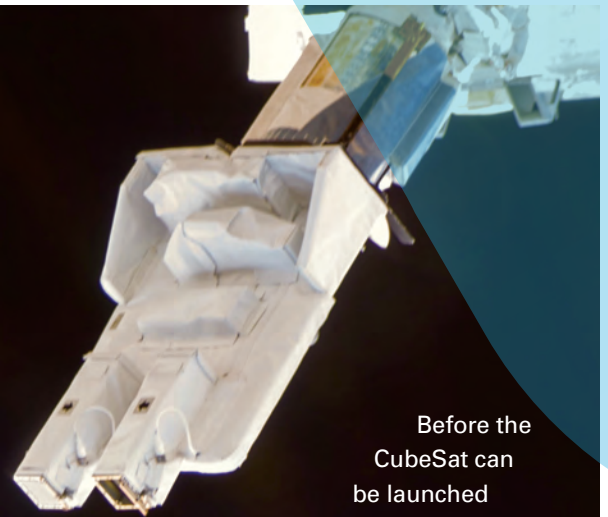
Beaming back radiation data is the key with CubeSat

Slightly larger than an apple, Vanderbilt's 2014 CubeSat is designed to piggyback on an orbiting satellite in space and beam back data on exposure to cosmic radiation.

Designed and built by a student design team, the cube-shaped miniature satellite's main goal is radiation testing. The five-member team is sponsored by Vanderbilt's Institute for Space and Defense Electronics, internationally known for its research into the damaging effects of radiation on electronics, and by California's Tyvak Nano-Satellite Systems.

For this year's CubeSat project, the students worked on integrating a satellite controller from ISDE with a new satellite system bus from Tyvak, creating an electrical interface card and a communication software package.

That was the easy part.



Before the CubeSat can be launched into space, the students have to be sure that the components gathering radiation data won't fail. So the team ran tests, including a cesium-137 radiation test to analyze changes from cumulative radiation exposure. Rather than travel to a national laboratory for expensive testing, the students headed to a lead chamber at Vanderbilt University Medical Center and blasted the Tyvak card with approximately a two-year dose of accumulated radiation in the course of a day. Early results show the radiation eventually will disable the card, but not before it gathers at least six months of data.

Learning from those who worked on the project before them, the team also crafted an intense vibration simulation designed to mimic random vibration in satellite frames to see if the CubeSat held up. It did. And with a pay-it-forward mindset, the students created circuit board layout tutorials, radiation and mechanical testing procedures, and simulation software that should lessen the learning curve for future CubeSat teams.



Three nanosatellites [CubeSats, top left] deploy from a robotic arm attached to the International Space Station.



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JOHN RILEY

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

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Department of Trauma Surgery

About Design Day

A bustling, buzzing crowd toured two floors of Featheringill Hall on April 21 for Vanderbilt University School of Engineering's Design Day 2014. This year, students showcased 63 innovative and high-impact engineering design projects sponsored by 59 companies, organizations and laboratories.

The day culminated with the awarding of the AT&T Innovation Award to the JustMyPACE student team. Its six members developed a working prototype of a modified Kaye Reverse Walker for a Vanderbilt University Medical Center cerebral palsy patient. Their design featured a front-wheel braking system that could be integrated easily onto an existing swivel-wheel walker and required only a minimum amount of exertion to engage and disengage the brake. The design has the potential to help the more than 1.7 million Americans who rely on walkers. The patient was thrilled.

He wasn't the only one. Engineers from a major global aerospace and defense company told us that the team

they sponsored far exceeded their wildest expectations in completing a project for disarmament of improvised explosive devices. A recruiter reading media coverage about Design Day contacted Vanderbilt immediately to inquire about placing students with a global medical device company.

Great engineering work makes for great news and outcomes. We are proud of our students and their achievements. At Vanderbilt, Design Day is not only a showcase for our students but also a celebration of their engineering education.

Key to the success of Design Day is the involvement of our industry

sponsors. We value design projects sponsored by industry and invite project sponsors—industry representatives and entrepreneurs, as well as research and clinical faculty—to submit project proposals. This enriching experience will allow you to work with Vanderbilt engineering seniors and discover what makes our students stand out.

If you or your colleagues are interested in sponsoring a project, please contact me.



A handwritten signature in blue ink that reads "Cynthia B. Paschal".

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The following is a reprint of the 2014 Design Day catalog.

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53 DESIGN FACULTY

Brochure data were collected and managed using REDCap electronic data capture tools hosted at Vanderbilt University¹. REDCAP (Research Electronic Data Capture) is a secure, Web-based application designed to support data capture for research studies, providing: 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources. REDCap is supported by a Vanderbilt Institute for Clinical Trials and Translational Research grant (UL1TR000011 from NCATS/NIH).

¹Paul A. Harris, Robert Taylor, Robert Thielke, Jonathon Payne, Nathaniel Gonzalez, Jose G. Conde, Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support, J Biomed Inform. 2009 Apr;42(2):377-81.

Ambulatory Temperature Sensor

TEAM MEMBERS:

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Pediatric Infectious Disease
Fellow

CLIENT:

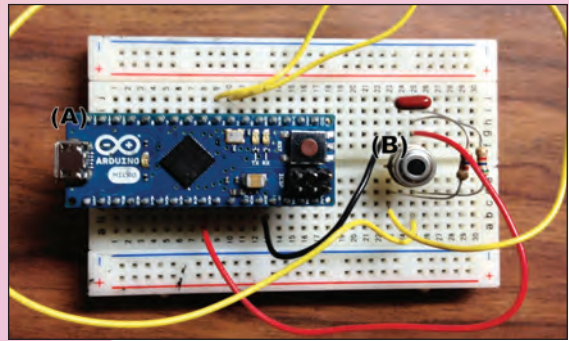
Vanderbilt University
Medical Center



Vanderbilt University Medical Center occasionally sees children who display recurrent fevers indicative of an unknown, underlying disease. To assist in diagnosis, physicians request that parents manually measure their child's temperature several times throughout the day, however, human error can prevent a proper diagnosis. In addition, temperature trends during infection are not well studied, but may contain clinically relevant information. This automated device can be used to determine a correlation between temperature patterns and infections.

The ambulatory device will be worn by the child, automatically measuring and recording the temperature at regular intervals throughout the day. It is affixed to the chest using an adjustable strap. The device utilizes an infrared (IR) temperature sensor that is connected to an Arduino microcontroller. The Arduino is programmed to automatically record and store IR measurements. The data are retrieved by the physician through the device's USB connection and displayed as a chart.

Currently, infrared and contact thermometers are used in hospitals. This device, however, is different because it is worn constantly by the patient, takes measurements automatically to remove the effect of human error and tracks trends. Ultimately, physicians will use the data gathered from the device to better understand a patient's unique pathology.



Internal circuitry of the device. An Arduino microcontroller (A) receives data from a MLX90614 Infrared Thermometer (B).

Anti-Distracted Driving Device

TEAM MEMBERS:

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Jacob Wolf
John Perez
Tyler Stanley
Bolutife Ogunjobi, CompE

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Danielle Rourke, Senior Intern
Purnima Unni, Program
Coordinator

CLIENT:

Monroe Carell Jr. Children's
Hospital at Vanderbilt, Trauma
Injury Prevention Program



Using a cell phone while driving can be dangerously distracting. In 2011, at least 23 percent of auto collisions involved cell phones, which equates to 1.3 million crashes. Our goal is to restrict teenage drivers from using their cell phones while driving since 77 percent of young adults believe they can safely text and drive.

We designed an Android mobile phone application that, when used in conjunction with a hardware device, blocks the driver's ability to interact with the phone during predetermined high-risk times.

Using the information obtained from the car's on-board diagnostics port, we programmed a microcontroller with an algorithm that determines when the vehicle is not in park. The device then transmits a Boolean signal through Bluetooth communication to the phone, activating a mobile application that restricts all phone functionality except for emergency calls. Unlike current products on the market, this device doesn't sacrifice safety for marketability, nor does it require active initiation of the application. The device will help decrease cell phone-related collisions among young adults and create a fundamental change in behavior concerning the use of cell phones while driving.



AccuTemp

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Fellow

CLIENT:

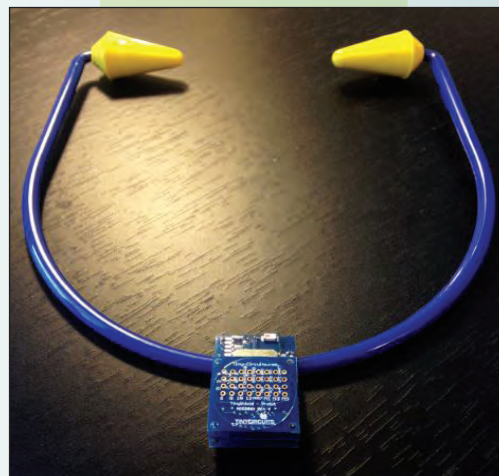
Vanderbilt University
Medical Center

VANDERBILT UNIVERSITY
MEDICAL CENTER

Physicians in pediatric infectious disease wards are currently unable to obtain accurate fever histories from children. This is due to the unrealistic expectation for parents to gather around-the-clock temperature measurements. Undersampling occurs due to this inability, causing an inaccurate or incomplete diagnosis of an infectious disease.

Nashville Health's goal is to prevent undersampling by creating a device that will continuously record core body temperature of children from 2-18 years old. We designed an ambulatory temperature tracking device, AccuTemp, that records core body temperature within the ear.

AccuTemp begins temperature measurement when a photodiode intercepts infrared light emanating from the tympanic membrane. The signal is converted into temperature, stored on an Arduino compatible board, and then subsequently transmitted to the physician's computer via Bluetooth for analysis. Currently, there are few correlative studies between fever patterns and certain diseases, affording AccuTemp the opportunity to expand the field of infectious disease research. AccuTemp differs from other existing devices with its ability to continuously track, store and relay temperature information. Compared to traditional temperature measurements made manually using axillary, rectal and oral thermometers, AccuTemp offers a reliable, noninvasive and automatic approach that will help revolutionize the future of infectious disease detection.



A photodiode placed within the ear cap canal will receive IR, relay that information to the Arduino compatible board, and transmit the temperature data via Bluetooth to a computer.

HyDRRA: Hydration Determination by Resistance and Reactance Analysis

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Deficient or inconsistent hydration leads directly to negative health impacts on patients. Annually, \$5.5 billion is spent on complications associated with dehydration. Traditionally, measuring hydration status quickly and noninvasively has been a difficult task due to variation between individuals and lack of easily targetable indicators.

To address this problem, we decided to use bioimpedance as a marker for hydration status. We have acquired an existing bioimpedance device and are optimizing it for this purpose by producing a reliable algorithm that correlates impedance measurements to hydration status.

Existing bioimpedance devices are inconvenient as they are bulky and do not allow for easy off-loading and display of data. Our improved device is better because of its slim design and Bluetooth connection that allows for easy display of both raw and manipulated values on an Android device. In addition, our device produces more reliable impedance values and will be a more precise indicator of hydration status. Thus, the HyDRRA system provides clinicians with a noninvasive quantitative method for rapid, convenient and accurate measurement of patient hydration status.



Implementing a Front Swivel-Wheel Braking System on a Kaye Reverse Walker

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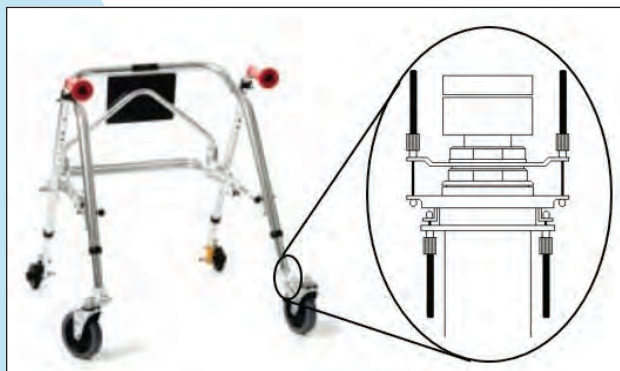
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Nearly 6.4 million Americans require an assistive device for mobility, which includes crutches, canes, walkers, wheelchairs and scooters. Of that number, 1.7 million people use a walker as their device of choice. Patients using swivel-wheel walkers find it difficult to remain stationary in certain situations because a front wheel braking system for this type of walker does not yet exist.

