
APRIL 21, 2014 | 4-6 P.M. | FEATHERINGILL HALL

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Vanderbilt University Medical Center, Department of Trauma Surgery

# PREFACE

On behalf of the School of Engineering, welcome to Design Day 2014. This year you'll see projects with Artiphon, Brown and Caldwell, DENSO, General Motors, NanoFerix, Schneider Electric, SSR, Triumph Aerostructures, and many more.

We recognize the value of senior 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 allows you to work with Vanderbilt engineering seniors and discover what makes our students stand out among other applicants when it comes to employment and postgraduate study.

Senior design courses provide students with experience working on real-world projects that involve design constraints, budgets, reviews and deadlines. Students learn about professionalism, licensing, ethics, entrepreneurship and the day-to-day implications of intellectual property. This tradition is a culmination of their undergraduate education.

As their projects take form, student teams interact with their industry and faculty advisers, hold meetings, write formal documentation and present their work. By the end of the academic year, the teams produce a prototype or virtual demonstration of their design. Design Day is their showcase.

If your or your colleagues are interested in sponsoring a project or to learn more, please contact me.

**Cynthia B. Paschal, Ph.D.**
Associate Dean of the School of Engineering
5321 Stevenson Center
(615) 343-3773
Cynthia.Paschal@vanderbilt.edu

*Mailing address:*
PMB 351826
2301 Vanderbilt Place
Nashville, TN 37235-1826

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Brochure data were collected and managed using REDCap electronic data capture tools hosted at Vanderbilt University[1]. 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).

[1]Paul 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:**

Kelsey Richards, BME/ChE
Jeremy Ford
Daniel Ratigan, BME/EE
Rameez Qurashi, BME/EE
Nicholas Visos

**ADVISER:**

Kalpana Manthiram, M.D.
Pediatric Infectious Disease Fellow

**CLIENT:**

Vanderbilt University
Medical Center

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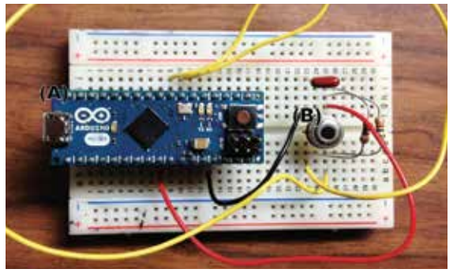
MEDICAL CENTER

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.




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

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.

# Anti-Distracted Driving Device

**TEAM MEMBERS:**

Frank Schumacher
Kyle Engelhardt
Steven Mehl
Jacob Wolf
John Perez
Tyler Stanley
Bolutife Ogunjobi, CompE

**ADVISERS:**

Brooks Gaut, Program Assistant
Danielle Rourke, Senior Intern
Purnima Unni, Program Coordinator

**CLIENT:**

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

Monroe Carell Jr.
Children's Hospital
at Vanderbilt

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

**TEAM MEMBERS:**

Caitlyn Ambrose
Dale Deas
Salman Mukhi
Fang-Wen Shen

**ADVISERS:**

Matthew Walker III, Associate Professor of the Practice of Biomedical Engineering

Kalpana Manthiram, M.D.
Pediatric Infectious Disease Fellow

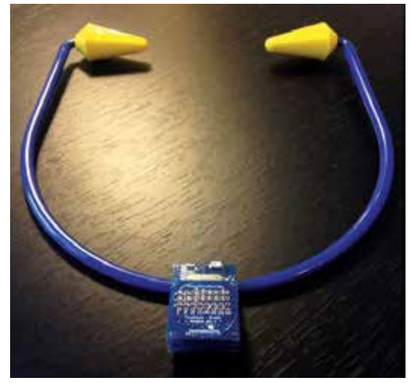
**CLIENT:**

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.



**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.**

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, non-invasive, and automatic approach that will help revolutionize the future of infectious disease detection.

# HyDRRA: Hydration Determination by Resistance and Reactance Analysis

**TEAM MEMBERS:**

Skylar Haws
Doug Hall
Cara Welker, BME/ChE
Mary Morgan Scott
Rachel-Chloe Gibbs, BME/ChE

**ADVISERS:**

Kevin Sexton, M.D.
Richard Boyer, M.D.

**CLIENT:**

Vanderbilt University Medical Center, Department of Trauma Surgery

VANDERBILT UNIVERSITY
MEDICAL CENTER

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 non-invasively 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 non-invasive quantitative method for rapid, convenient, and accurate measurement of patient hydration status.

