VANDERBILT

SENIOR DESIGN PROJECTS

SCHOOL OF ENGINEERING

TUESDAY, APRIL 26, 2011

3:00-5:00 P.M.

FEATHERINGILL HALL

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VANDERBILT UNIVERSITY School of Engineering

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Paul King, Professor of Biomedical Engineering, Emeritus

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Sanjiv Gokhale, Professor of the Practice in Civil Engineering

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John Bers, Associate Professor of the Practice of Engineering Management

Preface

Senior design courses provide students with experience by working on real-world projects that involve design constraints, budgets, reviews and deadlines. Students learn about the principles of design, professionalism, licensing, how ethics affect engineering decisions, entrepreneurship and the day-to-day implications of intellectual property. This course is a culmination of their undergraduate education and provides them with the opportunity to apply and develop their design, analytical, project management, interpersonal and communication skills through a team-based project.

Projects are completed as part of capstone design courses in each department. Students are encouraged to work in an interdisciplinary manner, with an integrated design seminar facilitating the exchange of ideas and talent from multiple disciplines. This exposes students to the kind of multidisciplinary teamwork they are likely to encounter in industry.

As their projects take form, student teams keep in touch 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. Students know their design must solve a real-world problem and work hard to achieve a high quality outcome.

As you read through this catalog and learn of the benefits of industry sponsorship, please consider becoming a senior design sponsor. The School recognizes the value of senior projects sponsored by industry and invites project sponsors — industry representatives and entrepreneurs as well as research and clinical faculty — to submit project proposals. This provides meaningful projects of value to the sponsor, and it instills a professional orientation in the student team. If you or your company is interested in sponsoring a project or to learn more, please contact:

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Novel Design of Vascular Clamp to Minimize Vessel Damage

DEPARTMENT OF BIOMEDICAL ENGINEERING

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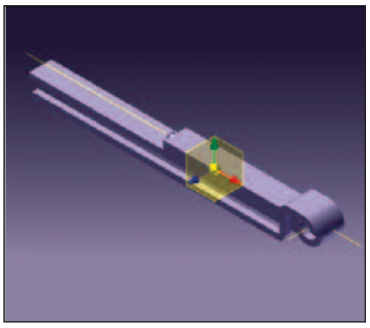
Project Adviser:
Dr. Colleen Brophy,
Vanderbilt University
Medical Center

Client:
Vanderbilt Vascular
Surgery Team

PROJECT DESCRIPTION

Complete occlusion of blood flow is necessary in a wide variety of surgeries, particularly vascular procedures, and is achieved by applying a clamp to the relevant vessels for a significant duration of the surgery. Current designs, which have not been modified in over 50 years, are harsh on the vessels and cause long-term endothelial and smooth muscle damage to the vessels they are used on contributing to future problems for the patient.



The new clamp design uses a round, inflatable surface to occlude the vessel.

Our project goal is to design a new vascular clamp with a focus on reducing vascular damage by altering the method of occlusion from simple clamping of metal surfaces on the vessel. We propose to do this by blocking flow using a circular, non-metal surface clamped on the vessel and inflated using a gas or sterile saline. The new design also aims to reduce training time necessary for surgeons to become comfortable with non-dominant hand control of the clamp. The new device should be equal or lesser in mass than current designs to reduce obstruction in the surgical field.

GOAL

- Design a new vascular clamp to reduce vessel damage and training time
- Create a working prototype and compare to current designs
- Make changes necessary for market viability

Abdominal Fascia Tension Measurement During Open Hernia Surgery

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Project Advisers:
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Medical Center

Dr. William Beck,
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Medical Center

PROJECT DESCRIPTION

Surgical intervention offers the only treatment for the more than five million Americans each year who develop hernias. However, excessive tension from the abdominal musculature can cause failure of the initial repair in nearly fifty percent of the surgical cases. This is especially true for larger hernias, which require open versus laparoscopic surgeries. Multiple painful corrective procedures follow that put the patients at greater risk for developing more hernias. No device currently exists for use in the operating room to quantify the in situ abdominal forces opposing closure of the hernia.

We propose the design of an instrument that can be used to numerically and objectively measure these transverse tensile forces across the fascia enveloping the musculature at multiple stages of the procedure. In conjunction with collection of future patient data, this will provide gastrointestinal surgeons with a tool for determining the tension levels at which surgical repair will be successful or require relaxing incisions. Implications also follow for its use during other surgical procedures requiring suture of two tissues experiencing opposing tension.

Along with the primary objective, the tensiometer should also be reusable, sterilizable, and easy to use. To this end, modification of currently implemented surgical clamps may be ideal. Calibration is necessary as the device must withstand up to 45 Newtons of force Data will be displayed on a simple user interface. It must be functional for use on hernias between about 3 and 20 centimeters in diameter and must minimize further damage of the musculature and underlying bowels

Football Helmet and Shoulder Pad System to Reduce Head Trauma by Mitigating Rotational Acceleration

DEPARTMENT OF BIOMEDICAL ENGINEERING

Team Members:
Douglas Browne **(ME)**
Jeffrey Markle
Tyler Severance

Project Advisers:
Dr. Jonathan Forbes, Vanderbilt University Medical Center

PROJECT DESCRIPTION

Over the past several years, American football has garnered significant publicity with regards to increasing amounts of traumatic head injuries. Helmet designers race to engineer helmets to further reduce translational acceleration, and thus generate better performance results for the standardized drop test – used to evaluate effectiveness of helmets. Unfortunately, new trends in helmet design fail to account for angular acceleration, which has been proven to cause strain in the blood vessels connected to the brain. Relative strain in these vessels leads to damage and rupture which can lead to catastrophic injuries in football collisions.

To address these issues, our team has created a helmet-shoulder pad system that would limit this angular acceleration and bring it back down to safer levels. This system involved spring loaded rotators connected to a modified butterfly collar. By incorporating this setup in three directions – one on each side, and one in the back – the athlete can still move his head in all directions, but will encounter resistance if the range of motion is too great or the impact velocity is too high. Additionally, the new setup will utilize an accelerometer to indicate when the athlete has undergone a severe collision and should receive medical attention. This will help avoid situations where minor injuries go untreated and become significant complications.

GOAL

- Study the effects of angular acceleration in football emulated collisions
- Improve existing helmet and shoulder pad design to create a new model to reduce the angular acceleration from collisions
- Develop a system to determine when a helmet has undergone a significant collision and the athlete should be examined by a professional

Ultrasound Imaging Capability for Surgical Drills

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Project Advisers:
Dr. Jadrien Young, Department of Otolaryngology, Vanderbilt University Medical Center

PROJECT DESCRIPTION

A mastoidectomy involves drilling through part of the mastoid bone of the ear and is performed primarily to insert cochlear implants and to treat anti-biotic resistant infections and mastoiditis. There are somewhere between 30,000 and 60,000 of these procedures performed annually in the United States. The goal of this project is to develop an intraoperative, detachable ultrasound device that will attach to existing surgical drills used by otologic surgeons performing mastoidectomies.

This would replace the current method of image-guided otologic surgery, which involves drilling a platform into the patient's skull and triangulating the position of the drill onto a preliminary CT scan. This new method of ultrasound imaging during otologic surgery will improve patient safety during otologic surgery, significantly reduce the time required for such surgeries and provide a new training tool for otologic surgeons.

The design goals of this project are two-fold. First, the device should calculate the thickness of the mastoid bone that separates the drill from vital structures, such as the facial nerve and semicircular canals. Second, the device should not interfere with the drill or require the surgeon to change their technique during the surgery.