The JustMyPACE team has developed a working prototype of a modified Kaye Reverse Walker for a Vanderbilt University Medical Center cerebral palsy patient. Our objective is to develop a front wheel braking system that easily integrates onto an existing walker with swivel-front wheels, uses a minimum amount of exertion to engage and disengage the brakes, and provides sustained engagement on the trigger without constant force application.

After we introduce a solution for the patient, the post-development goal of the project is to establish relationships with walker manufacturers including, but not limited to, Kaye Products. Moving forward, we hope to pursue mass production of the walker braking system as an attachment for all potential walker-using patients.



Toward a Bioartificial Kidney: Verification of Nanoporous Filtration Membranes

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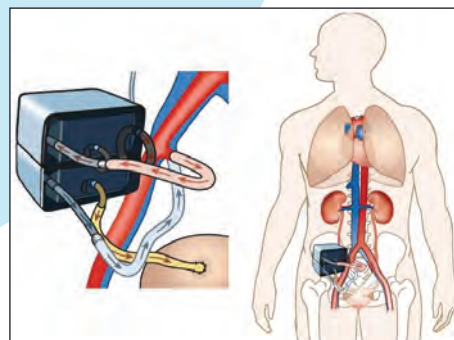
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End-stage renal disease imposes a huge burden on health care systems and patients due to its limited and costly treatment options. To alleviate this burden, the Renal Nanotechnology Lab of Vanderbilt University Medical Center is developing an implantable bioartificial kidney. Nanoporous silicon membranes provide the device's primary filtration capabilities, and must be experimentally characterized to determine their filtration performance.

Our goals are to streamline the verification of these membranes and reproduce physiologically accurate pressure and flow characteristics of the human cardiovascular system during membrane characterization. We have designed an automated test platform that allows the user to fully execute a variety of characterization protocols with the click of a button. An intuitive graphical user interface allows the user to effortlessly synchronize and integrate various pressure and flow control devices through a simple, portable hardware container.

Experimental steps, previously manually orchestrated, can now be automated with ease. Additional functionality also allows for the introduction of pulsatile flow profiles that simulate cardiovascular physiology. This integrated hardware/software suite will accelerate progress toward a life-saving bioartificial kidney, while also providing a generalized test platform for all blood contacting devices.



Artist's rendition of an implantable bioartificial kidney. Courtesy of William Fissell, M.D. and Shuvo Roy, Ph.D.

Laser Speckle Contrast Imaging System for Determination of Parathyroid Perfusion

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Endocrine surgeons performing thyroidectomies at Vanderbilt University Medical Center and other medical centers must assess the viability of the parathyroid glands following the operation and decide whether the parathyroid tissues may be left in situ or should be explanted and re-implanted in muscle tissues. This assessment is made entirely subjectively. This means that surgeons, particularly those with low thyroidectomy patient volumes, are prone to mistaken assessments, lowering optimal patient outcomes, and burdening the health care system with further need for treatment and medication.

Our device aims to employ laser speckle contrast imaging to determine the perfusion state, a primary indicator of tissue viability, of a selected parathyroid gland. Laser speckle is a well-validated imaging modality which can be applied at low cost using a low power laser with a CCD camera and software to process images of the light scattering on the tissue. Given knowledge of the perfusion state, a surgeon can now use this objective measure to make operative decisions for the parathyroid gland(s). This is a great improvement over subjective assessments relying on the surgeon's intuition. Our device is clinically applicable and will be able to inform surgeons making operative decisions in a post-thyroidectomy state.



An image of preliminary laboratory validation with all optical components (laser, CCD camera) visible.

Night Rider

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With the baby boomer population aging, a growing number of people suffer from difficulty associated with nighttime driving. In order to correct this issue that affects the elderly, but also those suffering from a vitamin A deficiency or pre-existing genetic conditions, there is a need to create a device that boosts visual acuity in low-light conditions. Night vision goggles solve this problem, however, they are expensive, display the visual field in green and are impractical for driving.

Our design incorporates two active pixel sensors placed on the outer brim of a pair of transparent organic light-emitting diode screens. These active pixel sensors capture the desired image, relay it to a microprocessor that outlines the objects in the visual field in addition to enhancing the image, and sends the final enhanced image to the OLED screens. The transparent screens allow for a superimposed image outline while simultaneously allowing the driver to safely see the road ahead. Our design is lighter, more comfortable and more practical than current night vision goggles.

Blood Products Smart Cooler

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In chaotic surgical or emergency situations requiring blood transfusions, medical personnel may misplace temperature-sensitive blood products into wrong containers. About \$110 million worth of platelets was reportedly wasted in 2011 due to the misplacement of platelet bags into red blood cell coolers. Several methods had been implemented to overcome the problem such as verbal reminders and warning labels, but the same mistake continues to occur. In addition, temperature-sensitive stickers help to detect the viability of blood products, but this method does not prevent human error. Thus, we designed a smart cooler that minimizes human error by automatically sorting the blood products into their specific compartments.

In our functional smart cooler, the blood bags will undergo three automated processes: scanning, sorting and dispensing. A particular blood product will be scanned using a color sensor to determine its type before it is mechanically sorted into its designated compartment. The blood product can also be dispensed upon request through an interface on the cooler. Plus, the compact design of the cooler would also ensure its portability in and around the medical institute.



Platelet bag (left) and red blood cell bag (right).

BrainScope Brain-on-a-Chip Impedance Analyzer

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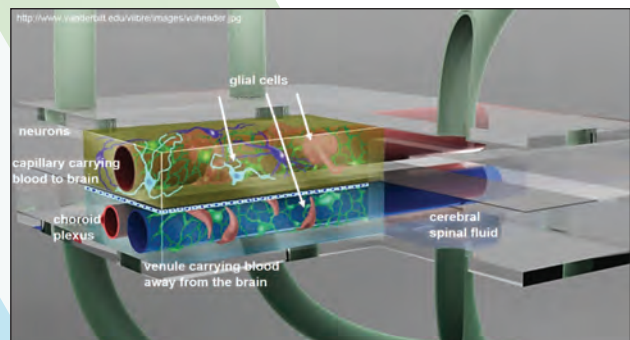
Vanderbilt Institute for
Integrative Biosystems Research
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Imagine a world where compound target engagement on artificial microfluidic chips is as accurate and insightful as those on real human subjects. To that end, we've developed BrainScope, a device to analyze impedance across specialized human cell layers cultured in an in vitro model of the blood-brain barrier called the brain-on-a-chip (BoC).

As a single component of the BoC, BrainScope measures the transendothelial electrical resistance (TEER), a value which correlates directly with cell junction integrity. TEER analysis helps validate the existence of the tight cell junctions found in the human blood brain barrier, and is a necessary step to verify the biomimicry of the system. Junction integrity can be quantified by applying sinusoidal electrical current across the BBB and measuring the phase difference between the input and output at different stimulation frequencies.

BrainScope performs this measurement using an impedance analyzer integrated circuit in combination with a custom-built analog front end. Since the measurements are performed on actual human cells rather than animal cells, there is potential for improved preclinical target validation and drug toxicity studies. We anticipate that BrainScope will accelerate the incorporation of the BoC in the pharmaceutical industry.



The New Instant Raman: Low-Cost Detection for Cancer

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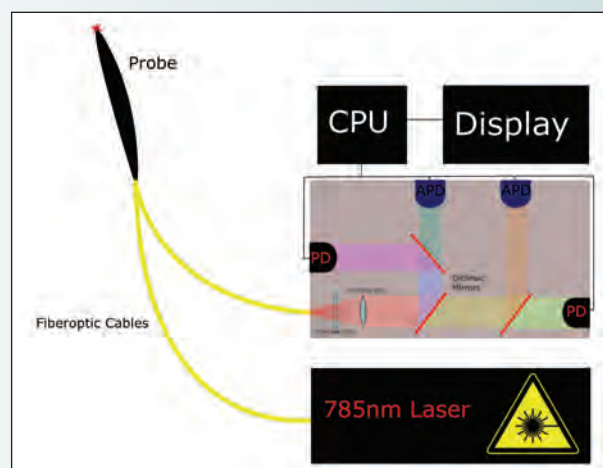
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Biomedical Photonics Lab

VANDERBILT UNIVERSITY

Due to its slow progression, cervical cancer is extremely preventable. However, 275,000 women worldwide unnecessarily die of cervical cancer every year. The majority of these deaths occur in low resource settings, where screening is inadequate because of the inaccessibility of an accurate screening technique.

Low resource clinics currently utilize a vinegar solution to highlight abnormalities in the cervix. However, this method generates many false positives, leading to costly overtreatment that can cause adverse outcomes such as infection. As an alternative, an optical technique called Raman spectroscopy that produces a biochemical “fingerprint” of a sample has been shown to be effective for early cervical cancer detection. Raman spectroscopy uses a computerized algorithm to provide a point-of-care result with minimal training. Unfortunately, available Raman spectroscopy devices currently cost upwards of \$50,000, making them impractical for low resource settings.

Our Raman detector reduces size, cost and complexity by using a cheaper dispersion element and photodetector and limiting data collection to a few bandwidths that are most important for cervical cancer screening. This device will increase accessibility to cancer screening in low resource settings, allowing cervical cancer to be detected and treated in early stages, ideally leading to a reduction in cervical cancer mortality throughout the world.



Ambulatory Sepsis Monitor

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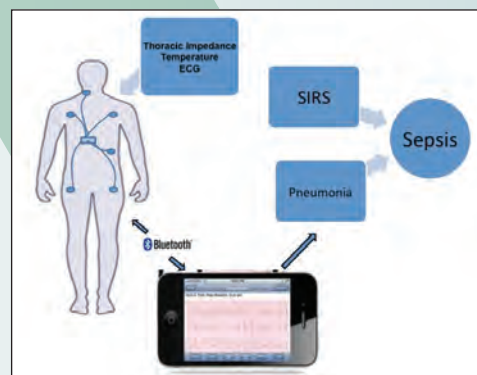
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MEDICAL CENTER

Sepsis is a rapidly progressing systemic inflammation that occurs with the combination of systemic inflammatory response syndrome (SIRS) and an infectious source. Every year, 750,000 Americans suffer from sepsis and 28 to 50 percent of these patients succumb to this condition. Sepsis can be successfully treated in a hospital setting.

Our goal is to detect its onset to allow for early treatment. We designed an algorithm that analyzes patient vitals and alerts the patient to seek treatment when these measurements indicate with a high amount of certainty that sepsis is present.

This system uses six electrode sensors that collect vitals through an Arduino microprocessor, which saves the data on an SD card and transmits it via Bluetooth technology to a mobile application. An algorithm contained within the microprocessor and application will assess the user's septic risk score based on temperature, heart rate, heart rate variability, respiration rate and thoracic impedance. A high-risk score will cue the application to alert users of the patient's risk of pneumonia-linked sepsis. Since the outpatient monitoring system alerts at the first sign of sepsis, patients can receive early treatment to help drastically increase sepsis survival rates.



Water Recycle and Reuse Software Design

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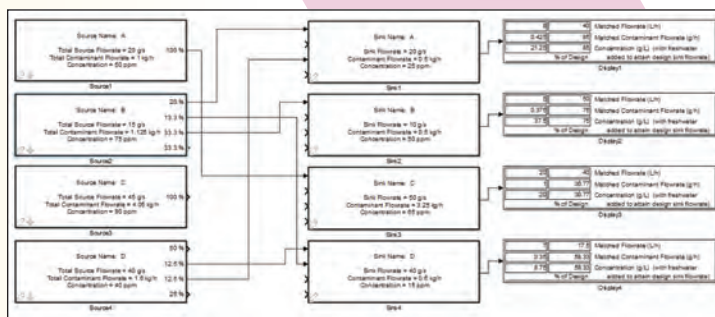
CLIENT:

Westlake Chemical



Recycling industrial process water increases the efficiency of water use, resulting in both freshwater conservation and raw material cost efficiency. Consequently, designing networks for allocating and recycling process water is a key competency for chemical engineering students. Our team designed software with MATLAB® and Simulink® for students learning to solve industrial-scale, process water problems. Generating visual tools for designing networks, the program includes a graphical user interface, graphical stream matching, a safety analysis module and an economic analysis module.

For a given set of process water sources and sinks, the program identifies the thermodynamic maximum for water recycle with a material recycle pinch diagram. In addition, the program generates a mass mapping diagram that presents the relative flow rates and concentrations of all streams. Within an interactive block diagram interface, the user matches sources of process water for recycle to sinks while considering safety and operations constraints. The program indicates progress towards maximum recycle and provides residual diagrams to guide further network design. The economics module enables comparison of networks, and the safety analysis module guides the user through a hazard and operability study.