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

**TEAM MEMBERS:**

Elaine Simpson
Christy Hsu
Jacob Books, ME
Molly Cowan, ME
Annie Daorai
Pere Cvitanovic

**ADVISERS:**

Matthew Walker III, Associate Professor of the Practice of Biomedical Engineering

Tammie McCain

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

**TEAM MEMBERS:**

Jacob Bumpus, BME/EE
Casey Fitzgerald
Michael Schultis

**ADVISER:**

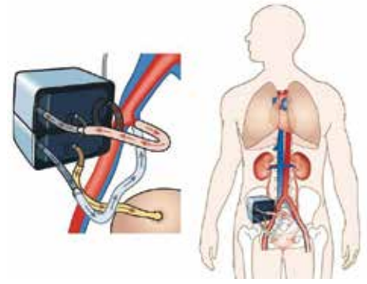
William Fissell, M.D.

**CLIENT:**

Vanderbilt University Medical Center, Department of Medicine, Nephrology and Hypertension Division

VANDERBILT UNIVERSITY MEDICAL CENTER

End stage renal disease imposes a huge burden on healthcare 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.



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

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.





# Laser Speckle Contrast Imaging System for Determination of Parathyroid Perfusion

**TEAM MEMBERS:**

Itamar Shapira
Gabriela de Caires Jesus
Tianhang Lu
James Tatum
Yu Zhou

**ADVISERS:**

Matthew Walker III, Associate Professor of the Practice of Biomedical Engineering

Anita Mahadevan-Jansen, Professor of Biomedical Engineering

Melanie McWade, Graduate Student Liaison

James Broome, M.D.

**CLIENT:**

Vanderbilt University, Biophotonics

VANDERBILT UNIVERSITY

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.

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

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.

# Night Rider

**TEAM MEMBERS:**

Michael Meyer
Christopher Preziosis
Brian Walsh

**ADVISERS:**

Andre Churchwell, M.D.

Duco Jansen, Professor of Biomedical Engineering

**CLIENT:**

Vanderbilt University, Department of Biomedical Engineering

VANDERBILT UNIVERSITY

With the baby boomer population aging, there is a growing number of people suffering 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 preexisting 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, which 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

**TEAM MEMBERS:**

Akhmal Hakim Zainal Ariffin
Ahmad Zulhilmi Abu Bakar, ME
Aireen Zulaikha Abdul Aziz, ChE

**ADVISER:**

Garrett Booth, M.D., M.S.

**CLIENT:**

Vanderbilt University Medical Center, Department of Pathology, Microbiology and Immunology

VANDERBILT UNIVERSITY MEDICAL CENTER

In chaotic surgical or emergency situations requiring blood transfusions, medical personnel may misplace temperature-sensitive blood products into wrong containers. About 110 million dollars worth of platelets was reportedly wasted in 2011 due to the misplacement of platelet bags into red blood cells 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, there are temperature-sensitive stickers that 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.

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

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.

# BrainScope Brain-on-a-Chip Impedace Analyzer

**TEAM MEMBERS:**

Orlando Hoilett
James Cribbs, BME/EE
Matthew Rabon
Dennis Xuan
Elizabeth Keller
Matthew Thompson

**ADVISER:**

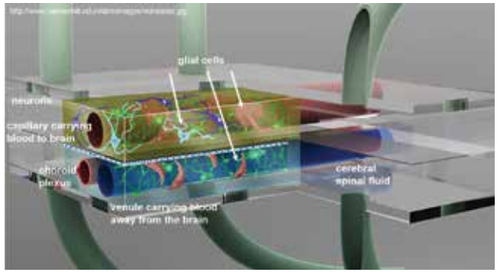
John Wikswo, Professor of Biomedical Engineering

**CLIENT:**

Vanderbilt Institute for Integrative Biosystems Research and Education

VIBRE

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 bio-mimicry 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 Cancer Detection

**TEAM MEMBERS:**

Matthew Dougan, BME/EE
Aisha Dotson
Mark Michael
Leandra Fernadez
Andrew Kong

**ADVISER:**

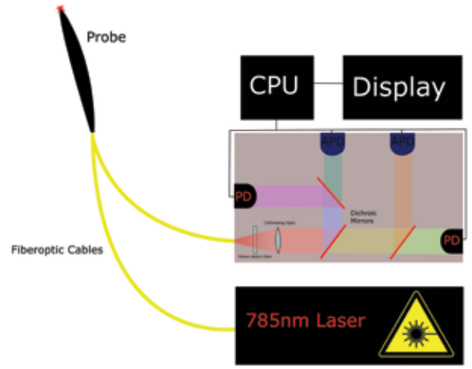
Anita Mahadevan-Jansen, Professor of Biomedical Engineering
Christine O'Brien, Ph.D. Candidate