Design of a Cochlear Implant Stabilization Device

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Project Adviser:
Paul King, Professor of Biomedical Engineering, Emeritus

Client:
Jaime Vernon
Songs for Sound

PROJECT DESCRIPTION

A cochlear implant (CI) is an electronic device that restores the ability to perceive and understand sound for people who suffer severe to profound hearing loss. There are two components of the CI – the internal (implanted) unit and the external unit (sound processor). The external unit sits on the wearers' ears where the unit picks up sound signals to be transmitted to the internal portion through a coil magnet that is held in position behind the ear.

Activities that quickly move the head around will cause the sound processing unit to come loose from the ear. The coil magnet is then dislodged from the head and all hearing is lost. Another problem is the possible damage caused by water. The most advanced processor in the market is the Nucleus 5 manufactured by Cochlear Ltd. It is water resistant and can be submerged in up to three feet of water for 30 minutes, but is not intended for swimming. Solving these problems can expand the range of activities of CI recipients. This project focuses on the external unit of the CI and the goal is to design a CI accessory that:

1) Stabilizes the external unit during periods of high activity (running, jumping, etc),
2) Waterproofs the external unit, and
3) Maintains the processor effectiveness and the comfort level of CI recipient

Lower Limb Prosthetic Socket Development

DEPARTMENT OF BIOMEDICAL ENGINEERING

Team Members:
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Amy Ostrowski

Project Adviser:
Aaron Fitzsimmons, The Surgical Clinic

PROJECT DESCRIPTION

The overall goal of our project is to develop a socket design for transtibial prosthetics that reduces force on predetermined high force areas on the limb. We will measure the forces using force sensing resistors that will be placed at the limb/socket interface at the pressure tolerant and pressure sensitive regions. We are testing with one patient to begin with and we will test the forces with three different liners while keeping the socket constant. We will then test three different feet that are commonly used while keeping the liner and socket constant.

Once we determine the foot and liner combination that produces the least amount of force, we will test various models of sockets. These sockets will be comprised of different materials that are commonly used, have varied soft and hard regions, and they will have different regions cut out while maintaining the same overall shape. This will allow us to determine the liner, foot, and socket combination that will produce the least amount of force and, therefore, grant the greatest amount of comfort to the patient. The socket fitting process is currently performed on a case-by-case basis and our findings will allow for a more uniform and efficient process while increasing patient comfort.

Flexible Stabilizing Arm for Ultrasound Probe

DEPARTMENT OF BIOMEDICAL ENGINEERING

Team Members:
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Project Advisers:
Dr. Rajnish Gupta, Department of Anesthesiology, Vanderbilt University Medical Center

Dr. Eric Briggs, Department of Anesthesiology, Vanderbilt University Medical Center

PROJECT DESCRIPTION

In the Department of Anesthesiology at Vanderbilt University Medical Center, localized pain management surgery is performed everyday with the help of ultrasound imaging. The problem is that the surgery requires three hands: one to insert a needle next to the nerve, one to hold an ultrasound probe, and one to thread the catheter. The only thing available to hold the ultrasound in place is another physician or technician. This can waste money and the resources of an employee whose services could be better allocated elsewhere. In order to fix this problem, we created a mechanical arm to aid in ultrasound guided surgery, which allows for free range of motion when the physician is finding the location to place the ultrasound. The arm then locks into place and becomes rigid once the ideal position has been located. Every clinic or hospital that does pain management or anesthesia will need one of these stabilization arms.

GOAL

- To research existing technologies in flexible stabilization arms and adapt a new idea around these existing ones
- To design a flexible arm with interlocking and flexible joints for use with ultrasound probes to aid in surgery
- To produce a working prototype for future modification and development

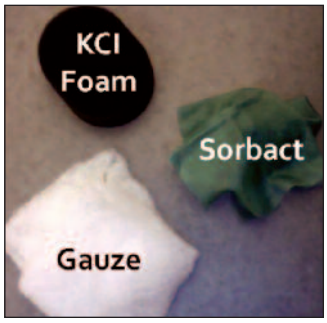
Determining Properties of Wound Dressings for Negative Pressure Wound Therapy

DEPARTMENT OF BIOMEDICAL ENGINEERING

Team Members:
Lora Aboulmouna
Ryan Frye
Lisa Lewicki

Project Adviser:
Josh Smith, Vice President, Pioneer Technology

PROJECT DESCRIPTION



Negative pressure wound therapy (NPWT) is the application of sub-atmospheric pressure to a sealed wound for the purpose of removing fluid and stimulating a cellular response through the mechanical stretching of wound tissue. This technique is used on chronic or poor healing wounds such as diabetic foot ulcers. The process of NPWT involves inserting a wound dressing into the wound bed, covering with a sealant drape, attaching a fluid drain tube and applying a vacuum. The wound dressings most often used in this technique are KCI foam and surgical gauze.

Pioneer Technology, a Nashville-based company aimed at creating eco-friendly solutions in wound care, has obtained the exclusive rights to a proprietary wound dressing known as Sorbact. Sorbact is a hydrophobic, wide-meshed material that has shown some promising results when used clinically in NPWT. However, the material properties of Sorbact, as compared to the other wound dressings, are unknown. Our goal is to design a series of experiments that allow us to determine the material resistance, flow rate, pressure gradient and saturation points pertaining to the three wound dressings in a controlled environment. This will ultimately help to determine if Sorbact is an appropriate option for a NPWT dressing.

Creation of a Cardiac Simulation Program

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Jacob Bauer
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Project Advisers:
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Dr. Jonathan Nesbitt, Vanderbilt University Medical Center

PROJECT DESCRIPTION

This project is created for the purpose of training medical students in cardiac surgery. A porcine heart is placed in a silicone well, and balloons are placed in the ventricles. Air is pumped into these balloons to mimic an actual heartbeat. Two computer screens will be used. One will display an ECG signal while the other will allow the user to change the heart rate in the pig heart. The ECG machine will reflect different ECGs representing different heart rates. The students need to notice when there is a change in the ECG and take preventative measures accordingly. To goal of our project is to provide a user interface which will allow for dynamic control of the heart rate and display and ECG reflecting different heart rates.

Endotracheal Tube Cleaning Device

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Matthew Sundermann
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Sarah Hodges

Project Advisers:
Dr. Neal Maynord, Monroe Carell Jr. Children's Hospital at Vanderbilt University Medical Center

Dr. Ty Berutti, Monroe Carell Jr. Children's Hospital at Vanderbilt University Medical Center

PROJECT DESCRIPTION

Ventilator Associated Pneumonia (VAP) is a major cause of prolonged hospital visits for patients in intensive care units, costing the average patient $10,000 or more in medical bills. The purpose of our device is to lessen the incidence of VAP through the sterilization of endotracheal tubes that are inserted in the trachea of the patient. Currently, endotracheal tubes are cleaned of bacteria growth only when the bacteria accumulation blocks the flow of air through the tube. This technique pushes bacteria into the trachea and has been linked to a possible cause of VAP.

Currently the only product available that hinders the growth of bacteria in endotracheal tubes is an applied silver coating on the interior surface of the inner tube. Our device allows the silver coated lining to be more effective by irradiating the inside of the tube with UV light. A UV light source located next to the patient's bed passes the UV light through a small bundle of fiberoptics to the endotracheal tube where it is reflected onto the walls of the tube to kill any bacteria present. The silver lining of the endotracheal tube then stops the light from reaching and harming the patient. The device is designed to be easy to use, requiring no additional training. We believe that this device could decrease the cost of care for many patients on mechanical ventilation by decreasing the likelihood of contracting VAP.