Polyester Polymer Quality System Design and Quantification

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CLIENT:

PGI



Humans have taken advantage of the versatility of polymers for centuries in the form of oils, tars, resins and gums. However, it was not until the industrial revolution that the modern polymer industry began to develop. Progress in polymer science was slow until the 1930s, when materials such as vinyl, neoprene, nylon and polyester were developed.

Polymer Group Inc. (PGI) is a worldwide leader in nonwoven polyester manufacturing. The PGI plant in Old Hickory, Tenn., processes textile grade polyester terephthalate flake from external manufacturers and internal recycling operations to produce specialty Reemay spunbond polyester filtration fabrics. Our goal is to design an improved quality system for the Old Hickory site's process through implementation of the ISO Quality Management Principles. We are developing a site-wide database in order to improve cross departmental communication and make the relationship between process parameters and disturbance variables more evident. From the observable trends, we will suggest methods for feed-forward quality control to minimize inefficiencies.



Design of an Optimized Silk-Screen Coating Process

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CLIENT:

Fiserv



Banks and other credit card providers maintain a competitive edge by increasing the visual appeal of their credit cards. Fiserv is able to meet this need through the production of cards using glossy, metallic inks with their silk-screen process. This process is a problematic step in their value chain, resulting in wasted materials and labor costs, increased production times and loss of other job opportunities.

Our goal is to identify the unique properties of the silk-screen causing failures and reduce the current failure rate to the industry standard of 7 percent. Since these failures primarily occur with the use of a few problematic inks, we limited our analysis to these specific inks to identify their unique properties. After analyzing batch failures and the composition of the inks, we hypothesized that the adhesion issues are driven by improper drying techniques. By designing dryer temperatures for the individual type of ink used, we will be able to properly dry the inks and improve laminate adhesion. Through the implementation of improved documentation practices and tailored production methods to the specific inks used, we will be able to achieve consistent batch success and reduce waste.

Development of a Business Line for Extracting Brown Dye From Black Walnut Hulls

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ADVISER:

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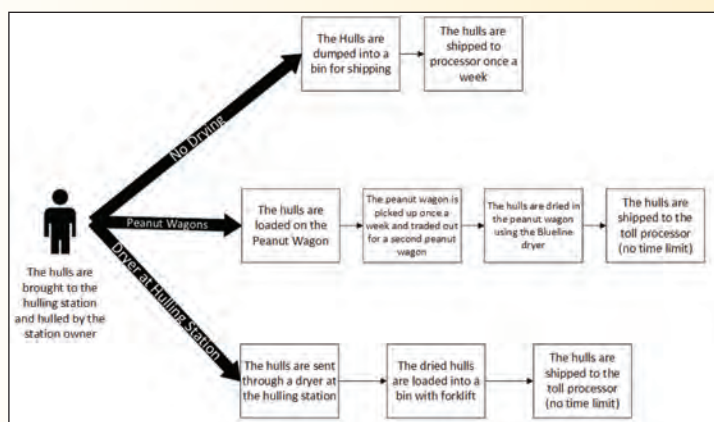
CLIENT:

Stony Creek Colors



Stony Creek Colors is a natural colorant company developing a new business line to sell a brown dye extracted from the black walnut hull. The black walnut tree naturally grows in the Southeastern region of the United States and produces walnuts between September and November. Walnut farmers already separate and discard hulls at hulling stations in the Middle Tennessee area. Stony Creek Colors seeks to compensate these farmers to obtain these discarded hulls and ship them to a processor prior to the decomposition of the juglone compounds which produce the color.

Our team has researched the dyeing process, and has designed two alternative walnut hull drying processes to both extend the decomposition time of the juglones and to minimize freight costs. One option is to place rotary dryers at several high-volume hulling stations. Another is to use mobile "peanut wagon" dryers which can travel from station to station. Preliminary assessments suggest that for processing at least 28,000 pounds of fresh walnut hulls, setting up rotary dryers at high-volume hulling stations will be the most profitable. Overall, this project will be more profitable than Stony Creek Colors' next best alternative.



Commercial Scale-Up of NANOferix Precision Drug Delivery System

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ADVISER:

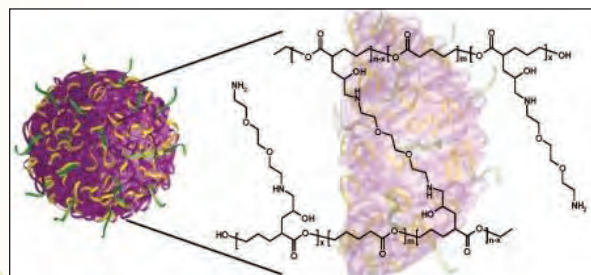
Tim Ruckh, Co-founder

CLIENT:

NANOferix



Current limitations with drug delivery include poor drug solubility, unstable active pharmaceutical ingredients (APIs) and quick release burst kinetics. NANOferix is developing a nanoparticle drug delivery system that overcomes these limitations. By cross-linking polymer chains, researchers have synthesized spherical “nanosponges” into which APIs can be injected. These nanoparticles are synthesized from a series of precursor molecules and coated in a compound that makes them hydrophilic and biologically compatible. Rather than a mechanical top-down approach to creating delivery systems, this chemical synthesis method allows for greater control of the nanoparticle properties, and thus the release rate of the API.



This synthesis has currently only been performed at the bench-top level. Our team is designing a scaled up process to produce the nanoparticles and their precursors, including detailed process flow diagrams that are programmed to determine the amounts of reagents needed and the cost of the raw materials. This will allow NANOferix to easily replicate the process at different production rates, and will lead to production on an even larger scale.

Nanoparticle Drug Delivery Process

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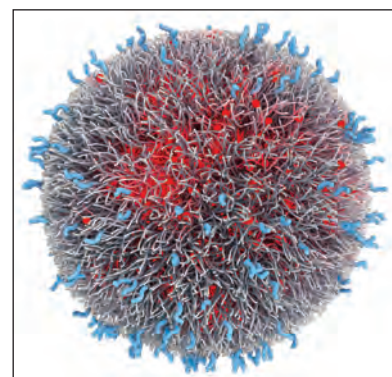
Tim Ruckh, Co-founder

CLIENT:

NANOferix



Nanotechnology offers the opportunity to create drug delivery systems that are sophisticated in their location of action and release profiles. NANOferix has developed a customizable nanoparticle that gives controllable release of any specific pharmaceutical in the body as well as the ability to be modified for tissue targeting, enhanced solubility or other purposes. Our project aims to design and evaluate a commercial process to produce these proprietary nanoparticles to be used in conjunction with existing pharmaceuticals. The evaluation of the process consists of cost estimation, compliance with FDA regulations and exploring alternative reaction methods.



The use of computer simulations is an integral part of our design. By setting the target production rate, the process flow can be simulated and a profitability analysis will be performed to compare the economic value of these nanoparticles and the cost of the process. Different cross-linkers are also being researched to determine the optimal production method. Currently, NANOferix's production of the nanoparticle is limited to a research setting that does not consider marketability or FDA compliance. Our desired result is a detailed process description of the production of these nanoparticles for sale to pharmaceutical companies.

Biohybrid Solar Cells Inspired by Nature

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EPA



Present energy consumption worldwide is expected to pass energy production capabilities in the near future. Solar power is an innovative solution that shows major potential as a key component of future sustainable energy solutions. There are a variety of issues associated with solar power, including inefficiency and the use of environmentally hazardous materials.

Our goal is to harness nature's own solar energy collection mechanism, photosystem I, to create a more environmentally friendly solar cell. In conjunction with the photosystem, a new silicon-based substrate has been chosen, based upon research and testing, which increases the efficiency of the cells beyond that of previous gold substrates. Nonhazardous mediator solutions and biodegradable casings are being utilized to achieve our goals. In addition, we've optimized a three-dimensional array of solar cells to replace the standard flat array configuration and to increase the energy output per unit of land area. Advanced research was conducted by previous design teams over the last two years.



Cell Therapy for Spinal Cord Injuries: Manufacturing Facility

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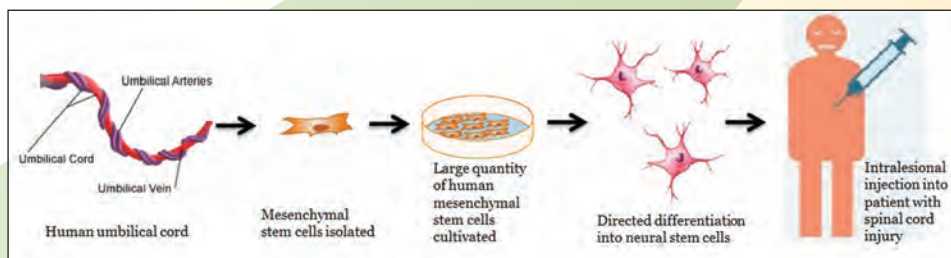
CLIENT:

Vanderbilt University



About 250,000 people in the United States live with chronic spinal cord injuries (SCI). Annually, there are between 12,000 and 20,000 new patients with SCI. Though there are many treatments for this injury, total motor and neural function restoration is not typically achieved. As a result, there is a need to develop treatment that will lead to complete spinal cord repair and is compliant with federal regulations.

Recently, stem cells have become an attractive treatment option for this particular injury because of the cell's multipotent potential and ability to regenerate the spinal cord. Keeping this in mind, our goal is to design a manufacturing process and facility to scale up the production of stem cells for the target population of 15,000 patients per year. We aim to determine the stem cell source, separation method, expansion protocol, differentiation strategy, downstream processing and packaging, and the layout of the manufacturing site. With this new platform, individuals with spinal cord injuries will have a future for independent life. We expect that the completion of our design will aid in the commercialization of this novel process as well as add to the body of knowledge for stem cell therapeutics.



Design of the Next Generation Bio-Based Lab with Scale-Up Modeling

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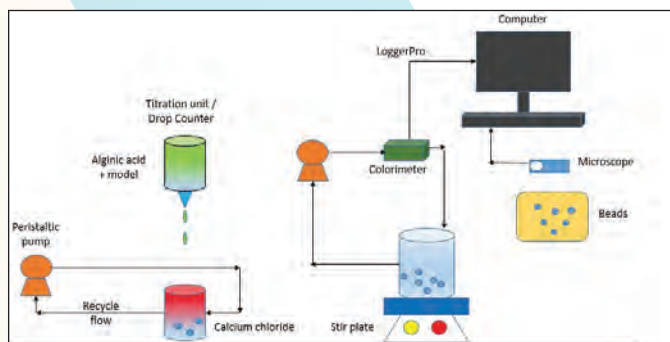
CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Numerous laboratory experiments have been established in the Department of Chemical and Biomolecular Engineering over the past several years, covering a variety of topics in the chemical engineering field. The goal of our project is to design the next generation bio-based lab module to expand the second semester of the chemical engineering laboratory. We designed the alginate bead and drug delivery module to introduce students to the important concept of designing drug controlled release systems with hydrogels. Alginate bead, a hydrogel with a liquid center, is formed by ionic crosslinking of the alginate with divalent calcium ions. Model drugs are loaded into the hydrogels and the fractional release rate is measured as a function of bead characteristics.

We have developed the important components of the lab module including selection of equipment and raw materials, incorporation of LoggerPro sensors and software, procedures for a three week experiment, scale-up and economic modeling, and safety analysis. Our design offers a new bio-based module that utilizes readily available sensors and allows introduction of a modern topic, not yet covered in the laboratory. In addition, it provides an opportunity for students to explore real world applications of hydrogels, such as that in the biomedical, pharmaceutical and food industries.



Model Development for an Eco-Friendly Dyeing Process for Polyester Fibers

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CLIENT:

John Tate
TateCraft LLC

The demand for fiber textile has grown dramatically over the years because of its properties of economy, durability and easy care. Due to environmental and energy conservation issues that arise from conventional fiber dyeing processes, there is a need to improve them to a more environmentally friendly and economically efficient process.

The main target of the TateCraft eco-friendly dyeing process is to eliminate negative environmental effects from wastewater and volatile organic chemicals.