**CLIENT:**

Vanderbilt University, 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

**TEAM MEMBERS:**

Savannah Fletcher
Holley Lewis
Kristen McNair

**ADVISERS:**

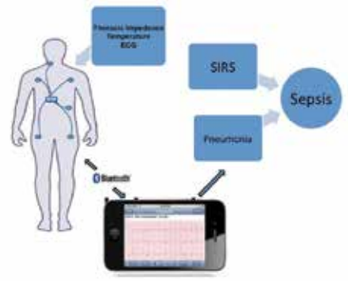
Richard Sexton, M.D., Senior Resident
Franz Baudenbacher, Associate Professor of Biomedical Engineering
Richard Boyer, M.D./Ph.D. Candidate
Kyle Hocking

**CLIENT:**

Vanderbilt University Medical Center, Department of General Surgery

VANDERBILT UNIVERSITY 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

**TEAM MEMBERS:**

Jill Durham
Jarrid Ristau
Kayte Johnston
Audrey Dang
Patrick Reed

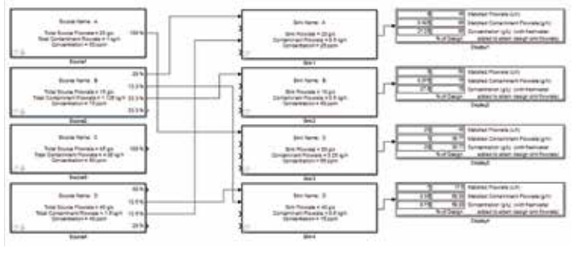
**ADVISERS:**

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

**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

**TEAM MEMBERS:**

Jayde Aufrecht
Nurul Alias
Nurul Rosli

**ADVISERS:**

Molly Leitch, Continuous Operations Manager

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

**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 terapthalate 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

**TEAM MEMBERS:**

Christoffer Bolvig
Benjamin Coleman
Madison Gray
Syed Nizar Syed Tarmizi Jamalulil

**ADVISERS:**

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

**CLIENT:**

Fiserv

Banks and other credit card providers maintain a competitive edge by increasing the visual appeal of their credit cards. Fiserv solutions 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

**TEAM MEMBERS:**

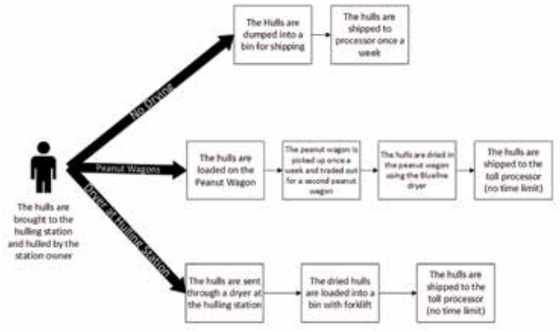
Kayla Swatzell
Nursyuhada Azman
Muhammad Haseen
Anuj Patwardhan

**ADVISER:**

Sarah Bellos, CEO

**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.

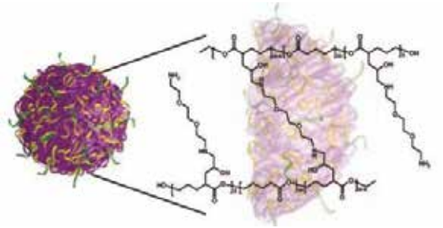
Our team has researched the dyeing process, and has designed two alternative walnut hull drying processes to both extend the decomposition time of the juglones and to minimize freight costs. One option is to place rotary dryers at several high volume hulling stations. Another is to use mobile "peanut 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

**TEAM MEMBERS:**
Stephanie Fisher
Andrew Spencer
Natalie Schieber
Graham Rucker

**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.

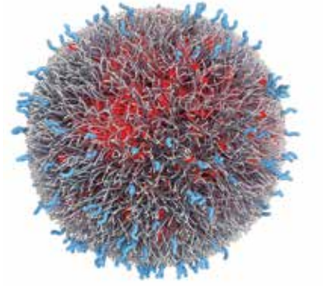
This synthesis has currently only been performed at the bench top level. Our team is designing a scaled up process to produce the nanoparticles and their precursors, including detailed process flow diagrams that are programmed to determine the amounts of reagents needed and the cost of the raw materials. 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