Lactate Sensor Design: A Novel Approach to Lactate Sensing

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Faculty Adviser:
Franz Baudenbacher, Assistant Professor of Biomedical Engineering

PROJECT DESCRIPTION

There is great need in the market for a Type-II Diabetes prescreening device and this lactate sensor is the perfect means for filling the void. Diabetes is a chronic and life-threatening illness that affects more than 170 million individuals worldwide with predictions at 300 million people by the year 2050. Not only can diabetes cause serious health problems, but there is not a prescreening device on the market that can accurately predict the onset of Type-II Diabetes. The current standard for diagnosing diabetes, the fasting blood glucose test, is only effective in diagnosing patients after the onset of diabetes in which prevention is no longer possible. However, this novel approach to lactate sensing utilizes the correlation between high lactate levels and the development of Type-II Diabetes, so that patients can accurately determine their risk of developing the disease and take steps to prevent it if necessary.

This device will in no way replace tests used to diagnosis Type-II Diabetes, but instead adds another level of screening and testing to current protocols so that patients can have earlier knowledge of diabetes indicators. This novel lactate sensor employs a hydrogel design that utilizes the directional change caused by swelling as well as a colorimetric assay to indicate specific lactate concentrations in the saliva that can then be correlated to the probability of developing diabetes. If the patients' lactate levels indicate a sufficiently high probability of the developing the disease, then they can affect lifestyle changes before the onset of the disease, effectively preventing the disease before it can become a serious problem.

Fiber Optic RS-OCT Probe

DEPARTMENT OF BIOMEDICAL ENGINEERING

Team Members:
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Project Advisers:
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Anita Mahadevan-Jansen, Professor of Biomedical Engineering

Client:
Vanderbilt University

PROJECT DESCRIPTION

Epithelial cancers make up about 85% of all cancers. Currently Chetan Patil, under the direction of Professor Mahadehaven-Jansen, has developed a novel medical probe that uses Optical Coherence Tomography (OCT) and Raman Spectroscopy (RS) in order to locate and detect epithelial cancer. OCT uses elastic light scattering to form real-time cross sectional 2-D images. RS uses inelastic scattering to differentiate between malignant and non-malignant tissues. Inherently, RS and OCT complement each other. The current design uses a combination of lenses and mirrors to create a bulky detection arm that inhibits the ease of use of the probe. Therefore, it is limited to detecting cancer in skin cells. In order to improve the facilitation of the detection arm and expand the breadth of detection to all types of epithelial cells, we developed a design to miniaturize the detection arm by using a fiber optic based system instead.

Our design involves combining two known methods for OCT and RS into one fiber optic probe. The first challenge we faced was developing a scanning technique for OCT in such a small area so that it does not interfere with Raman collection. The second challenge was the spatial co-registration of OCT and RS to ensure the area being detecting by OCT is the same area being sampled by RS. The OCT component uses a forward facing high voltage electrostatic scanning technique with one fiber serving as the light source and collection source. The RS component surrounds the center OCT fiber with the light source fiber on one side and the collection fiber on the other side of it.

GOAL

- Miniaturize current probe design using fiber optics
- Improve collection efficiency of Raman Spectroscopy
- Create functioning prototype

A Point of Care Diagnostic Device for Monitoring CD4 Levels in HIV Patients in a Resource Poor Setting

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Peter DelNero **(ChBE)**
Parker Gould **(EE)**
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Chris Madison **(BME/EE)**
Stephen Schumacher **(ChBE)**

Adviser:
Kevin Seale, Assistant Professor of the Practice of Biomedical Engineering

Client:
Vanderbilt Institute for Integrative Biosystems Research and Education

Systems Biology and Bioengineering Undergraduate Research Experience

PROJECT DESCRIPTION

The goal of this project is to design a point-of-care device and procedure to quickly and cost-effectively determine whether an HIV patient is a suitable candidate for antiretroviral treatment. To accomplish this, we propose a lab-on-chip device for quantifying the CD4 count in patient blood samples. The device will comprise a microfluidic platform for immunology and membrane-separation of white blood cells, coupled with a TRF imaging system to capture and quantify fluorescent signals. If successful, this device will facilitate the prescription and management of antiretroviral treatment in resource-poor settings. The primary objectives of this project are:

- Develop a lymphocyte capture membrane by polishing the bottom of microfabricated pyramidal wells to precise dimensions for blood separation.
- Design and fabricate a prototype microfluidic platform for mixing antibodies with blood samples and filtering lymphocytes through a membrane.
- Couple the microfluidic platform with the imaging system to quantify the fluorescent signal from CD4 antibodies.

Neonatal Chest Compression Device

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Jillian Zeber

Advisers:
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Paul King, Professor of Biomedical Engineering, Emeritus

MONROE CARELL JR. Children's Hospital at Vanderbilt

PROJECT DESCRIPTION

The purpose of the project is to design a device that will perform proper chest compressions on infants less than 30 days old weighing approximately three pounds (or less) while undergoing certain procedures performed on the chest and abdomen regions. The device will be applied directly below the nipples of a small infant and exert enough force on the chest to reduce the width of the child by one-third, just as a physician would do with his hands and thumbs. However, when other procedures are being performed on that area of the infant, there is too little surface space to get another set of hands in to do the compressions. Therefore, the device must occupy minimal space around the infant to be performed in conjunction with other procedures. The device will be composed of adjustable straps to fit infants of various sizes, a rigid back support and a force exerting component applied in place of a physician's thumbs.

Our developed device will:

- Be small but adjustable to fit the size of the baby
- Provide enough force (approximately 11 pounds) for sufficient chest compressions
- Maintain a rate of 80-100 compressions per minute

Bluetooth Stethoscope

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Project Adviser:
Andrew Cross, Biomedical Engineer II, Simulation Technologies Program

Client:
Center for Experiential Learning and Assessment

PROJECT DESCRIPTION

Simulation Technologies Program under Center for Experiential and Learning Assessment is a training program that involves feedback methods in which learners practice tasks and processes in real-life circumstances using models and or virtual reality with feedback from observers, peers, standardized-patients, and video cameras to assist improvement in skills.

The encountered problem during the training was the trainee can hear the breathing sounds from either lung compartments or the heart if and only if the stethoscope was placed right on top of the sound-producing speakers embedded in the mannequin. This is not the case in human body since breathing sounds can be heard anywhere near the lungs.

Development of applications for small low-power handheld devices such as mobile phones had intrigued us to develop an application that can be used by instructors to upload sound files from five different breathing sounds, heart sound, or desirable problematic breathing sounds to be evaluated by the trainee. The trainee will hear the sound through the stethoscope that receives the sound files via Bluetooth and come up with a diagnosis of the cause of the problem.

There is currently a single working mannequin available for us to assess its mechanical properties and design development in the simulation lab, which can produce all types of breathing and heart sounds needed to be heard by trainees.

GOAL

- To obtain a sleek and reliable design of Bluetooth stethoscope that allows the user to hear different heart and lung sounds from a mobile device.
- To create a compatible software that will accompany the Bluetooth stethoscope that allows users to upload breathing sound files stored in the mobile device into the application.
- To create a complete prototype of a Bluetooth stethoscope specific for mannequin-based training

Adaptable Retractor for Total Hip Replacement Surgery

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Adam Vandergriff
Sandra Wadeer
Brian Rappa

Project Advisers:
Dave Martinez, VP of Sales, Zimmer, Inc.