The goal is also to increase process efficiency by reducing energy and water consumption by approximately 70 percent and 95 percent, respectively. The main components of this project are the fabric dye and raw material recycle streams. A dye solution with 99.7 percent glycerin was used to maintain the color concentration and eliminate chemical odor from the yarn. In addition, a scouring solution along with cooling and heating water were recycled throughout the process.

Our team optimized the water-recycling network, reducing the water and energy consumption associated with the dyeing process. We also used an existing pilot plant design to develop a full-scale process. Finally, an economic assessment was performed to determine the viability of the full-scale TateCraft process.



Production of Chemicals from Ethane Derived from Marcellus Shale

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Marcellus shale is a rich and relatively untapped source of natural gas located in the Northeast and Mid-Atlantic regions of the United States. Our design goal was to create a plant to isolate the ethane and use it to produce ethylene, acetic acid and vinyl-acetate monomer (VAM). An Integrated Ethoxene Vinyl Acetate Monomer process was selected because it produces all of the desired chemicals. This process consists of three reaction steps followed by procedures to isolate the desired products. The first reaction converts ethane to ethylene through oxidative dehydrogenation, the second converts ethylene to acetic acid, and the third produces VAM through acetoxylation of ethylene and acetic acid. The annual production goals of 200,000 metric tons of acetic acid and VAM and 100,000 metric tons of ethylene were achieved using an input of 460,000 metric tons of ethane.



Dreamstime.com

CHEMICAL & BIOMOLECULAR
ENGINEERING

Multiproduct Brewing

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ADVISERS:

Kenneth Debelak, Associate
Professor of Chemical and
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Russell Dunn, Professor of
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CLIENT

Vanderbilt University

VANDERBILT  UNIVERSITY

The demand for microbrewed beer has steadily increased in recent years. From 2011 to 2012, the craft brewing industry recorded a 15 percent increase in volume and a 17 percent increase in sales. These regional breweries have become cultural icons with loyal customer bases that take pride in their local fare. As these companies seek to increase their capacity to meet demand, they require the help of engineers to optimize their production processes.



Our group is designing a microbrewery capable of brewing 100,000 barrels of beer per year in a variety of styles. Our goal is to evaluate the economic viability of this production goal either by contract brewing at an existing brewery or by constructing a new facility. Using simulation software and citing published fermentation reaction rates, we have created an accurate model of operation times and product compositions that meet the investors' target specifications for parameters such as alcohol by volume and International Bitterness Units. Through process optimization and economic analysis, we will make a decision as to the best option for our investors.

Natural Gas to Aromatics–Team 1

TEAM MEMBERS:

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Mark Miller
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Khairul Daud

ADVISERS:

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering
Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

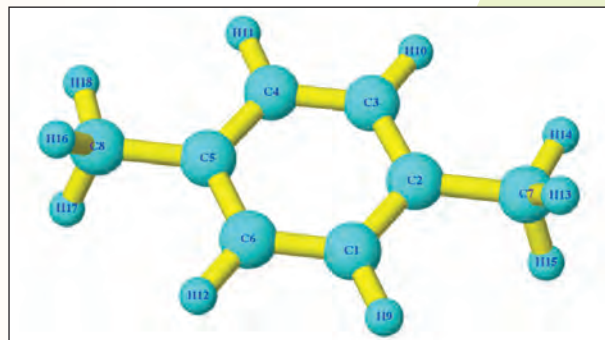
CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Aromatic compounds such as xylene, benzene and toluene (BTX) are used in several industrial applications. The desired product is p-xylene, which is primarily used to produce polyethylene plastic bottles via a purified terephthalic acid intermediate. Besides p-xylene, the other products are benzene, toluene and mixed xylenes. Traditional methods for producing BTX use petroleum-based feedstocks. With the relatively high price of petroleum, companies have been working towards both a more economical and sustainable solution.

The goal of our project was to build a plant in the Gulf of Mexico based off U.S. Patent 8,138,384. This patent describes a process of converting natural gas to aromatics through the use of methanation, dehydrocyclization and aromatic alkylation. The approach used to achieve the goal was to use the provided patent and further kinetic research to formulate a working design. After preliminary calculations, the process was modeled using Aspen Plus Simulation software to reach the desired production rate of 1 billion pounds of BTX per year. Once the model was built, a profitability analysis was done to determine the economic viability of the project, considering both capital and operating costs.



Natural Gas to Aromatics–Team 2

TEAM MEMBERS:

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ADVISERS:

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CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Aromatic compounds, especially p-xylene, are especially profitable compounds in the economy due to their use in the plastics industry. With the abundance of natural gas, the ultimate goal is to find a suitable and feasible process of converting natural gas,

composed of methane and carbon monoxide, to benzene, toluene, and xylene with the specific goal of producing p-xylene. The main sequences of reactions to this process start with a dehydrocyclization reaction, which converts natural gas to benzene. The byproducts of this reaction (CO_2 , H_2) are sent to a reverse shift reaction that allows for the creation of methanol used in the alkylation step. The alkylation step combines benzene from the dehydrocyclization and methanol from the reverse shift to create toluene, xylene and C_9+ products which can be separated to attain xylene. Using clever separating and recycling techniques, an economically feasible process that produces high concentrations of toluenes and xylenes is to be created producing 1 MMM lb/year of benzenes, toluenes and xylenes per year, and a calculated preliminary net profit to be approximately \$5.4 million per year after all fixed costs, such as reactors, pipes and other equipment have been accounted.



General Mills Inc. Wastewater Treatment Plant Conversion

TEAM MEMBERS:

David Aronoff
Chelsea Carroll

ADVISERS:

T. Houston Flippin, P.E., BCEE
Thomas Steinwinder, P.E.
Steve McGuire, P.E.

CLIENT:

Brown and Caldwell



The General Mills Inc. (GMI) plant located in Murfreesboro, Tenn., recently expanded to include a new facility to accommodate production of Greek yogurt. Before the expansion, GMI treated concentrated process wastewater from the pastry and yogurt facilities at an on-site treatment plant. The previous treatment process could not accommodate the increased waste concentration from expanded production. GMI commissioned for the downstream activated sludge treatment process to be converted to an anaerobic contact process including a membrane bioreactor.

The previous system included screens, activated sludge treatment with dissolved air floatation and sand filtration. To account for increased wastewater concentration, we developed a process design of upgrades to retrofit the previous system to include an anaerobic contact process. The most significant addition to the system was to convert the previous activated sludge treatment to a membrane bioreactor. This anaerobic digester not only allows GMI to treat waste of higher concentration, but it also captures methane biogas as a reusable energy source. The upgraded anaerobic treatment system allows for GMI to treat the entirety of wastewater produced from all facilities, eliminating the need for off-site disposal.



28th Avenue Bridge Extension

TEAM MEMBERS:

Daniel Anderson
Ryan Oberlin
Ian Shaw

ADVISER:

Justin Eckel, P.E.

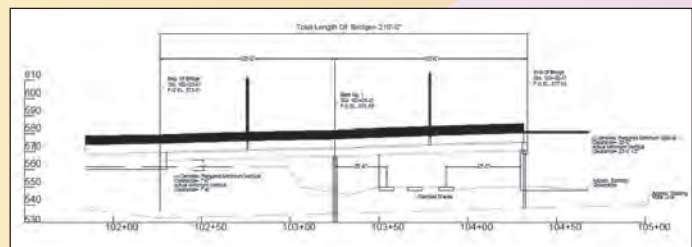
CLIENT:

Barge Waggoner Sumner and
Cannon Inc.



There is a need to provide better access for vehicles traveling from West End Avenue to north Nashville. The current roadway arrangement produces inefficient traffic patterns for vehicles traveling between locations such as Vanderbilt University, Hospital Corporation of America, and the Metro General Hospital. The 28th Avenue Bridge Extension serves to rectify the traffic problems and unite these communities.

This 210-foot steel bridge contains a four-lane roadway with sidewalks and bike lanes. The main design elements of the bridge include the framing, girders, concrete deck, bearings, abutments and the bent. For our design assumptions, the steel bridge design is advantageous to a concrete bridge design due to implications surrounding the vertical clearance over the CSX railroad tracks and effects on the current intersection of Park Plaza and 31st Avenue. Ultimately, the 28th Avenue Bridge Extension improves traffic flow and provides better access between communities.



Concrete Canoe

TEAM MEMBERS:

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Matthew Ginn
William Haydon Osborne
Samuel Greene

ADVISER:

Lori Troxel, Associate
Professor of the Practice
of Civil and Environmental
Engineering, and ASCE
student chapter adviser

CLIENT:

Vanderbilt University

VANDERBILT  UNIVERSITY

Civil engineering students come together annually to represent their respective universities at the American Society of Civil Engineers (ASCE) conference. One of the most substantial events at this competition is the concrete canoe. At its core, the canoe competition involves the construction of a functioning canoe made from lightweight concrete and reinforcing materials, which is capable of supporting four paddlers. At the ASCE conference, the canoe is judged in four categories: design paper, oral presentation, final product and race performance. Work is conceptual and experimental in the fall, while construction and “hands-on” labor occur in the spring.

Our team is responsible for radically changing the concrete mix design in order to optimize its strength-to-weight ratio. We’ve reintroduced a lightweight, specialized aggregate called Poraver. We also redesigned the canoe mold to include a width reduction, the addition of a keel that runs two-thirds the length of the canoe, and gun-wales atop the canoe’s walls. The name of the 2014 canoe is *Vanderbuilt*, and the design will be construction themed with a black and gold color scheme.



Team members and volunteers constructing *Vanderbuilt*

Antioch Office Building

TEAM MEMBERS:

Theodore Lawrence
Jonathan Smith

ADVISERS:

Mark Mize, P.E.
David Ahnquist, P.E./S.E.

CLIENT:

Carpenter Wright Engineers,
PLLC



This project consists of performing the structural design of a new corporate headquarters for the company CGM Electronics in Antioch, Tenn. The ultimate goal is to provide an economic structural support system for the proposed building that meets the building code requirements and the various conditions that CGM has specified for their headquarters.

CGM Electronics has indicated that their building will be five stories, have a base plan of 90 feet by 120 feet, and have a first floor clear height of 16 feet with a clear height of 10 feet 6 inches on all remaining floors. Working with the firm Carpenter Wright Engineers, our team first determined the building loading demands under gravity, wind and seismic loading. Then, we selected the primary structural framing, produced sketches of the building column grid, and determined the sizes of the structural members that make up the building. We are responsible for submitting detailed drawings of connections and organized engineering drawings showing all the relevant structural elements of the building. The final result is a set of deliverables containing the necessary structural information which could be used by a general contractor to build this structure. The image shows the building’s structural steel.



Polk County Medical Center Site Development

TEAM MEMBERS:

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Theodore Swift
Jennifer Frego

ADVISER:

Adam Crunk, P.E.

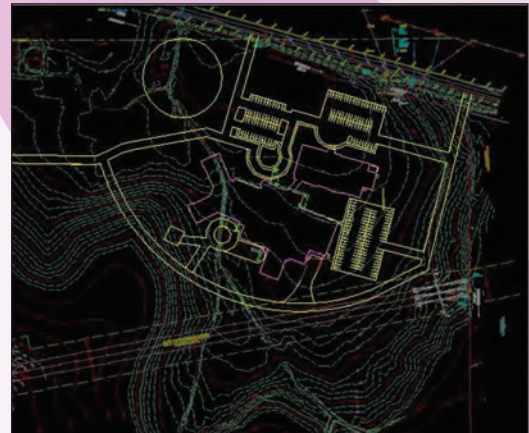
CLIENT:

Littlejohn Engineering
Associates



The city of Cedartown and Polk County, Georgia, are looking to build a 20-bed replacement hospital and medical office within a 40-acre parcel of land. Our goal is to provide site layout and land development for the project including due diligence, parking layout, grading plans, utility plans and storm water design.

We reviewed the Cedartown zoning codes and the existing topography to determine the best location for the project within the land parcel, and we examined the existing utilities. Then, we analyzed the use and occupancy of the building to determine an appropriate number of parking spaces. We laid out the parking, entrances, driveways, emergency room and medical center drop offs, helipad, loading dock and ambulance drop off in AutoCAD. Next, we altered the existing topography by creating a grading plan in conjunction with a utility plan, including culverts and pipes, which will carry all water on the site to either the detention pond or the city wastewater network. Lastly, we will design the detention pond which will help mitigate the amount of water the project will contribute to the city's wastewater.