**TEAM MEMBERS:**
Nicholas Gould
Azman Sampol
Andrew Vancura
Brendon Wade, BME/ChE

**ADVISER:**
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

**TEAM MEMBERS:**
Tyler Cooksey
Collin Grimes, ME
Dylan Losey, ME
Kyle Stachowiak

**ADVISERS:**
Kane Jennings, Professor of Chemical and Biomolecular Engineering
Amrutur Anilkumar, Professor of the Practice of Mechanical Engineering

**CLIENT:**
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. We'll take this new and improved solar assembly to present to the EPA in late April.

## Cell Therapy for Spinal Cord Injuries: Manufacturing Facility

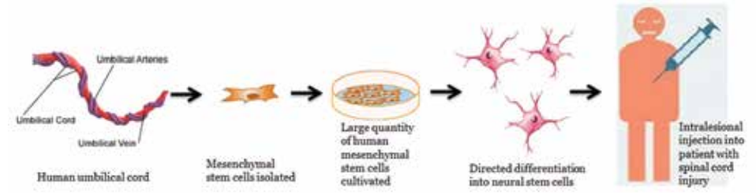
**TEAM MEMBERS:**
Luqman Ahmad Mahir
Madeline Williams
Siti Nur Aishah Mohd Zain
Amulya Pervaje
Elaine Qian, BME

**ADVISER:**
Tiffany Rau, Ph.D.

**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

**TEAM MEMBERS:**

Naufal Nashih Ahmad Zabidi
Nur Azmina Kamaruzaman
Nurul Shahidah Esa
Nur Aishah Ahmad Zhaki

**ADVISERS:**

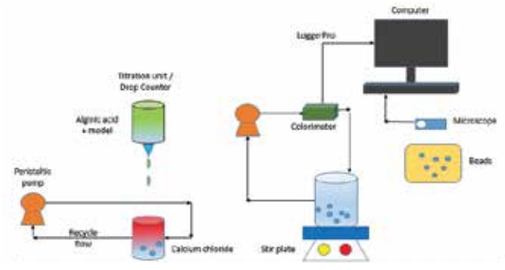
Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

**CLIENT:**

Vanderbilt University

VANDERBILT UNIVERSITY




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

**TEAM MEMBERS:**

Muhammad Zulkifli Suhaili
Nur Afiqah Mohamad
Muhammad Khairul Azmi Mohd Khairul Fazwa Md Yang Ghazali

**ADVISERS:**

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

**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

**TEAM MEMBERS:**

Jared Bullock, BME/ChE
Andrew Coppola
Dylan Johnson
David Dubetz, BME
Kevin Jaeger, BME/ChE

**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

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.

Deamstime.com

## Multi-Product Brewing

**TEAM MEMBERS:**

Emily Golan
Alexander Jagoe
Joseph Cassiere
Eric Beiter

**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

The demand for micro-brewed 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:**

Andrew Roche
Mark Miller
Michael Ellman
Khairul Daud

**ADVISERS:**

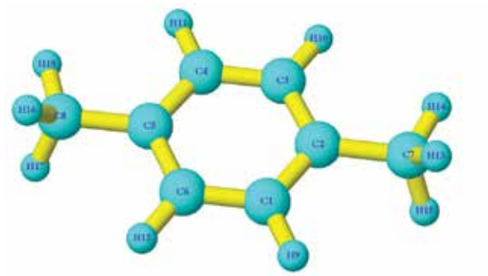
Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

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 of 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:**

Michael Van Sant
Anurag Bose
Mohamad Abdullah

**ADVISERS:**

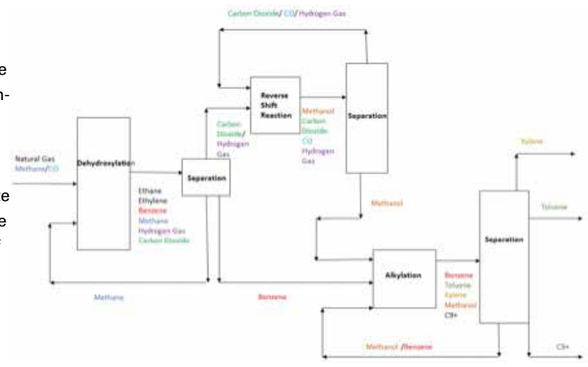
Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