Dr. Michael Christie, Orthopedic Surgeon, Southern Joint Replacement Institute

PROJECT DESCRIPTION

Current retractors used in total hip replacement surgery, especially in overweight patients, are unsuitable for the orthopedic surgeon. Current retractors are narrow and unable to hold back adipose tissue that obstructs the surgeon's view in the incision window. Multiple retractors can be used to keep back adipose tissue, but this will also impede the surgeon's view, due to the number of surgical technicians that surround the patient, and will also cost the hospital additional money. The object of our project is to design an adaptable retractor system that consists of a retractor and an attachment piece that is able to:

- Effectively hold back the obstructive adipose tissue
- Increase the vision and work room for the surgeon
- Fit multiple patient sizes
- Reduce cost for the hospital

Implementation of Information Technology and Electronic Medical Records in Public vs. Private Hospitals

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Project Advisers:
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Ray Erlandson, VUSE Computer Systems Administrator

PROJECT DESCRIPTION

The Patient Protection and Affordable Care Act was signed into law March 2010, in an effort to make quality, affordable health care and health insurance more universally accessible in the United States. Part of the new legislation includes provisions for health care providers to convert from current paper methods to a system of electronic record keeping. This involves both electronic medical records, the legal record of what happened to the patient during a single experience, and electronic health records, a patient's complete medical history. The intent is to make medical records easier to access, manage, and share with other health care providers. This allows for faster, more accurate diagnosis and prevents complications like mixing medicines and allergic reactions.

The government has outlined seven stages in the process of converting technologies; starting with every hospital having the three main ancillary systems – radiology, pharmacy, and laboratory – and ending with closed loop medication administration and physician documentation in every department. These stages are supposed to be completed by every health care provider by 2014, at the risk of losing government funding for certain programs like Medicaid. The design team will design a procedural guide of the steps necessary to convert a hospital from its current IT practices to those required in the new health care legislation. Focusing on the emergency department, we plan to explain the automated factors that compare and contrast Vanderbilt, a public, not-for-profit organization, to HCA, an investor owned, for-profit organization.

Development of an Infrared Nerve Cuff Stimulator

DEPARTMENT OF BIOMEDICAL ENGINEERING

Team Members:
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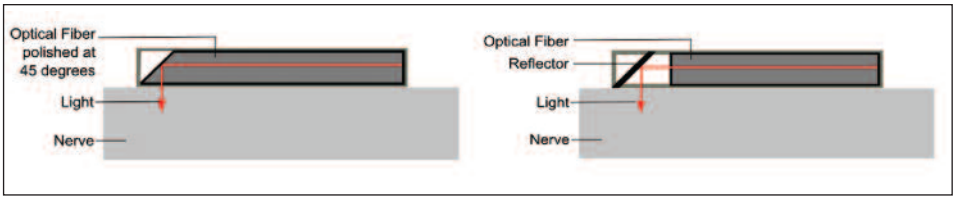
Melanie Gault

Project Adviser:
E. Duco Jansen, Professor of Biomedical Engineering

PROJECT DESCRIPTION

Recent scientific discoveries have found infrared laser light to be capable of neural stimulation. Unlike electrical stimulation, infrared stimulation has proven to be damage-free, artifact-free, and spatially selective (Wells, 2005). Furthermore, optical stimulation by an infrared laser does not require contact and has spatial selectivity that can precisely excite only one nerve (Izzo, 2006). Through a partnership with the Vanderbilt University Biomedical Optics Laboratory, the design team proposes to construct an infrared nerve stimulator cuff for implantation that can be used for treatment of neural disorders. We will perform initial proof-of-concept experiments and development of a large-scale prototype that contains optical fibers that lie in parallel with a nerve bundle and are capable of side-firing an infrared laser signal to stimulate neural activity in a spatially precise fashion. This design may be extended out to four channels that are wrapped around the nerve for spatially selective stimulation of nerve fascicles. The future implantation of a nerve cuff will lead to innovations that can be integrated in the next generation of prosthetic devices, and be used as long term therapeutic modalities for a wide variety of diseases including Alzheimer's disease.



Two single fiber prototypes. The figure on right shows a flat polished fiber with an angled mirror. The figure on the left shows a 45 degree polished fiber to allow side-firing of infrared light.

Portable Automatic Arm Blood Pressure Monitor Recalibration

DEPARTMENT OF BIOMEDICAL ENGINEERING

Team Members:
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David Lee
Haniff Nor **(ME)**

Project Adviser:
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Paul King, Professor of Biomedical Engineering, Emeritus

PROJECT DESCRIPTION

Hypertension is one of the most common diseases in the U.S. More than 75% of adults are suffering from hypertension. In order to fight this epidemic, close regulation on patients is strongly suggested. However, today's digital blood pressure monitor is not designed to be recalibrated. Thus a large amount of money will be put on repurchases of blood pressure monitors that will give accurate ratings for patient. In this design project, we are trying to design a method that can re-zero the digital blood pressure monitor. Our top three objectives are:

- Understand how digital blood pressure monitor works, not only specific to one brand but a general schematic working process, both mechanically and electronically.
- Design a re-zero or calibration method that will give the same reading as mercury sphygmomanometer.
- The calibration device can be attached or plugged into the digital blood pressure monitor and compatible with all digital blood pressure monitors.

Models for Axial Loading of Murine Long Bones

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Dr. Jeffry Nyman, Research Assistant Professor of Biomedical Engineering

PROJECT DESCRIPTION

Bone fractures are a painful and costly problem, and osteoporosis can cause an increase in their frequency. One of the contributing factors to osteoporosis is the loss of mechanosensitivity in bone. An understanding of the signaling mechanisms required for bone to adapt to mechanical loading may provide new avenues and targets for therapeutics, but preclinical animal models are needed. Another topic of interest when examining bone fractures is the structural strength of the femoral neck. In order to determine new therapeutic targets to increase fracture resistance, bones from genetically altered mice are harvested for biomechanical analysis. However, when testing the strength of the femoral neck there are difficulties in correctly positioning the mouse femur for a uniaxial, load-to-failure test. The purpose of our project is to design and calibrate testing fixtures that can successfully mechanically load a small bone in a physiological manner, so that we may test the strength of the murine femoral neck and apply dynamic loads to the tibia of live mice.

GOAL

- Design, test, calibrate, and utilize two systems for axial loading in murine long bones, specifically the femur and tibia.
- Determine whether murine femoral neck strength is compromised in mice with Perthes disease.
- Determine the requirement of the gene Sirt1 in osteocytes for the mechanical response to axial loading in murine long bone.

Digital Craniometer Design

DEPARTMENT OF BIOMEDICAL ENGINEERING

Team members:
Cody Hall
Jorge Perez
Chris Heelan

Project Adviser:
Bob Galloway, Professor of Biomedical Engineering

PROJECT DESCRIPTION

The purpose of the project is to measure the necessary dimensions of an infant's head in order to determine if they are developing plagiocephaly. These measurements include two linear distance measurements (combined to calculate a ratio) and an angular measurement (indicating alignment of the ears relative to the mid-line of the head). If the values of these measurements pass certain thresholds, the pediatrician will recommend the infant to a specialist. To accomplish this goal, we will be creating an iPhone application to be used by pediatricians. The device will utilize the camera API, allowing the user to take a new picture or load a previously taken picture. Once the picture is loaded, markers will appear giving the user the ability to drag these markers to the positions on the head that the doctor will like to measure (placement differs depending on whether the ratio or angle calculation is needed). In 'Ratio-mode', the application will take into account the ratios of the diagonal distances across the head along with the angle from the mid line. A ratio will be calculated and will be displayed as an output to the doctor. Likewise, in 'Angle-mode' the application will calculate the angle between the lines designating the mid-line and the ear-line. The angle will be displayed as an output. With the ratio and angle values, the pediatrician can determine if the infant should seek a specialist's help.