Cedartown Hospital site layout

Road Widening of State Route 76

TEAM MEMBERS:

Elizabeth Bentley
Peter Kozey

ADVISERS:

Eric McElroy, P.E.
Marshall Fall

CLIENT:

SSR Inc.



Roadway demand has increased exponentially over the past few decades, resulting in a greater need for capable roads. Preventing unsafe road conditions that worsen during natural disasters has also become essential due to the many recent climatic events and excessive roadway deterioration. Reconstructing SR-76 in Carroll County is a proactive step towards enhancing the performance and safety of the roadway for decades to come. A 4.8-mile section of SR-76 will be widened from two lanes to four lanes. The bridge structure at the crossing of the Obion River will also be raised to prevent flooding in the event of a 100-year flood.



The first objective includes reviewing a variety of surveys of the project area and making utility and drainage relocation plans. Secondly, typical roadway sections will be designed on AutoCAD and compared to the existing sections. In addition, watershed calculations for the 100-year flood event at the Obion River will help determine the required bridge elevation. Lastly, traffic impacts will be analyzed to retune any affected traffic signals nearby.

Steel Bridge Competition

TEAM MEMBERS:

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Yates Bateman
Keith Marson
Andrew East

ADVISER:

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Professor of the Practice
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Engineering, and ASCE
student chapter adviser

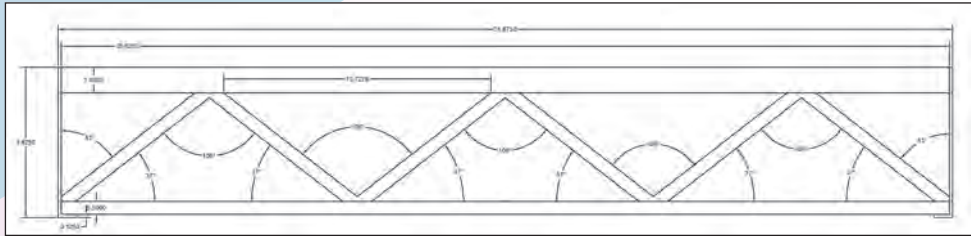
CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

The Vanderbilt Steel Bridge team has been challenged to design and construct a bridge for the American Society of Civil Engineers/American Institute of Steel Construction steel bridge competition. ASCE provides guidelines that must be met in order for the bridge to be allowed to compete. The bridge is scored based on three different categories: weight, time of construction and deflection under a 2000-pound load.

This year's bridge differs from previous bridges in many ways. One of which is the decision to fabricate using Chromoly Steel, which is much lighter than the steel typically used, albeit more difficult to weld. We have run many deflection tests using smaller sections of the bridge to test the new steel and have extrapolated that data to a full-length bridge, producing encouraging theoretical results.



State Route 25 Bridge Replacement

TEAM MEMBERS:

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Andrew Eckart

ADVISERS:

Blake Mayo, Hydraulic
Engineer
Eric Slayton P.E., Structural
Engineer
Jon Zirkle P.E., Project
Manager

CLIENT:

Tennessee Department of
Transportation



The safety of the State Route 25 bridge over Honey Run Creek in Robertson County, Tenn., was the central concern in the redesign of the existing bridge. The bridge was deemed structurally deficient in a bridge inspection report which noted cracking throughout the structure and flood debris caught under the roadway.

The goal of our project was to design a new bridge that was structurally stable, reduced the occurrence of roadway flooding and was cost effective. The project scope was broken into two parts: one focusing on hydraulic design, and the other on structural design. After analyzing the flows of both normal and flood level stream conditions, a hydraulic design, including overall length and pier locations, was created to minimize flooding impact on the roadway and substructure. The hydraulic layout was then used to complete the structural design following AASHTO Bridge Design Specifications and TDOT standards. The specifications took into account loading and bridge geometry in determining the stability of the two span bridge, and the necessary slab, beam and substructure reinforcement was determined. Finally, the completed design was depicted in a set of design drawings and details.



Automated Medicine Dispenser

TEAM MEMBERS:

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Seth Dean
Azizi Azizan Khamat
Zahra Tajuddin

ADVISER:

Alfred B. Bonds, Professor
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Emeritus

CLIENT:

Vanderbilt University

VANDERBILT  UNIVERSITY

Every day, millions of senior citizens must go through the mundane task of taking their daily medications. Most people use plastic weekly pill boxes, but these often lead to medication errors if the patient accidentally takes the wrong pills or forgets to take their pills at the correct times.

The Chill Pill is a machine designed to sit on a patient's countertop at home and dispense individual pills from large containers of pills at pre-set times. The machine will alert the user when pills are ready to be taken and monitor if the user picks up the cup of pills and takes them. If the patient does not take their pills, the device will continue to alert the user until they take their pills.

For demonstration purposes, the Chill Pill will dispense two different types of pills and be controlled by an Arduino microcontroller. The device will also have a simple user interface consisting of a two-line LED display with six buttons that allows the user to set pill times and check pill information. The Chill Pill presents a smart replacement to the traditional plastic weekly pill containers and removes the guesswork from taking one's daily medications.



Camgian M2M

TEAM MEMBERS:

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ADVISERS:

Gary Butler, Founder/CEO
Janos Sallai, Research
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CLIENT:

Camgian Microsystems



Energy managers need to identify where their energy is going, and how to minimize the energy used for their facilities. In order to do this, most energy managers perform periodic energy audits of their facilities. An energy manager will walk through a building to check on several things. Is the room too hot or too cold? Are there lights on? When do people typically occupy this room? For example, if he/she discovers a room that often has its lights on and is warm when no people are present, then he/she can save energy by turning the lights off and turning down the heat in that room during the times when the people are not there.

It is tedious to acquire and analyze this data. Currently, many energy managers conduct energy audits with a clipboard and a vigilant mind. Computers are good at collecting data and displaying it. Our team designed a computer solution to help the energy manager conduct an energy audit. Our solution is a computer that records data such as temperature, humidity, room occupancy level, and light switch status. It will connect to a dashboard that displays the information on a graph. The graph correlates the presence of people in a room with the temperature, humidity and luminosity of the room to help the energy manager discover opportunities to save energy.



Clean Hybrid Energy Scalable System

TEAM MEMBERS:

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Joshua Frase, ME
Matt Sun, ME
Tim Altmansberger
Alya Syamimi, Che

ADVISER:

Ralph Bruce, Professor of
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Engineering

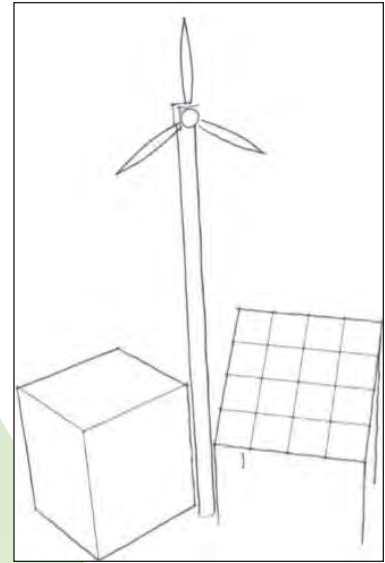
CLIENT:

Jetstream Energy Systems



The Clean Hybrid Energy Scalable System (CHESS) design project is intended to continue last year's project team efforts in the development of a portable, hybrid power system. The system utilizes power from three distinct power sources: wind, solar and an auxiliary fossil fuel generator. CHESS is intended to address the intermittent nature of wind and solar power, supplementing those sources with clean, natural gas generation. The design integrates commercial off-the-shelf components to create a plug-and-play system that can be installed as a standalone unit or as a retrofit kit to existing systems. CHESS will have the ability to be scaled and adapted to meet specific user/application demands.

Our team worked with Jetstream Energy Systems to produce a working, field-validated pilot unit to demonstrate the efficacy of the system. The prototype is a trailer-mounted unit that incorporates solar panels, a wind turbine and an auxiliary generator. The wind and solar units charge a corresponding battery bank and are intended to provide the majority of the power for the system. The auxiliary generator is configured to automatically provide supplemental power to the batteries when renewable components cannot meet the demand on the system.



CubeSat: Developing Vanderbilt's Capabilities

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Kevin Warren,
Senior Electrical Engineer
Robert Reed, Professor of
Electrical Engineering
Robert Weller, Professor of
Electrical Engineering
Eric Barth, Associate Professor
of Mechanical Engineering

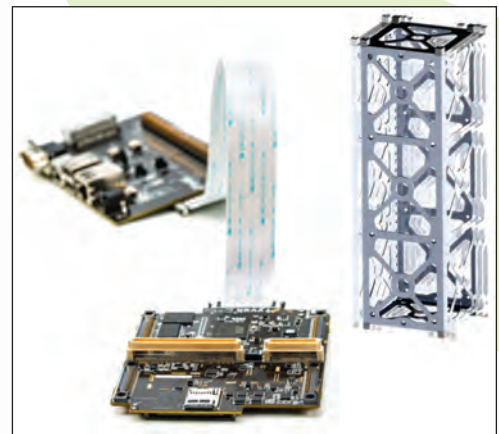
CLIENT:

Tyvak Nano-Satellite
Systems LLC
Vanderbilt Institute for Space
and Defense Electronics



Vanderbilt's Institute for Space and Defense Electronics (ISDE) has an extensive research program studying the potentially damaging effects of radiation on electronics. Three years ago, ISDE joined the CubeSat community to develop lower-cost radiation tests for space. Since then, the program has consistently grown, positioning Vanderbilt for leadership in the field. By sponsoring design projects, ISDE encourages student interest in satellites and expands Vanderbilt's capabilities.

This year's CubeSat design team integrated an ISDE satellite controller with a new satellite system bus from Tyvak, creating an electrical interface card and a software package for communication. We also performed Cesium-137 radiation tests on important components and the satellite system to analyze changes from cumulative radiation exposure. To develop mechanical testing capabilities, the team created software models which simulate random vibration in satellite frames and evaluated the validity of the simulations with a shaker-table. Throughout the project, we took steps to decrease learning curves on future CubeSat projects, such as creating circuit board layout tutorials, radiation and mechanical testing procedures, and simulation software.



CubeSat satellite system bus and computer model of a vibrating frame

Metova Leaderboard

TEAM MEMBERS:

Drew Hamilton
Fabian Okeke
James Tiller

ADVISER:

Dave Lane, Vice President
of Technology

CLIENT:

Metova



Competition in a working environment can be beneficial for a company if done properly. The ability to measure one's work effectively can give an employee a sense of satisfaction and a benchmark of their own ability. The Leaderboard's purpose is to provide software developers at Metova with a tool that allows them to monitor the efficiency of their own work and to compare themselves to their co-workers.

Previously, work could only be measured manually by reading the lengthy logs, and did not portray an accurate picture of a developer's work. This tool provides programmers with visual data and scores that can be easily interpreted, as well as notes about their progress to keep increasing their efficiency. The Leaderboard measures developers' scores using various metrics, including amount of code written over a period of time and comparisons between project time estimates and results. Scores are assigned to individuals as well as project teams. Higher scoring developers take notes to pass down their techniques to lower scoring individuals, with the overall goal of increasing the company-wide score. This will result in the company becoming more efficient, thus satisfying their customers and increasing business.



Augmented Reality Technical Support Application

TEAM MEMBERS:

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Austin Keith

ADVISER:

Ralph Bruce, Professor of
the Practice of Electrical
Engineering

CLIENT:

Schneider Electric



Communication is an essential component of any sort of interaction, especially if an engineer is giving technical support to someone in the field. Miscommunication can cause damage to the products or even injure the field engineers themselves. The goal of the ARTS project is to improve communication between engineers in the office and engineers or clients in the field using a mobile application. The team is designing a Google Hangouts application to allow for live-video annotation. The ARTS application allows for device-to-device video and audio communication, file sharing, and picture and video annotation. Its intended use is for technical support communication between a customer or technician in the field and an experienced technician in an office.

Compared to existing applications, which are paid services, this would be a free application under the framework of Google Hangouts. Users could log in using their Google Plus accounts or create a quick free one. Any operating system supporting the full Chrome web browser can use this lightweight application. As a result of these advantages, the team expects that the application will easily integrate into any workspace.



Radio Frequency Sensor for Risk Mitigation in Laparoscopic Hysterectomies

TEAM MEMBERS:

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Peter McNally
Syazana Azmi
Jesse Hayes

ADVISER:

Francisco Aguirre, M.D.