**CLIENT:**

Vanderbilt University

VANDERBILT UNIVERSITY




Aromatic compounds, 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 C9+ 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

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 for 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

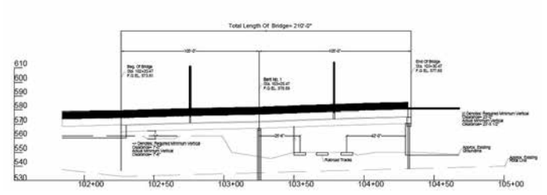
**ADVISER:**

Justin Eckel, P.E

**CLIENT:**

Barge Waggoner Sumner and Cannon Inc.

Creating a better life by design.®
BWSC BARGE WAGGONER SUMNER & 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:**

Wesley Langham
Matthew Ginn
William Haydon Osborne
Samuel Greene

**ADVISER:**

Lori Troxel, Associate Professor of the Practice of Civil and Environmental Engineering,

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.

**Team members and volunteers constructing *Vanderbuilt***

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 gunwales atop the canoe's walls. The name of the 2014 canoe is Vanderbilt, and the design will be construction themed with a black and gold color scheme. Our team hopes to have a strong performance at the 2014 ASCE Southeast Conference held at the University of South Florida.

## 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

Carpenter Wright Engineers CWE Structural Consultants

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:**

Taylor Zurcher
Theodore Swift
Jennifer Frego

**ADVISER:**

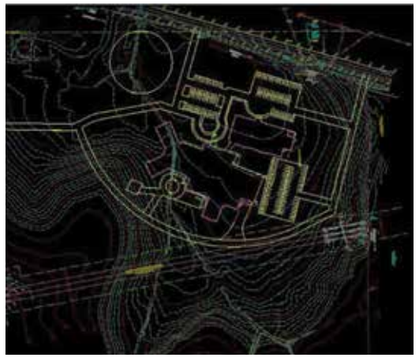
Adam Crunk, P.E.

**CLIENT:**

Littlejohn Engineering Associates

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.



**Cedartown Hospital site layout**

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.

## Road Widening of State Route 76

**TEAM MEMBERS:**

Elizabeth Bentley
Peter Kozey

**ADVISERS:**

Eric McElroy, P.E.
Marshall Fall

**CLIENT:**

SSR Inc.

SSR Smith Seckman Reid, 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 floor event at the Obion River will help determine the required bridge elevation. Lastly, traffic impacts will be analyzed to retime any affected traffic signals nearby.

## Steel Bridge Competition

**TEAM MEMBERS:**

Scott Sloan
Yates Bateman
Keith Marson
Andrew East

**ADVISER:**

Lori Troxel, Associate Professor of the Practice of Civil and Environmental Engineering

ASCE student chapter adviser

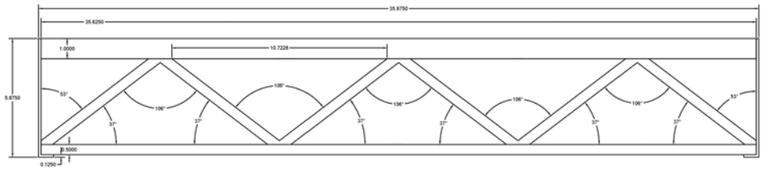
**CLIENT:**

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. We expect our bridge to be one of the front-runners in this year's regional competition.



## State Route 25 Bridge Replacement

**TEAM MEMBERS:**

Ellen O'Brien
Andrew Eckart

**ADVISER:**

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

**CLIENT:**

Tennessee Department of Transportation

TDOT

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:**

Kasey Hill
Kramer Allen
Andrew Bridges, ME
Seth Dean
Azizi Azizan Khamat
Zahra Tajuddin

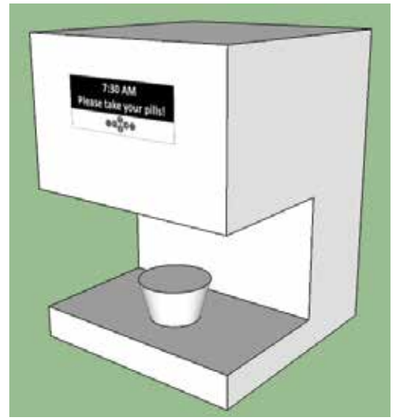
**ADVISER:**

Alfred B. Bonds, Professor of Electrical Engineering, 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:**