Neurocognitive Screening for POCD via the iPad

DEPARTMENT OF BIOMEDICAL ENGINEERING

Team members:
Sarah Waring
Emily Whitaker

Project Adviser:
Dr. James Blair, Anesthesiology, Vanderbilt University Medical Center

PROJECT DESCRIPTION

Our goal is to create a program for the iPad that will be used to administer up to three neurocognitive tests to elderly patients before surgery in order to assess their risk for post operative cognitive dysfunction (POCD). Each test should be in a user friendly, simple, touch screen format. Since each of the tests being considered – the Stroop Color Word Test, the Hopkins Verbal Learning Test - Revised (HVLT-R), and the Wechsler Adult Intelligence Scale (WAIS-III) Digit Symbol test – has already been successfully adapted for computer-based administration by other parties, we should be able to successfully program them to support the collection of data to potentially indicate patient risk.

Purification of Wastewater from the Microelectronics Industry

DEPARTMENT OF CHEMICAL AND BIOMOLECULAR ENGINEERING

Team members:
Kate Woodburn
Katie Lammers
Morgan Knapp
Julianne Landry

Project Adviser:
Kenneth A. Debelak, Associate Professor of Chemical and Biomolecular Engineering

PROJECT DESCRIPTION

The amount of wastewater produced by the semiconductor industry has recently come under strong environmental scrutiny. Microelectronic processes consume millions of gallons of water daily to rinse microscopic dirt and chemicals from the surface of chips. Land disposal of these types of waste are prohibited unless they are pretreated to Best Demonstrated Available Technology standards. Current emphasis is being placed on reducing the amount of waste produced.

Until a more suitable means of production is established, the waste stream must be treated. There are several different waste streams that are produced throughout microelectronics manufacturing processes. When considered individually, these wastes are fairly typical and easily treatable.

Due to ongoing research to determine the best way to treat the waste, the individual streams are sometimes combined and stored. It is required to design a plant to clean 15,000 gpd of the following waste stream from a wafer fabrication/computer manufacturing facility:

Cu	120 mg/L	as Cu
Pb	20 mg/L	as Pb
Sn	20 mg/L	as Sn
Oil and grease	250 mg/L	
Suspended solids	650 mg/L	
(suspended copper, fiberglass,		
bentonite clay, etc.)		
Acids		
Fluoroacetic Acid	100 mg/L	
Fluoroboric Acid	300 mg/L	
Acetone	350 mg/L	
EDTA	120 mg/L	
Methyl Methacrylate	200 mg/L	
Ammonium Hydroxide	200 mg/L	
Formaldehyde	50 mg/L	
Methanol	200 mg/L	
Hardness	150 mg/L	as CaCO3

Alaskan Natural Gas to Liquid (GTL) using Microchannel Reactors

DEPARTMENT OF CHEMICAL AND BIOMOLECULAR ENGINEERING

Group 1 team members:
Doug Denniston
Noel Zulkifli
Fares Alzahrani

Group 2 team members:
Alex Rothman
Katie Kirkland
Caitlyn Cox
Elizabeth Ammarell

Group 3 team members:
Nur Nabila Abdul Hamid
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Project Adviser:
Kenneth A. Debelak, Associate Professor of Chemical and Biomolecular Engineering

PROJECT DESCRIPTION

The development of technology to convert methane to useful hydrocarbons has been escalating in recent years. This family of technologies – designated as Gas to Liquids or GTL – can target a variety of end products, such as methanol, gasoline or diesel fuel. As of today, most of the natural gas produced by oil wells in remote locations – sometimes referred to as stranded gas – is wasted. As a result, a premium is put on technologies most easily adapted to hostile environments.

For most technologies the first step is the steam reforming of methane into a mixture of mostly CO and H2 – usually called syngas. The syngas is then converted to a useful liquid, such as methanol, gasoline or diesel fuel in a catalyzed synthesis reaction. Our client is a major oil company that is exploring technology options in this area. We have been asked to evaluate a promising technology that offers the possibility of a compact plant through the use of microchannel technology.

Butanol by Two-Stage Fermentation

DEPARTMENT OF CHEMICAL AND BIOMOLECULAR ENGINEERING

Team Members:
Nate Martin
Jose M Garza
Nurhidayah Md Shukor
(Mia) Nor Amirah Farhana Nawawi

Project Adviser:
Kenneth A. Debelak, Associate Professor of Chemical and Biomolecular Engineering

PROJECT DESCRIPTION

Prior to the advent of the petrochemical industry, which made the process uneconomical, acetone, butanol and ethanol were produced together by fermentation using one of several Clostridia strains. With the growth in interest of biofuels and the increase in price of petrochemicals, fermentation routes to butanol are being revisited by several parties.

Butanol is an excellent biofuel, with many advantages over the incumbent biofuel, ethanol. It has higher fuel value, meaning more miles per gallon. It can be blended to higher levels without requiring engine modifications. It has lower vapor pressures than ethanol and comparable octane number.

Students are to design a process to convert corn to make 50MM gallons per year of butanol in the U.S. Corn Belt. Corn costs $4.00/bushel (56 lbs). Butanol can be sold, according to marketing forecasts, for $4.00/gal. As in the ethanol process, unfermented corn is dried and sold as an animal feed coproduct, called DDGS, for $150/dry ton. Prices are in 2009 dollars. Due to the wild swings in corn prices, the design team will want to determine the sensitivity of economics to the corn price. Determine the maximum royalty that you can pay to ButylFuel LLC, in cents per gallon of product, and still earn a 12% IRR on the investment. This will help guide your negotiating team in setting license terms.

Production of R-134a

DEPARTMENT OF CHEMICAL AND BIOMOLECULAR ENGINEERING

Group 1 team members:
Alex Trzeciak
Matt Irwin
Edward Buehler

Group 2 team members:
Nurfadhila Rozlan
Aliya Anhar
Nurbahirah Ibrahim
Mawarni Mohamad

Faculty Adviser:
Kenneth A. Debelak, Associate Professor of Chemical and Biomolecular Engineering

PROJECT DESCRIPTION

In the 1930's, chlorofluorocarbons (CFC's) were developed as a supposedly safe alternative to ammonia and sulfur dioxide refrigerants. While sulfur dioxide is toxic and ammonia is both toxic and highly flammable, CFC's were found to be nonflammable, nonexplosive and noncorrosive. CFC's quickly became the compounds of choice for refrigeration as well as for cleaning and foam blowing agents. The discovery of a hole in the ozone layer over Antarctica in 1985 led to a movement to reduce the use of CFC's. Due to their high ozone depleting potential, CFC's were scheduled to be phased out completely by 1996.

This led to the need to find alternative refrigerants that are not ozone depleting substances. Some experts have suggested the use of hydrochlorofluorocarbons (HCFC's) for this use. Unfortunately, HCFC's also have some ozone depleting potential, and are scheduled to be banned by 2030. With this in mind, one replacement for CFC's in refrigeration is CF3CH2F (R-134a).

R-134a is very attractive as a refrigerant because it has zero ozone depleting potential as well as a low direct global warming potential. One factor limiting the use of R-134a had been the fact that conventional lubricants are not miscible with R-134a. However, new lubricants have been developed which allow R-134a systems to run efficiently and reliably long-term. This, along with the need to find refrigerants with a low ozone depleting potential, will greatly increase the market for R-134a in the future. Student team members have been asked to design a process to produce 10,000 metric tons per year of R-134a.