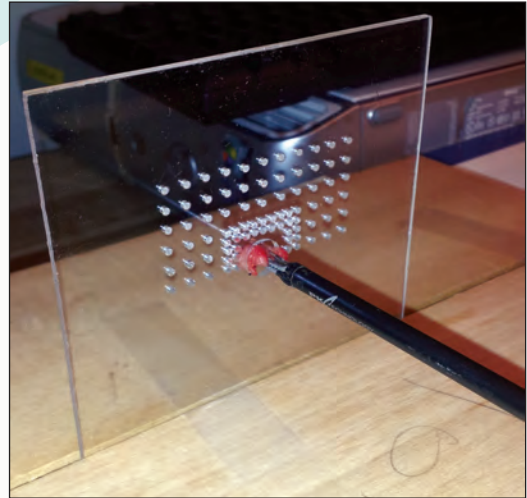
CLIENT:

Vanderbilt University Medical Center, Department of Obstetrics and Gynecology

VANDERBILT UNIVERSITY
MEDICAL CENTER

The Department of Obstetrics and Gynecology at the Vanderbilt University Medical Center is investigating a technology for laparoscopic hysterectomies that desiccates tissue around the uterus with forceps that emit an electromagnetic signal. Desiccated tissue can be cut with minimal blood loss, resulting in a simpler and safer surgery. This process can create heat, which may lead to undesirable thermal spread. The spread can damage surrounding tissue, like the ureter. Ureter damage is only serious if it goes undetected by the surgeon. However, it is difficult for surgeons to identify if damage to the ureter occurred, resulting in post-surgery complications.

The project goal is to design an antenna that is attached to a stent in the ureter and can detect some fringing signal surrounding the cutting forceps. Because this signal travels further than the thermal spread, the antenna can be used to notify the surgeon of proximity to the ureter and help prevent any damage. In order to design this antenna, the emitted signal was characterized at specific locations around the forceps. A suitable antenna for this data was then designed, with close attention paid to the disparity between the size of the ureter and the wavelength of the signal.



Development of a Quality Assurance Inspection Process for Static Line Workers

TEAM MEMBERS:

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Ryan Hess
Jacob Steiger
Joesph Polt, EE

ADVISERS:

Donnie Cameron, Shift
Manager, Product Quality
Assurance
Ashley Gatlin, Senior Manager,
Product Quality Assurance

CLIENT:

Nissan North America



Nissan North America manufactures and ships automobiles to customers throughout the world. The manufacturing plant in Smyrna, Tenn., produces approximately 130 Nissan and Infiniti vehicles per hour. Due to the plant's high throughput, quality inspection must be completed swiftly and thoroughly.

Our team was tasked with improving the Product Quality and Assurance area of the plant, specifically the static inspection line. The line inspectors check for dents, scratches and other quality concerns on the finished models. Current training requires inspectors to memorize tedious routines, leaving opportunity for confusion and human error during the time-sensitive inspection. A system of audio cues was determined to be the optimal method of ensuring that inspectors adhere to Nissan's standardized procedures. Audio files lend themselves well to time-sensitive commands, and may be easily implemented into the existing line and training systems.

Using a wireless headset and mounted camera, inspectors will be able to easily adhere to Nissan standards. This system's modular design allows easy modification to the audio commands for future inspections. As a result, the headset's audio will maintain automation along the line, while the camera will communicate specific defects with the existing computer logs. This new system should help the inspectors increase the efficiency of their inspections, as well as their effectiveness in properly identifying car defects.



Static Inspection Line at Nissan in Smyrna, Tenn.

Design of an Improved Preventative Maintenance System in an Engine Block Machining Line

TEAM MEMBERS:

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Matthew Landolphi
Patrick Stumberg
Farhana Harun
Raden Ain Nabilah Hambali

ADVISER:

Mark Traxler, Senior Product
Development Engineer

CLIENT:

General Motors Corp.



As automobile production increases, unplanned downtime becomes a costly problem in the modern factory. General Motors at Spring Hill, Tenn., has a required output of two complete engines per minute, making regular maintenance a top priority. Reactive maintenance, only performed after failure has occurred, is insufficient for these sorts of needs. As a result, our team set out to design a system of predictive, proactive maintenance for their machining line.

The proposed solution relies on active data collection and sensor fusion. By correlating the outputs of multiple sensors (including temperature and auditory measurement) working in tandem to occurrences of a specific failure, it becomes possible to identify signs of impending disaster. The present system employed by General Motors collects numerical data infrequently, forcing a considerable amount of data mining in order to determine relationships between sensor output and operation failure.

Our project aims to demonstrate the usefulness of sensor fusion in not only predicting failure, but in determining the exact nature of the defect causing it. With adequate experience and existing data, a technician will ideally be able to determine the precise state of the operation using only current data readings.



Automated Guided Vehicle System for Factory Floor Supply Distribution

TEAM MEMBERS:

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ADVISER:

Britt Autry, Vice President
Robert Ridley,
Ceramic Products Specialist

CLIENT:

DENSO Manufacturing



Each year, companies spend thousands of man-hours relocating supplies across their factory floors. In order to circumvent this costly routine process, many companies have invested in autonomous guided cart systems (AGCs) which can seamlessly transit supplies for a minimal expense. While many such systems exist on the market today, their associated cost tends to be discouragingly high, and they typically require a substantial alteration of the work environment in order to function. The purpose of our project was the design of a cheap, minimally invasive AGC sensor suite for implementation on a larger scale vehicle.

By building on last year's design, which implemented a ceiling-mounted Aruco marker system for global positioning, this year's team is building a robot that is also capable of local sensing using a Microsoft Kinect camera. This allows it to navigate between markers while avoiding walls and identifying obstacles. The resulting sensor suite is extremely cheap to replicate and readily scalable for a larger scale model. The result is a cheaper, functional alternative to the present market standard that, with some minor adjustments, can fulfill all of the necessary roles that DENSO requires.

Improved Stringer Painting System for Aircraft Component Fabrication

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Alan Leaser
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ADVISERS:

Melissa Holobach,
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Director of Engineering

CLIENT:

Triumph Aerostructures



Stringers are essential components in every airplane, responsible for stiffening various sections of the aircraft. Currently, airplane part manufacturers have a method of painting stringers that can take up to 15 hours per part. The process includes painting the top three sides of the stringer, baking the stringer according to company specifications, and then flipping the stringer and repeating the process for the fourth side. This process is both tedious and inefficient, slowing down production rates and raising costs of labor. Our goal is to create a way to decrease the time needed to complete this painting process.

Our design consists of rows of Y-shaped, variable-height steel stands that include two vertical, small-diameter pegs to support the stringer. By limiting the points of contact to the pegs, the entire surface of the stringer can be almost completely covered, eliminating the need to repeat the whole process for any unpainted side. By focusing on the longest step—the need to flip the part and repeat the process—we designed a painting method that allows for all sides of the stringer to be painted at once, cutting the total time nearly in half.



Relocation of the No. 5 Snack Bar Repackaging Line

TEAM MEMBERS:

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Joseph Shields
Isaiah Spinney
Aiman Johan Ahmad Jaafar

ADVISER:

Jimmy Spradley, CEO

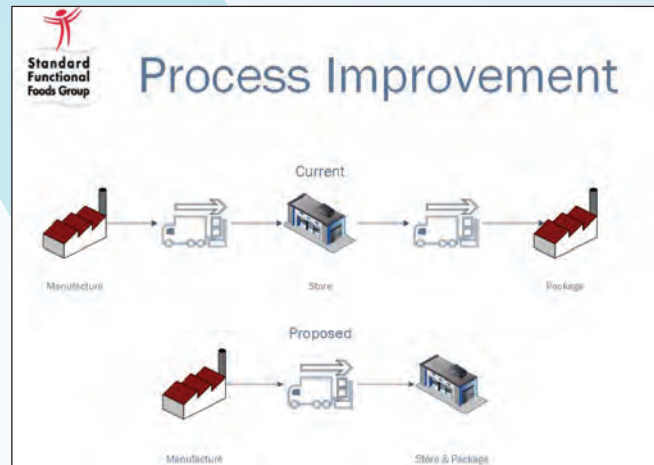
CLIENT:

Standard Functional Foods



Our team is working with Standard Functional Foods (SFF), a leading manufacturer of snack bars. Our project deals with a common request by SFF's clients: to create variety packs with several different flavors. To achieve this, SFF has to make each flavor separately and store them in their warehouse until all the requested flavors are completed. Since the warehouse is 0.5 miles away, a truck has to transport the work-in-progress (WIP) to the warehouse for storage and then back to the factory for repackaging on Line No. 5.

Our team is designing a plan to move the No. 5 repackaging line to the warehouse so the WIP has to be moved once. This move will save SFF time and labor, creating substantial savings. To create a feasible design, our task was primarily logistical. Some of the major elements include: electrical power and compressed air required to run the assembly line, adequate space for the line and workers, miscellaneous components and improvements, and a cost-benefit analysis of the move. Our goal is to present a thorough report to our sponsor detailing how the relocation will be accomplished and how our project will fiscally benefit SFF.



Rapid Testing Apparatus for Plastic Film Packaging Specifications

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Khairul Kamarulzaman

ADVISERS:

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Industrial Engineer
Bradford Sims,
Maintenance Manager
Curtis Hill,
Operations Excellence
Manager

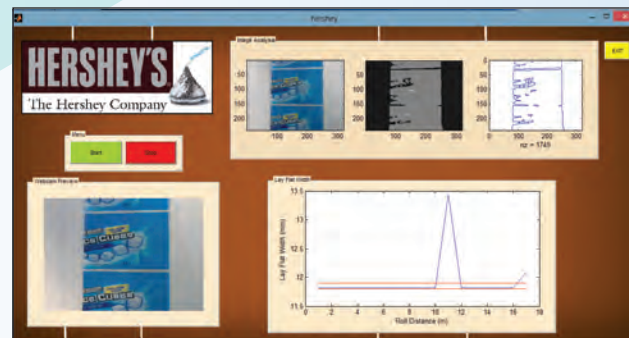
CLIENT:

The Hershey Co.



Hershey uses manufacturing lines to package chocolate and nonchocolate confectionery products in plastic films. Inconsistencies in lay-flat width and coefficient of friction of these packaging materials are two defects causing downtime and material losses in Hershey's plants. The goal of our project is to analyze and report these defects in a user-friendly manner for a variety of plastic films. The team designed a stand-alone testing unit with an integrated photo measurement system for dimensional analysis and a coefficient of friction testing structure to quantify these defects.

A mounted camera takes a continuous stream of photos. It measures the width of the plastic film as it travels through the testing apparatus. The measurement data is output to an on-screen monitor for real-time inspection, as well as to a final Excel document with the raw data for the entire film roll. Coefficient of friction is measured simultaneously on the inside of the film to protect the integrity of the plastic film. This results in a numerical value used to characterize the entire roll of film. An alarm will trigger should a defect be detected, alerting the user of an issue, which can be viewed on the on-screen monitor. The overall testing unit for Hershey's provides a quick, accurate measurement of these defects which was previously nonexistent.



Design of Laser Printer Shroud System for Production of Diabetic Test Strips

TEAM MEMBERS:

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ADVISER:

Peter Goodwin,
Manufacturing Engineer

CLIENT:

Roche Diagnostics



One step of this process is laser printing a 2D bar code on a vial. Making any experimental changes in the production process for diabetic test strips requires costly downtime of the equipment. Recently, the quality of the laser printer assembly, which includes the laser printer and the shroud, has been questioned. The objective of our project is to deliver a set of possible designs for a more robust laser printer shroud. To accomplish this, a separate mechanism was constructed to run experiments on alternative shroud designs.



The new designs aim to eliminate the current shroud's most common failure modes. These include the test strip vial jamming underneath the shroud and the laser printer producing wavy 2D bar codes, causing excessive debris buildup on the vial. The proposed design solutions are advantageous compared to the current shroud design because they increase the stability of the vials both outside and inside the shroud and add an additional debris removal process. Our team anticipates that the new solutions will help to reduce the frequency of the shroud failure modes thus creating a more efficient process.