Brian Neaves
Seth Patton
Muhammad Ahmad
Wan Ibrahim

**ADVISERS:**

Gary Butler, Founder/CEO

Janos Sallai, Research Scientist, Institute for Software Integrated Systems

**CLIENT:**

Camgian Microsystems

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:**

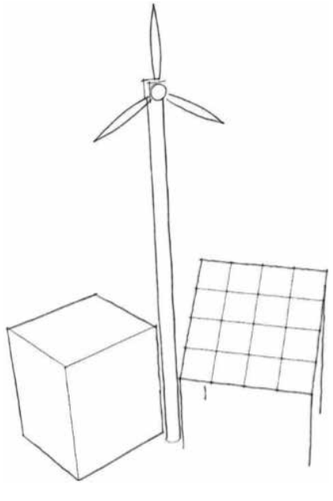
Bryan Carney
Van Kegel
Alex Smith, ME
Joshua Frase, ME
Matt Sun, ME
Tim Altmansberger
Alya Syamimi, Che

**ADVISER:**

Ralph Bruce, Professor of the Practice of Electrical 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

**TEAM MEMBERS:**

Rebekah Austin
Ben Draffin
Will McKenna, ME
Colin Thomas
Patrick Voytek

**ADVISERS:**

Austin Williams, Electronics Designer
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

**CubeSat satellite system bus and computer model of a vibrating frame**

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 for future CubeSat projects, such as creating circuit board layout tutorials, radiation and mechanical testing procedures, and simulation software.



## Metova Leaderboard

**TEAM MEMBERS:**

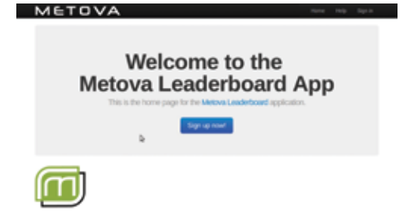
Drew Hamilton
Fabian Okeke
James Tiller

**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 coworkers.

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:**

Siana Aspy
Daniel Dudugjian
Emily Holden
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:**

John Nevins
Peter McNally
Syazana Azmi
Jesse Hayes

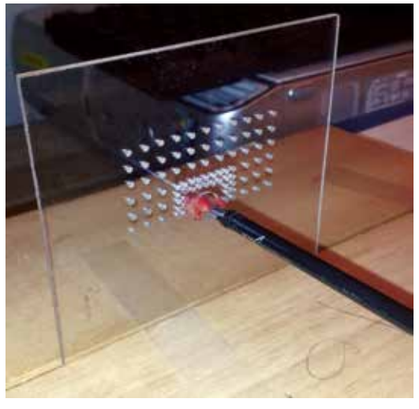
**ADVISER:**

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 their 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:**

Brian Felder
Nick Shirley
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

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.

Dreamstime.com

**Static Inspection Line at Nissan in Smyrna, Tenn.**

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.

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

**TEAM MEMBERS:**

Zachary Greenberg
Matthew Landolphi
Patrick Stumberg
Farhana Harun
Raden Ain Nabilah Hambali

**ADVISER:**

Mark Traxler, Senior Product Development Engineer

**CLIENT:**

General Motors Corp.

GM

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:**
Nathan Hall
Robert Cook
Connor Baizan
Kaivi Suhada
Izzat Zulkifli

**ADVISER:**
Britt Autry, Vice President
Robert Ridley,
Ceramic Products Specialist

**CLIENT:**
DENSO Manufacturing

DENSO

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

**TEAM MEMBERS:**
Cory Walsh
Akram Faqih
Alan Leeser
Scott Kudialis
Nisa Rahimi

**ADVISERS:**
Melissa Holobach,
Operations Director
Richard Drumright,
Director of Engineering

**CLIENT:**
Triumph Aerostructures

Triumph Group, Inc.

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.

MECHANICAL ENGINEERING



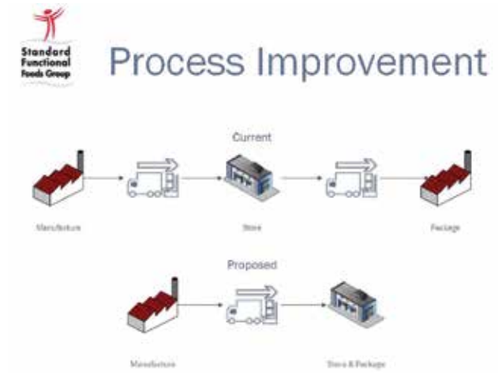
## Relocation of the No. 5 Snack Bar Repackaging Line

**TEAM MEMBERS:**
Elizabeth Hill
Joseph Shields
Isaiah Spinney
Aiman Johan Ahmad Jaafar

**ADVISER:**
Jimmy Spradley, CEO

**CLIENT:**
Standard Functional Foods

Standard Functional Foods Group




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.