A Low-Cost Point-of-Care Diagnostic Device for Analysis of CD4/CD8 Ratio in HIV Patients

DEPARTMENT OF CHEMICAL AND BIOMOLECULAR ENGINEERING

Team Members:
Rosie Korman **(BME)**
Chris Madison **(BME/EE)**
Parker Gould **(EE)**
Lina Aboulmouna
Peter DelNero
Stephen Schumacher

Faculty Adviser:
Kevin Seale, Assistant Professor of the Practice of Biomedical Engineering

PROJECT DESCRIPTION

The goal of this project is to design a device and procedure to quickly and cost-effectively determine whether an HIV patient is a suitable candidate for anti-retroviral treatment. The primary design goals are to make the device cost less than two dollars per test, to make the device able to function with low electrical power, to make the device operable by technicians with minimal training, and to make the device able to return test results within minutes. The device must be able to contain hazardous materials and be reusable over several uses, meaning it must incorporate biohazard containment and cleaning procedures into the design. The team members have outlined a preliminary study of the device components below:

- A finger stick of blood is obtained using existing technology, such as that used by diabetes patients.
- The blood is deposited in a reservoir and pumped into the device using a hand-cranked micro-pump.
- The blood is mixed with fluorescently labeled anti-CD4/CD8 antibodies in a microfluidic mixer.
- The sample is filtered through a plane of pyramidal-shaped wells. The bottoms of the wells are polished, leaving a 5um hole to capture white blood cells while draining all other blood components.
- The filter is backlit using a mirror and sunlight. The signals from fluorescent labels are amplified by the mirrored walls of the wells.
- A CCD camera records the fluorescent signal and assigns each well to a block of pixels.
- A computer program (perhaps executed on a phone) calculates the ratio of each fluorescent label to determine the CD4/CD8 ratio. This is the basic diagnostic value used to determine whether a patient is a suitable candidate for treatment.

The motivation for this project stems from a Gates Foundation initiative for a low-cost, point-of-care device to replace flow cytometry in identifying suitable candidates for anti-retroviral treatment.

Glycerol to Ethanol

DEPARTMENT OF CHEMICAL AND BIOMOLECULAR ENGINEERING

Team members:
Matthew DeVito
Katie Schier
Cameron Kheradi
Zira Mohd Aini

Faculty Adviser:
Kenneth A. Debelak, Associate Professor of Chemical and Biomolecular Engineering

PROJECT DESCRIPTION

Glycerol is a byproduct of biodiesel manufacture, with relatively few industrial uses. As the production of biodiesel increases, the price of glycerol is expected to continue to decrease. A team of researchers recently isolated a naturally occurring E. coli, code-named VU09, that will ferment glycerol to ethanol and a small amount of succinic acid. Ethanol is in high demand for transportation fuel, and succinic acid is a high-value specialty chemical.

The team members have been asked to determine whether this technology could be commercially successful, using the following assumptions, determined by their research director. They will design a plant that will make 50MM gallons per year of fuel ethanol using this technology and estimate the economics.

Polyethylene Terephthalate Recycling Facility

DEPARTMENT OF CHEMICAL AND BIOMOLECULAR ENGINEERING

Team Members:
Cole Carlson
George Sunderland
Brian Hassett
Dalilah Zainal

Faculty Adviser:
Kenneth A. Debelak, Associate Professor of Chemical and Biomolecular Engineering

PROJECT DESCRIPTION

Currently, there is considerable concern about materials "running out," and a renewed intent in conserving natural resources and increasing recycling. As landfill space runs out, recycling is also becoming increasingly attractive. This project concerns the recycling of polyethylene terephthalate (PET) bottles, typically used in the soda and bottle water industries. PET is the main constituent in a variety of consumer and industrial products including plastic fibers, videotape, audiotape, film, engineered resin, food containers and beverage bottles. In 1997, approximately 2.5 billion pounds of PET were available for recycling. Only 22.7%, or 580 million pounds, of the available PET is reclaimed yearly, thus allowing for potential market growth. This process is based on a patent for recycling of film consisting largely of PET. The goal is to determine if this process could be applied to PET bottles and be profitable.

Coal to Methanol

DEPARTMENT OF CHEMICAL AND BIOMOLECULAR ENGINEERING

Team Members:
Nabi Nizamidin
Thomas Shattuck
Peter Tomlin

Faculty Adviser:
Kenneth A. Debelak, Associate Professor of Chemical and Biomolecular Engineering

PROJECT DESCRIPTION

The rapid rise and sustained high price of crude oil and the continuing increase in demand for chemical feedstocks fueled by double digit economic growth in the Asia-Pacific region have stimulated a world-wide industrial hunt for alternate sources of energy and chemical feedstocks. The United States has more energy reserves in the form of coal than Saudi Arabia has in oil. Experts estimate that the U.S. has about 265 billion tons of coal reserves. This vast amount of coal makes the U.S. the world leader in known coal reserves.

The production of methanol from available U.S. coal deposits has been presented as a feasible method for storing energy and a convenient intermediate for the chemicals industry. In fact, the expanded utilization of methanol has been suggested as a foundation meeting future energy needs and requirements (Beyond Oil and Gas: The Methanol Economy, Wiley, 2006).

Your company wants to complete a technical and economic evaluation of a potential project to design, construct and operate a new global-scale methanol production facility on the Texas Gulf Coast, using coal as the primary raw material and coal gasification as the coal conversion technology. The results of your work will be considered as a primary input to the company senior leadership in deciding whether or not to proceed with developing, authorizing, and executing the proposed project. The objectives of the students work are to provide a preliminary design for a coal-to-methanol process and determine the economic feasibility of the project.

Smyrna Water Treatment System

DEPARTMENT OF CHEMICAL AND BIOMOLECULAR ENGINEERING

Team Members:
Stephanie Bruse
Craig Bullington
Jennifer Green
Mallory Smyth

Faculty Adviser:
Kenneth A. Debelak, Associate Professor of Chemical and Biomolecular Engineering

PROJECT DESCRIPTION

Our group will design and evaluate the economics of a process that will help the Town of Smyrna Water Treatment Plant to treat water that comes from the J. Percy Priest Reservoir in Smyrna, Tenn. Our goal in our design is to address the Smyrna plant's chief concern, that the quality of their water is decreased during regular periods of seasonal turnover. We will be designing a process to reduce the high levels of hardness, manganese, hydrogen sulfide and carbon dioxide in the drinking water produced by the plant during these seasonal peaks.

The Smyrna plant was built in 1961 to treat water year-round from the reservoir, and it underwent expansions to its facilities in the late 1960s and again in the 1990s. To treat its water, the plant uses common water purification techniques such as conventional flocculation, sedimentation, and mixed media filtration. The plant also uses potassium permanganate to oxidize iron and manganese in the water, and an aerator installed at one of the raw water intakes removes much of the carbon dioxide and hydrogen sulfide present in the lake water already.

However, even with the existing water purification systems, the Smyrna plant still receives many complaints about the hardness (a high concentration of calcium and magnesium ions) and manganese content (a secondary contaminant that affects taste and color) of the drinking water produced at the plant. We will focus our design on reducing the levels these contaminants.

Recent chemical and biomolecular engineering students identified an application that would utilize the glycerol produced by Vanderbilt's small biodiesel processing facility eliminating the need for its disposal.