Design of a Mobile Adjustable Support System for an Infrared Sealant Curing Emitter for Aircraft Fuel Tank Repair

TEAM MEMBERS:

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Steven Strasburger
Jay Reynolds
Abdul Fauzi

ADVISERS:

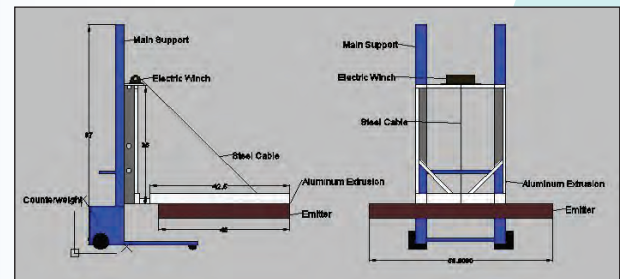
Xavier Bourdeau,
Design Office Manager
Havan Tucker, Production and
Maintenance Manager

CLIENT:

Aerowing Inc.



Leaks in fuel tanks of aircraft require immediate repair. Repair processes such as sealant curing can ground planes for 24 hours or more, resulting in a loss in transportation of goods. The use of infrared emitters can decrease sealant curing time to only four hours. This project investigated and built a system to support a nine-by-three-and-a-half-foot emitter for use on an assembly line. The system must be mobile, height adjustable and rotatable up to 90 degrees.



The new design integrated both a manufactured material-lifter for mobility and height adjustability and aluminum extrusions for support of the rotation. The design must also be reliable and user-friendly because of its continued use on assembly lines. This design is unique compared to similar solutions because of its ability to support and manipulate an emitter of such a large size and weight while maintaining the mobility and control of typical emitter supports. Through the implementation of this design, the emitter is height adjustable through a range of motion of three to eight feet, rotatable from vertical to horizontal through a range of 90 degrees and mobile enough to be successfully used on the manufacturing line for large aeronautical structures.

Automated Vial Verification System

TEAM MEMBERS:

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Alicia Fan
Yasmin Zaidi
Ahmad Affandi

ADVISER

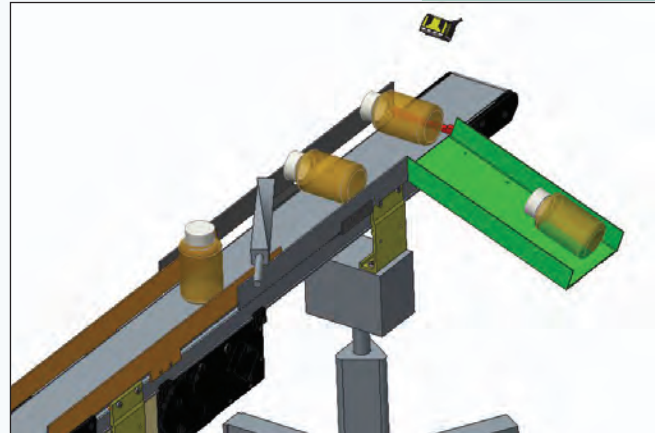
Lie Tang, Ph.D.

CLIENT:

Quality Manufacturing
Systems Inc.



Quality Manufacturing Systems Inc. develops and manufactures custom, industrial control and automation equipment in a range of industries, including pharmaceutical distribution. In order to improve system productivity and accuracy, QMSI would like to automate packaging in their pharmaceutical distribution solutions to ensure the accurate and efficient distribution of medicine to the correct pharmacies and customers.



The goal of our project is to design an automated vial verification and packaging system to replace and improve upon QMSI's current manual procedure. The current procedure requires an operator to manually scan and bag every vial as it comes off the assembly line. The current verification system takes up to three seconds to process each vial which limits the production to 270 orders per hour. Automating this procedure has the potential to improve overall distribution speed and accuracy.

Our team has come up with a solution that rotates the vials automatically to allow for digital scanning of the vial bar codes to verify each order. By attaching modular components, such as pneumatic pistons, exit ramps, and singulation/reorientation mechanisms, we aim to provide a low cost, compatible, solution for QMSI that meets their design needs of exceptionally high accuracy and improved system productivity.

End Effector for Improvised Explosive Device Disarmament

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Samantha Munoz

ADVISERS:

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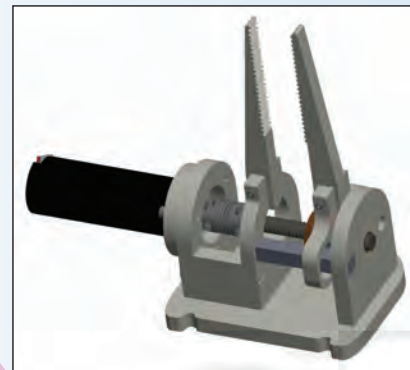
CLIENT:

Northrop Grumman



Improvised explosive devices (IEDs) threaten the lives of soldiers and civilians alike in war-stricken areas. Disarming these bombs is a dangerous and risky task for soldiers. To keep soldiers out of harm's way, robotic systems have been developed to allow for remote disarmament. Since these robots must be capable of small manipulations and be easily expendable, our goal is to create an end effector for a robotic arm. We designed a new end effector for an IED disarming robot that is lightweight, inexpensive, and versatile, three critical design criteria for the bomb-disposal task.

Our end effector contains interchangeable fingers that are capable of grabbing and manipulating small objects and cutting through wires and external casings. To demonstrate its capabilities, we interface it with Rethink Robotics' Baxter robot, which has two seven-degree-of-freedom arms, and we use the system to tie a shoelace via teleoperation. To teleoperate Baxter, we design and implement a resolved rates control scheme. Our gripper differs from existing robotic grippers by its minimized cost, simplicity of design, ease of control, and its incorporation of multiple tools relative to bomb disarmament.



Energy and Cost Analysis of Insulating Irregularly Shaped Piping

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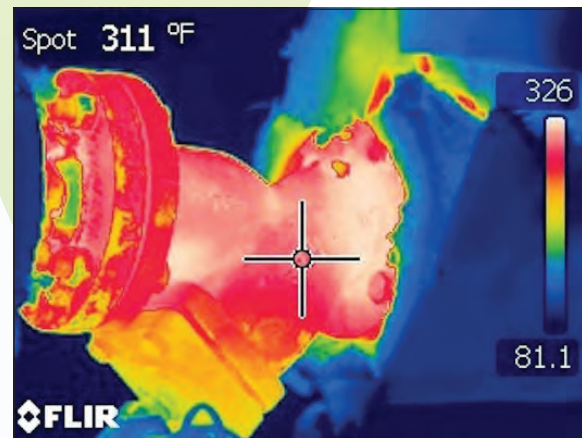
CLIENT:

Vanderbilt University Plant
Operations



Properly designed insulation systems result in increased energy efficiency and a safer working environment. Vanderbilt University Plant Operations monitors a complex steam pipe system that provides hot water across campus. This system includes a number of irregularly shaped pipes that require routine maintenance and are left uninsulated. Our goal is to show the resulting energy and cost impact, as well as provide a removable insulation alternative that will safely improve system performance, conserve energy and reduce costs.

Our team uses three methods to determine the total heat loss and associated cost of the uninsulated piping: a thermal imaging camera and heat transfer equations, an experimental prototype and software modeling. We then analyze removable insulation alternatives and determine the resulting energy and cost savings over time. Our project displays an in-depth energy and cost analysis of insulating irregularly shaped pipes on Vanderbilt's campus, concluding with a suggested removable insulation alternative. Vanderbilt University Plant Operations currently uses fiberglass insulation, which is not suitable for pipes that need continuous servicing since it is difficult to reinstall once removed. Our team's removable insulation alternative is advantageous to the current method because it does not hinder routine pipe maintenance. Furthermore, insulating these pipes results in reduced energy operating costs and increased safety.



Structural and Mechanical Design for Traction-Tillage System

TEAM MEMBERS:

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Peter Ingram
Sharifah Musliha Almatar
Mohd Izzuddin Mohd Zahar

ADVISER:

Tommy Thompson,
Founder/ Owner

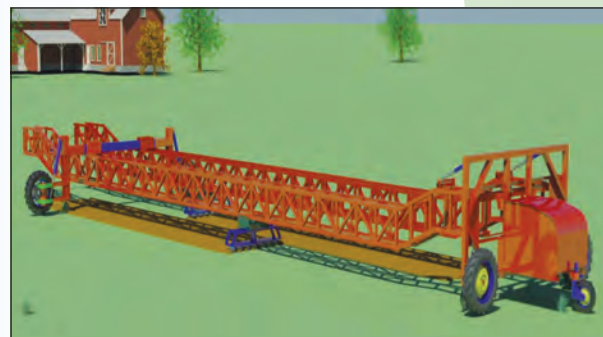
CLIENT:

NuAg Agricultural Systems



Modern tractor-based agricultural systems suffer several shortcomings. Among these are compaction of underlying soil, which decreases crop yields by as much as 20 percent, and inefficient expenditures of fuel. NuAg Agricultural Systems' traction-tillage system aims to solve both of these problems by replacing the tractor with a linear and flexible system. By supporting a variety of farming operations on two long, parallel booms, the traction-tillage system reduces the footprint of the weight-bearing wheels and separates motion of the entire system from farming operations. Our team partnered with NuAg to design the truss structure that holds the system together and, most importantly, the components that use that structure.

The team performed an in-depth design of the truss structure, including an analysis of possible materials and a force analysis of the proposed structure. Also, the team further designed the carriages which run along the trusses and hold each farm implement, the track system which supports the carriages, and the cable system which provides for locomotion of the carriages. Finally, the team designed a large-force sensor which will be used to determine whether there is an obstacle in the path of the implements so that appropriate action can be taken.



The traction-tillage system during plowing operations

Polariscope for Strain Field Visualization

TEAM MEMBERS:

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ADVISER:

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Research/Development
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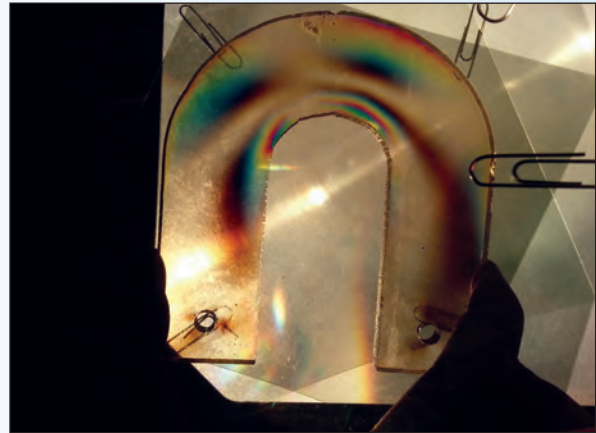
CLIENT:

Vanderbilt University,
Department of Mechanical
Engineering

VANDERBILT  UNIVERSITY

The ability to quickly visualize strain fields of a loaded specimen is useful in pedagogic and industrial applications, especially to confirm computer simulation results. Our goal is to design and construct an inexpensive polariscope, using polarizing filters to reveal the strain field of a loaded specimen (a commercial polariscope costs ~\$20,000). The polariscope is intended for use as a teaching aid in a finite element analysis (FEA) class at Vanderbilt University.

Specimens are coated with a relatively thin layer of transparent photostress film, which has a localized index of refraction proportional to strain (i.e., subjecting the film to a force produces colored fringes under filtered light). Using a camera, a computer captures and analyzes this image to identify principal strain values at all points on the specimen. A dedicated light source and a closed-form polariscope design are used to minimize ambient light to the specimen and to improve image quality. The colored fringes appear in a particular order and a calibration table is used to identify the corresponding strain in each fringe. The results are then compared to calculated FEA results to test for accuracy.



Colored fringes on a U-shaped specimen

Characterization of Heat Transfer Applications for Cryogenic Fuel Boil-Off in Upper-Stage Rockets

TEAM MEMBERS:

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ADVISER:

Peter Wilson, Propulsion and
Fluids and Thermal Analysis
Lead

CLIENT:

United Launch Alliance



Due to the physical interaction between a spacecraft's storage tanks and cryogenic fluids, inherent heat transfer can cause excessive boil-off. This decrease in usable propellant limits the spacecraft's flight time, thus reducing the return on investment for space programs. In an effort to improve the vehicle's efficiency and to increase the longevity of missions, the propellant boil-off should be repurposed before it is vented offboard. Through the process of internal convection, fuel tank boil-off can be minimized by reducing the amount of heat transfer to the spacecraft. Within this larger scope, our task is to design a test set-up which characterizes the heat transfer properties of cryogenic fluids, principally saturated nitrogen vapor.