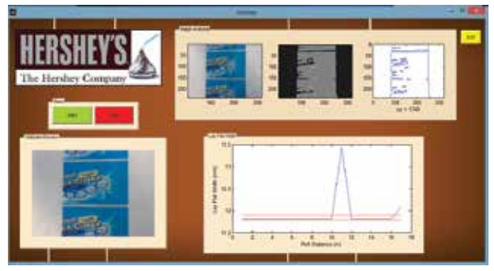
## Rapid Testing Apparatus for Plastic Film Packaging Specifications

**TEAM MEMBERS:**
William Yates
Nicholas Souder
Khairul Kamarulzaman

**ADVISERS:**
Joe Beaudry, CPIM,
Industrial Engineer
Bradford Sims,
Maintenance Manager
Curtis Hill,
Operations Excellence Manager

**CLIENT:**
The Hershey Co.

HERSHEY'S The Hershey Company




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 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.

MECHANICAL ENGINEERING

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

**TEAM MEMBERS:**

Reuben Talukdar
Taufiq Rohimini
Allison Iglehart

**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 that include the test strip vial jamming underneath the shroud, the laser printing 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:**

John Hoyle
Steven Strasburger
Jay Reynolds
Abdul Fauzi

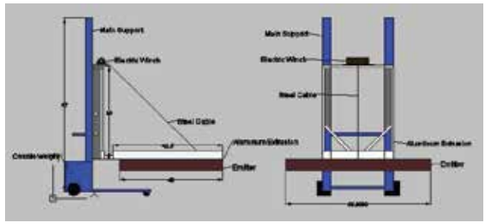
**ADVISERS:**

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:**

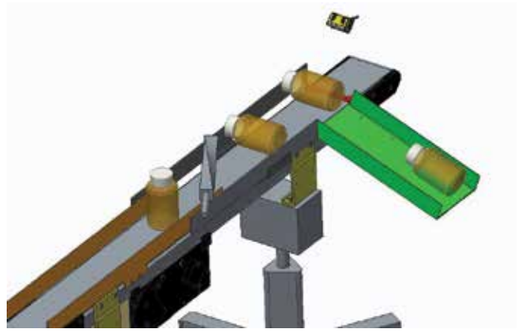
Jake Noble
Alicia Fan
Yasmin Zaidi
Ahmad Affandi

**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

**TEAM MEMBERS:**

Peter York
Christopher Marince
Azlan Bacho
Muhammad Arif Zainal Abidin
Samantha Munoz

**ADVISERS:**

Michael Kariya, Software Developer and Systems Engineer

Michelle Kao, Information Technology Manager

**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 and 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 disbarment.

# Energy and Cost Analysis of Insulating Irregularly Shaped Piping at Vanderbilt University

**TEAM MEMBERS:**

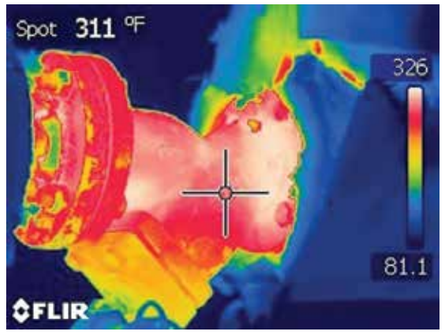
Bridget Coakley
Joan Scheirman
Azeem Yusof
Mujahid Mokhtar

**ADVISERS:**

Mitch Lampley, Director of Engineering and Technical Support
Mark Petty, Assistant Vice Chancellor
James Darren Bevill, Campus Energy Manager

**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:**

Ethan Schurkman
Peter Ingram
Sharifah Musliha Almatar
Mohd Izzuddin Mohd Zahar

**ADVISER:**

Tommy Thompson, Founder/ Owner

**CLIENT:**

NuAg Agricultural Systems

**The traction-tillage system during plowing operations.**

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.