Implementation of Renewable Energy Solutions in Developing Communities

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Team Members:
Leslie Labruto
Jessica Canfora
Lee Hopkins

Project Advisers:
Jay Harrison, P.E.
Ed Wansing, AIA

Client:
Architectural Energy Corporation
www.archenergy.com

PROJECT DESCRIPTION

Architectural Energy is requesting that Vanderbilt civil engineering students develop an implementation strategy for an energy harvesting device designed by Lipscomb University students in Nashville, Tenn. The device created is a pico-hydroelectric generator that will generate power through cost-effective technology. The assessment is to take place in the Ulpan Valley region of Guatemala in conjunction with Project Ulpan. The students will be required to:

- Analyze local resources based on previous data acquired and determine if the current design model is sustainable
- Understand cultural and governmental norms
- Survey current energy usage in the Ulpan Valley
- Create topographic map through surveying techniques
- Examine design alternatives to the current alternator such as a water wheel
- Apply fluid mechanics/water resource knowledge to determine location for generator
- Develop economic analysis to see sustainable outlook
- Assess the impact of the technology and how it can foster sustainable educational growth

2011 Vanderbilt University Concrete Canoe – Army Dore

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Team Members:
Anna Fargo
Michael Mensing
Sean Fitzpatrick
Scott Moskowitz

Project Adviser:
Lori Troxel, P.E., Associate Professor of the Practice of Civil and Environmental Engineering

Client:
American Society of Civil Engineers (ASCE) Concrete Canoe
www.cee.vanderbilt.edu

PROJECT DESCRIPTION

Vanderbilt University is requesting that engineering students submit a proposal for the design, construction, presentation and competition of a concrete canoe. All phases shall meet the requirements of the 2011 ASCE Concrete Canoe Design Competition and the Vanderbilt University Civil Engineering Department. Project scope includes:

- Develop the mold, reinforcement, concrete mix, fabrication and finished surface for a concrete canoe.
- Develop a safety program for mixing concrete, fabricating the canoe, finishing the surface and racing the canoe.
- Develop a detailed schedule.
- Calculate total costs including reinforcement, mold, additives, transportation and finishing.
- Calculate maximum stresses and buoyancy.
- Fabricate the canoe according to ASCE and Vanderbilt rules.
- Make an oral presentation, display the canoe and race at the 2011 ASCE Southeast Regional Student Conference.

2011 Vanderbilt University Steel Bridge

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Team Members:
Bradley Montgomery
Jamie Kaplan
Courtney Rhodes
Ross Muirhead

Project Adviser:
Lori Troxel, P.E.,
Associate Professor of the Practice of Civil and Environmental Engineering

Client:
AISC Steel Bridge
www.cee.vanderbilt.edu

PROJECT DESCRIPTION

Vanderbilt is requesting that engineering students submit a proposal for the structural design, fabrication and erection of a scale model of the river crossing. The proposed location of the project is a river crossing. The design will use steel as the structural material. All phases shall meet the requirements of the 2011 AISC Steel Bridge Design Competition. Project scope includes:

1. Develop 3 preliminary designs showing steel layout, sizes and fabrication costs.
2. Develop a safety program for fabrication and erection.
3. Final design shall consist of:
   - Design of beams, columns, base plates and connections.
   - Construction sequencing.
   - Design and construction schedule.
   - Cost estimates.
   - Fabrication techniques.
   - Provide detailed structural drawings for fabrication of bridge.
4. Fabricate the bridge
5. Erect the bridge according to AISC and Vanderbilt rules.

Civil Engineering Land Development – Cleghorn Avenue Project

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Team Members:
Lauren Tamarkin
Afnan Mansoor
Michael Semeraro, III
Ashley Bekerman

Project Advisers:
Anna Maddox, P.E.
Daniel Barge III, P.E.

Client:
Barge Cauthen & Associates
www.bargecauthen.com

PROJECT DESCRIPTION

The proposed project, located at Cleghorn Avenue in Green Hills, entails designing the site to incorporate a two-story mixed-use building with corresponding surface parking and a circulation route to properly serve the site. The site will require new water, sanitary sewer lines and storm drainage. Project scope includes:

1. Development of two preliminary site layouts showing arrangement of building with vehicular parking, loading docks and truck access. The owner will approve the layout for final design for submittal to the Metropolitan Planning Commission for compliance with Metro's Zoning Ordinance.
2. Design the final layout including the following:
   - Verification of site circulation for automobiles and delivery and fire trucks
   - Development of utility plans
   - Development of grading plans, including critical spot elevations
   - Development of erosion control plans
   - Hydrologic and hydraulic analyses
   - Drainage design
   - Water quality design
   - Detention design
3. Develop cost estimate for infrastructure improvements

Woodlawn Water Treatment Plant

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Team Members:
Brian Kearney
Nathan Presmyk
John Ramsay Bellinger

Project Adviser:
Bill Hamilton, P.E.

Client:
Barge Waggoner
Sumner & Cannon
www.bargewaggoner.com

PROJECT DESCRIPTION

The Woodlawn, Tennessee Utility District is requesting a proposal from engineering students for the design of a new water treatment plant. The new facility must provide high quality water to meet anticipated demands of the District's customers, and to address current and foreseeable regulatory requirements. The scope of work will consist of the following:

1. Perform population projections and design demand calculations for a suitable design life.
2. Evaluate potential site locations and make recommendations for final site location
3. Provide a process flow diagram for the proposed treatment plant and indicate any modifications necessary to integrate into the existing distribution system.
4. Model system hydraulics to evaluate connection points and system storage.
5. Prepare a complete hydraulic profile, integrating existing system and new treatment units.
6. Provide plant footprint and piping diagrams for the water treatment plant.
7. Specify required chemical addition and pumping needs for the new treatment units.
8. Provide opinion of probable construction cost based on equipment manufacturer quotations and other factors from Means Estimating documentation or similar reference.
9. Provide preliminary engineering report (including hydraulic calculations) for submission to Tennessee Department of Environment and Conservation-Division of Water Supply in accordance with the Division's design criteria for community public water systems.

Newpaper Effluent Study

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Team Members:
Nicole Gayda
Bryn Pittinger
Nick Brunson

Project Adviser:
T. Houston Flippin, P.E.

Client:
Brown and Caldwell
www.brownandcaldwell.com

PROJECT DESCRIPTION

NEWPAPER, Inc. (NEWPAPER) owns and operates a pulp and paper mill in western Tennessee. The mill is under administrative order by the Tennessee Department of Environment and Conservation (TDEC) to meet the current discharge limits specified in their NPDES permit to discharge to Knob Creek. Per the Administrative Order, a preliminary engineering report must be submitted to TDEC detailing a plan for meeting the permit limits.

NEWPAPER is requesting that the students prepare for a technology evaluation and conceptual design for modifications to their current wastewater treatment system that would allow them to meet the effluent limits. It should be noted that per NEWPAPER company policy, all facility modifications should be accompanied with a memorandum detailing the impact on greenhouse gas inventory and water footprint made available to shareholders. The students are required to perform the following tasks:

1. Perform a technology evaluation of all known and demonstrated treatment systems and assess which of these could allow the NEWPAPER Tennessee mill to meet the discharge limits.
2. Perform an alternatives analysis for the technology/treatment processes shown in Task 1 to viably meet the limits.
3. Develop a conceptual design for the chosen alternative including the following:
   - General layout
   - Block flow diagrams
   - Major equipment list, sizing, and electrical load
4. Develop conceptual level capital and operational cost estimates.
5. Prepare preliminary engineering report summarizing Tasks 1- 5 to be submitted to TDEC as required by the Administrative Order.
6. Submit a memorandum discussing the impact of the conceptual design on the Mill's GHG inventory and water footprint.

Kuwahee Wastewater Treatment Plant Aeration System Upgrade

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Team Members:
Dylan Bunch
Tyler McCoy
Kate Martin

Project Advisers:
Katie Bell, P.E.
Stephen King, P.E.