A cryogenic dewar feeds liquid nitrogen through a heat exchanger, vaporizing the fluid. The resulting gas flows through a pipe attached to a large fin, which in turn creates a desired two-dimensional temperature gradient. Measured by an array of thermocouples and a thermal imaging camera, the experimental data will show heat transfer correlations specific to saturated cryogenic fluids. These results, combined with a thermal software simulation, will provide an innovative design basis for vapor cooling of spacecraft structure.



Suspension Analysis and Design for the Vanderbilt University Formula SAE Team

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ADVISER:

A. B. Bonds, Professor of
Electrical Engineering and
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Emeritus

CLIENT:

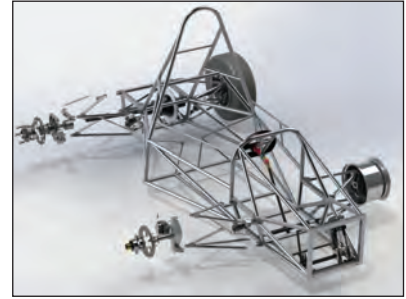
Vanderbilt University
Formula SAE



Vanderbilt Motorsports is a team of undergraduate and graduate students from multiple engineering disciplines that designs, fabricates and tests an open-wheeled Formula car for the Formula SAE (FSAE) international design competition. The team designs and markets the high performance Formula car under the premise of selling the design for production and sale to amateur racers.

Our team focused on the suspension and handling of the Formula car, preparing for competition and compiling design and testing methods which the Vanderbilt Motorsports team can build upon for future designs. We developed the suspension with particular attention to control forces so that the driver can maintain high acceleration without excessive physical stress. Vehicle analysis began with constructing suspension and tire models for kinematic and dynamic analysis. Simulations and driving tests revealed important factors for successful suspension design and tuning and called for changes to suspension geometry.

In addition to the research and physical testing, we analyzed the suspension value in terms of cost, marketing and necessary manufacturing resources. This contributes to the overall vehicle package in preparation for competition, and the accumulated data benefits the team with information for producing improved Formula cars in future years.



Liquid Fuel Management and Landing Site Evaluation for Rocket Flight

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Jordan Salik
Christopher Twedell

ADVISERS:

Amrutur Anilkumar, Professor
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Graduate Student Advisers:
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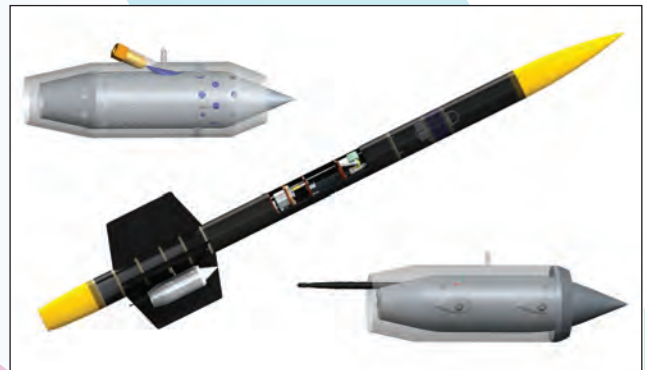
CLIENT:

NASA



Fuel containment and slosh abatement in space is a major challenge that has to be addressed to ensure continuous fuel delivery for liquid-fueled engines. The Vanderbilt Aerospace Club has designed a novel slosh abatement fuel tank that ensures maximum fuel extraction during rocket flight, where the gravity-free conditions are stronger than in space flight for the NASA student launch competition.

The performance of the fuel tank is verified through combustion in a novel opposing fuel injected ramjet engine where kerosene is pressurized at 450 psi and then finely atomized upon injection into the manifold to increase combustion efficiency. The ramjet engine design has been optimized with computational fluid dynamics analysis and ground-based testing. Detection and evaluation of landing site hazards is important for the successful recovery of a rocket following a mission. To this effect, the team has designed a system that can continuously track and process the landing site topology for hazards as a first step towards developing a fully-recoverable rocket. We have focused on modular, inexpensive solutions to address the issues of slosh abatement and hazard detection as a means of contributing to the development of NASA's Space Launch Systems initiative.



Carbon Fiber Implementation and Redesign of Rhoades Car Quadricycle

TEAM MEMBERS:

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Andrew Marione
Daniel Tepper
Willie Carter

ADVISER:

Phyllis Shelton,
Vice President, Marketing

CLIENT:

Rhoades Car International

Rhoades Car is a premier quadricycle manufacturer that has developed a variety of products for industrial and personal use. With such a diverse product line, a Rhoades Car can be used by anybody looking for a greener alternative to transportation, or by someone looking to stay active. The design team has been tasked to add to this product line, and is investigating the feasibility of a redesign in several areas.

With consultation from Oak Ridge National Labs, carbon fiber will be implemented in the frame to reduce weight, and the frame will have provision for disassembly to facilitate storage or transportation in the trunk of an SUV. The new design will include an upper body workout mechanism that will enhance the bike's capability as an exercise machine. We have developed a design that incorporates these features and built a working prototype as a model for future production.



Artiphon Instrument I

TEAM MEMBERS:

Kayte Johnston, ChE
Patrick Foran, ME

ADVISER:

Mike Butera, Founder
John Bers, Associate
Professor of the Practice of
Engineering Management

CLIENT:

Artiphon

Artiphon creates musical multi-instruments that can be accessed and played in multiple positions with a variety of playing styles. The INSTRUMENT 1 accomplishes this through pressure sensitive digital strings, an iPhone dock, and speakers built into its hardwood body. It's a studio in an instrument, engineered for the mobile musician. Elements of the INSTRUMENT 1 will be assimilated into multiple future products, which include accessible mass-market devices for nonmusicians.



Due to the unique nature of the INSTRUMENT 1 and its successors, our team is determining the market space that Artiphon's devices will occupy as well as compiling pertinent market research that will benefit the development of future mass-produced Artiphon devices. This market sits in a hazy gray area between the musical instrument market and the consumer electronics market. Additionally, we are assisting Artiphon in determining how to design their components for mass-manufacturing, as well as converting their 2D part files to solid models. Finally, our team is focusing on improving component playability by pursuing product designs that respond in a consistent manner. This improves the confidence of the player and makes the transition from a traditional stringed instrument to an Artiphon product more fluid.

VEXTEC

TEAM MEMBERS:

Marquicia Pierce

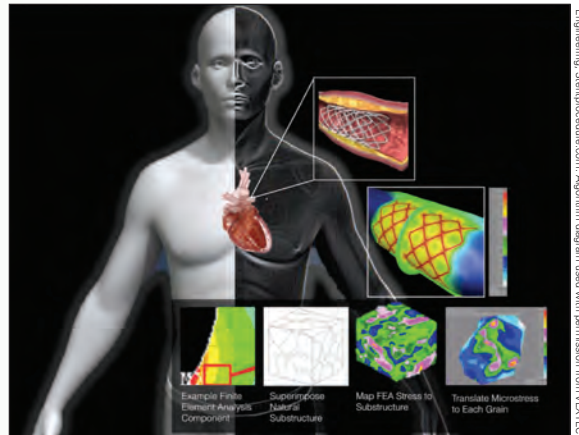
ADVISERS:

Robert Tryon, CTO and Co-founder
Ganapathi Krishnan, Vice
President, Modeling and
Simulation
John Bers, Associate
Professor of the Practice of
Engineering Management

CLIENT:

VEXTEC Corporation

Amidst competition, medical device makers strive to bring new products to the market faster and more economically than ever before. Success requires the use of powerful computational tools and analysis capabilities. Current testing procedures are costly and time-consuming. Current design systems do not provide a methodology to integrate material damage mechanics with finite element analysis (FEA). VEXTEC, through VLM—Virtual Life Management®, provides a comprehensive solution that integrates FEA with material damage models to provide a complete picture of component durability at a fraction of the cost.



A key objective for this project was to navigate the extensive ecosystem of the medical device simulation market and identify an entry point for VEXTEC's VLM technology. Companies within this industry have varying capabilities to computationally model different biomedical scenarios. It was important to determine what specific solutions existed and how firms interacted with one another. VEXTEC's goal is to establish collaborative partnerships with key players. To this end, research included situation and opportunity analysis, competitor strategy analysis, business intelligence study and strategy formulation that focused on the assessment of prospective partners and collaboration.

Clean Hybrid Energy Scalable System

TEAM MEMBERS:

Travis Allen, ES

ADVISERS:

Steven Cornelius, President/
CEO

John Bers, Associate
Professor of the Practice of
Engineering Management

CLIENT:

Jet Stream Energy Systems



This engineering management capstone is in collaboration with the EECS senior design project. The Clean Hybrid Energy Scalable System (CHESS) is intended to address the intermittent nature of wind and solar power, supplementing those sources with clean, natural gas generation. CHESS integrates commercial off-the-shelf components to create a modular plug-and-play system that is easy to install as a stand-alone unit or as a retrofit kit to existing systems. CHESS can be scaled and adapted to meet specific user/application demands.

Our team partnered with JetStream Energy Systems to develop a commercialization plan for CHESS, focusing on market identification and segmentation, product specification, competitive analysis and overall opportunity assessment. We're working in parallel with an EECS design team that is constructing the first CHESS prototype.

At this stage, our market focus is on small systems for micro-grid and portable power applications, and those should serve as a launching point into additional applications in commercial and industrial power. There is significant interest in these initial markets for a hybrid system like CHESS that can overcome the challenges of wind and solar energy. The primary obstacle to CHESS right now is developing a customer-ready system. Once this is accomplished, JetStream Energy Systems has a promising path into the clean energy industry.



Orchid Optics

TEAM MEMBERS:

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Stanley Wang, ES
Justin Huntress, ChE

ADVISERS:

Matt Lang, CTO and Chairman
of the Board

John Bers, Associate
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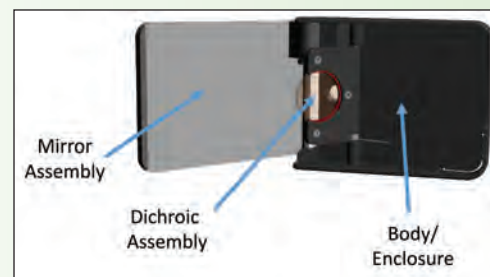
CLIENT:

Orchid Optics LLC

Orchid Optics produces devices that enable users to capture images and video in 3D using their iPhone. The ultimate vision is to empower the general public to create 3D media. Alongside the company's product development, the capstone team was responsible for identifying potential customers, prioritizing user feedback, developing strategy and finding business funding.

We conducted literature market research to determine the feasibility of a product of this sort. Our research led us to the following key insight: growth in 3D media is stagnant, meaning broad, rapid adoption is unlikely within the near future. However, comparable products have seen success within various niche markets, because they limit the typical inconveniences associated with 3D products—glasses, red-blue colors, and cost-prohibitive hardware.

We tested iterative prototypes of the Orchid i1 with students, faculty and our specific target audiences within the Nashville community to determine how well our premise matched specific user behaviors. From these tests, we continually improved the requirements for existing designs of the Orchid i1 and gained insight into what factors might affect buying decisions. After successive iterations of testing, we launched social media and crowdsourcing campaigns to build a following and raise capital for further product development and production.



Impedance-Based Hydration Monitor

TEAM MEMBERS:

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ADVISER:

Kevin Sexton, M.D.

John Bers, Associate
Professor of the Practice of
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CLIENT:

Kevin Sexton, M.D.

This engineering management capstone is in collaboration with a biomedical engineering (BME) senior design project. The BME team is designing an impedance-based hydration monitor to be initially implemented in the Vanderbilt University Medical Center, and eventually the commercial market. Dehydration is a common morbidity that precedes many serious illnesses. Early detection and treatment is vital to a patient's recovery. The hydration device serves as a new best practice method for measuring a patient's total body water volume. The device is less invasive to patients, more cost effective to medical institutions, and also maintains the efficiency and accuracy of the incumbent method: urine specific gravity test.

The purpose of the capstone is to create a business plan to bring the device to market. As mentioned, the device initially penetrates the medical institution market segment within the general surgery department at Vanderbilt University Medical Center, eventually spreading into other clinical departments. From there, comparable research hospitals will implement the device to strengthen its standing in the market. Eventually, the device will penetrate secondary medical market segments, including emergency medical technician services and long term care facilities. The ultimate goal is to establish the device within the commercial consumer market.



Design Faculty

Our advisers are an important and vital part of the senior design program. We take great pride in recognizing their outstanding contributions and excellence as instructors, advisers and mentors.



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VANDERBILT  School of Engineering

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