# Polariscope for Strain Field Visualization

**TEAM MEMBERS:**

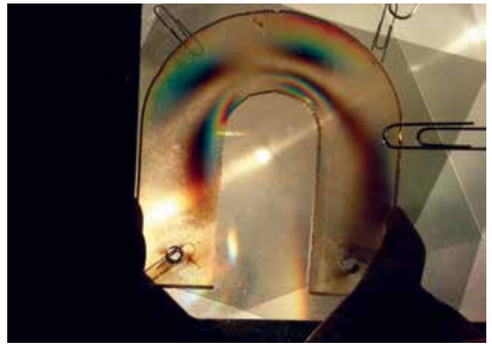
Robert Hiland
Nithin Kumar
Syed Mohd Radi Syed Ali Annuar
Nathan Freehling

**ADVISER:**

Jason Mitchell, Research/Development Engineer

**CLIENT:**

Vanderbilt University, Department of Mechanical Engineering



**Colored fringes on a U-shaped specimen**

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 identity 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.

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

**TEAM MEMBERS:**

Daniel Freudiger
Lucas Kunsman
Alden Marton

**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

**TEAM MEMBERS:**

Eric Bramlett
Abigail Sheridan
Patrick White

**ADVISER:**

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

**TEAM MEMBERS:**

Shivaprem Bernath
Kevin Bush
Brandon Dimmig
Patrick Foran
Jordan Salik
Christopher Twedell

**ADVISERS:**

Amrutur Anilkumar, Professor of the Practice of Mechanical Engineering

Graduate Student Advisers: William Emfinger and Carl Hall

Robin Midgett, Electronics Technician

**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:**

Allan Regis
Lloyd Ambrose
Chufei Yu
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 will build 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

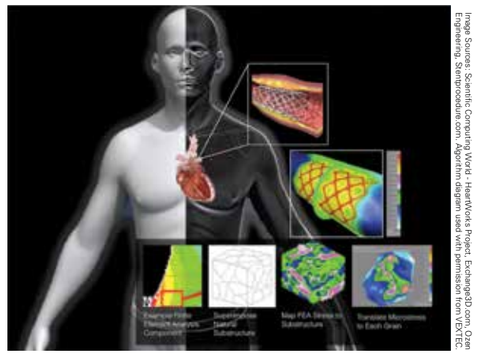



Image Sources: Scientific Computing World - HeartWorks Project. Exchange3D.com. Ozen Engineering. Stentorcoroplus.com. Algorithm diagram used with permission from VEXTEC.

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 and 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.

ENGINEERING MANAGEMENT



## 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 standalone 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 Jet Stream 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.

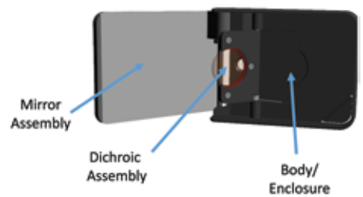
At this stage, our market focus is on small systems for micro-grid and portable power applications, and those should serve as a launching point into additional applications in commercial and industrial power. There is significant interest in these initial markets for a hybrid system like CHESS that can 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:**
Marc Panu, ChE
Stanley Wang, ES
Justin Huntress, ChE

**ADVISERS:**
Matt Lang, CTO and Chairman of the Board
John Bers, Associate Professor of the Practice of Engineering Management

**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.

ENGINEERING MANAGEMENT

## Impedance-Based Hydration Monitor

**TEAM MEMBERS:**

Anna Rose Kelsoe, ES

**ADVISER:**

Kevin Sexton, M.D.

John Bers, Associate Professor of the Practice of Engineering Management

**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.

ENGINEERING MANAGEMENT

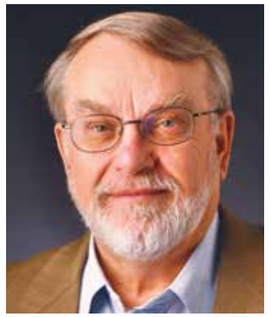


## DESIGN FACULTY

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.

**Joel Barnett**
Associate Professor of the Practice of Mechanical Engineering

**John Bers**
Associate Professor of the Practice of Engineering Management



**Ralph Bruce**
Professor of the Practice of Electrical Engineering

**Kenneth Debelak**
Associate Professor of Chemical and Biomolecular Engineering

**Russell Dunn**
Professor of the Practice of Chemical and Biomolecular Engineering

**Sanjiv Gokhale**
Professor of the Practice of Civil Engineering

**Matthew Walker III**
Associate Professor of the Practice of Biomedical Engineering

**Robert Webster**
Assistant Professor of Mechanical Engineering

VANDERBILT School of Engineering

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