Client:
Camp Dresser & McKee
www.cdm.com

PROJECT DESCRIPTION

The Kuwahee WWTP is an advanced wastewater treatment facility originally constructed in the 1950s to serve residential, commercial and industrial customers. The facility underwent a major expansion and upgrade in the late 1970s. The plant is designed to provide advanced secondary treatment to an average daily flow of 44 million gallons per day (mgd) with a maximum sustained daily flow of 70 mgd. A recent comprehensive facility plan update included major recommendations to integrate sustainable components, with the goal of lowering energy consumption and life-cycle costs to offset rising energy costs and improve treatment operations.

The Knoxville Utilities Board (KUB) is requesting that students provide an engineering alternatives evaluation, design, bidding and construction services related to implementation of aeration system upgrades at the Kuwahee WWTP. The students will be required to:

1. Collect and review data from the facility necessary for developing the basis of design for aeration system upgrades.
2. Obtain equipment proposals from vendors that manufacture different blower technologies and develop construction costs, annual operating and maintenance costs, and lifecycle costs for each blower type evaluated.
3. Accompany Kuwahee WWTP staff to on-site visits and use information gathered during site visits to develop a non-cost factor evaluation of the systems evaluated.
4. Based on the results of Tasks 3 and 4 make recommendations to KUB on the preferred system and develop final engineering design drawings of the preferred system.
5. Develop bid and construction documents.
6. Provide construction, startup and system acceptance for the selected system.

Land Development and Engineering Services – Hurstbourne Park

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Team Members:
Cole Hunt
Jacquelin Lopez
Gennadi Kaboulov
Julia Litchford

Project Adviser:
Mike Hunkler, P.E.

Client:
Gresham Smith & Partners
www.gspnet.com

PROJECT DESCRIPTION

Gresham Smith & Partners is requesting that the students prepare a proposal to design utilities, drainage, and transportation infrastructure for a 132-lot single family subdivision in Franklin, Tennessee. Engineering services are required in the areas of transportation planning, water distribution engineering, sanitary and environmental engineering, and hydrology. The initial phase of the project will include a due diligence report for all utilities, a traffic study and a conceptual infrastructure plan consistent with the layout provided by the developer's land planning consultant. Working in conjunction with the developer's land planning consultant, the team will perform the following tasks:

1. Design a water distribution system with required fire fighting capabilities.
2. Design a sanitary sewage system including any associated pump stations and force mains.
3. Design a storm water drainage system and associated storm water detention and storm water quality treatment.
4. Evaluate traffic generation as well as impact on adjacent road network capacities.
5. Recommend needed improvements.
6. Develop construction cost estimates for the infrastructure improvements.
7. Prepare application packages for grading and environmental permits.

Structural Design of an 8-Story Medical Office Building

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Team Members:
Kari Matulewicz
Lizzie Young

Project Advisers:
Sean B. Smith, P.E.
Bryan Tharpe, P.E.

Client:
Gresham Smith & Partners
www.gspnet.com

PROJECT DESCRIPTION

The proposed project is a new high profile 8-story medical office building adjacent to Interstate 65, in Nashville, Tenn. The structure will be comprised largely of glass and structured utilizing composite steel framing and steel moment frames to resist lateral forces. A geotechnical investigation has been preformed indicating a shallow foundation system consisting of soil bearing spread footings will be necessary to support the structure above. The team will be required to perform the following:

1. Prepare a code analysis report indicating required design dead, live, snow, wind and seismic load criteria. Code references shall be included. Serviceability requirements, including dead and live load deflections, wind drift limits and seismic drift limits shall be included in the support.
2. Perform the necessary calculations using the load criteria defined above to determine the required gravity and lateral design loads for the beams, girders, columns and foundations.
3. Using the provided structural floor and layouts, design all primary gravity members.
4. Design the steel moment frames per the locations shown on the provided plans.
5. Design the shallow spread footings.
6. Develop a cost estimate based on the design structural steel and concrete quantities.
7. Prepare engineering drawings to convey the design information above.

Land Development and Engineering Redesign of Franklin Public Housing Complex

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Team Members:
Paul Marshall Ticer
Muhammad Nasaruddin
Christopher Oben
Lorin Jaeger

Project Advisers:
Lennie Arnold, P.E.
Adam Crunk, P.E.

Client:
Littlejohn Engineering Associates
www.leainc.com/

PROJECT DESCRIPTION

The project shall consist of the site development for the Franklin Housing Authority Reddick Street Redevelopment located in Franklin, Tenn. Services shall consist of the following elements:

1. Site due diligence to determine the feasibility of constructing this product on this site. This shall include investigating existing zoning, surrounding infrastructure and regional storm water requirements.
2. Preparation of Engineering Drawings, to consist of the following:
   - Design of finish contours for grading the site, including critical spot elevations.
   - Design surface and subsurface drainage systems, denoting the size and invert elevations of structures as appropriate.
   - Site layout plan locating the building on the site and providing geometry for the layout of roadways, parking areas and walkways.
   - Site utility plan locating water and sanitary sewer services to the building envelope.
   - Site details appropriate for the referenced project including, but not limited to, storm sewer structures, headwalls, curb details, flumes, pavement details and concrete walkways.
3. The design of a storm water detention facility that will limit the post-development peak runoff rate to less than the pre-development runoff rate.

Structural Design of Art Circle Public Library

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Team Members:
Jeremy Luther
Nathan Wright
Derrick Pugh, Jr.

Project Advisers:
Elizabeth Surface, P.E.
Randall Wilson, P.E.

Client:
Ross Bryan
Associates, Inc.
www.rossbryan.com

PROJECT DESCRIPTION

The proposed project is a library in Crossville, Tennessee, just off the town square. The new two-story library building with a connecting one-story meeting room, clad in crab-orchard stone and brick. The building will consist of a two-story atrium in the center of the library space and a grand, monumental stair leading to the main reading rooms on the second floor. The children's area is being designed around a country fair theme. The structure will be comprised largely of structural steel framing and steel moment frames to resist lateral loads caused by seismic and wind forces. A geotechnical investigation has been performed indicating a shallow foundation system consisting of spread footings will be adequate for supporting the structure. The students are required to perform the following services:

1. Prepare a code analysis report indicating required design dead, live, snow, wind, and seismic load criteria. Code references shall be included. Serviceability requirements, including dead and live load deflections, wind drift limits and seismic drift limits shall be included in the report.
2. Perform the necessary calculations using the load criteria defined above to determine the required gravity and lateral design loads for beams, girders, columns and moment frame elements.
3. Using the provided structural floor and roof layouts, design all typical gravity members.
4. Design steel moment frames per the locations shown on plans.
5. Design typical spread footing foundations.
6. Develop a cost estimate based on design structural steel and concrete quantities.
7. Prepare engineering drawings to convey the design information.

Cumberland Northeast Pedestrian Bridge

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Team Members:
Anne Hopkins
John Fontaine
Drew Hauser
Brittany Shepherd

Project Advisers:
Ken Diehl, P.E.
Bo Butler, P.E.

Client:
Smith Seckman Reid, Inc.
www.ssr-inc.com

PROJECT DESCRIPTION

The project is a proposed pedestrian/bicycle bridge connecting the Neuhoff complex (six blocks north of the Metro Nashville Courthouse) on the west bank of the Cumberland River to the proposed Cumberland Northeast Park on the east bank of the river. The bridge will provide a link from the Germantown area to new open space and recreation on the east bank. The proposed bridge will be approximately 950 feet in length and have a deck width of 14 feet. Citizens have expressed interest in the bridge being an iconic design element throughout the river front viewshed. The team of students will be required to design the bridge to meet the following requirements by providing the following services:

1. The bridge must facilitate joint use by cyclists and pedestrians.
2. The bridge must be accessible as defined by the Americans with Disabilities Act.
3. Identify and provide copies of required environmental documentation including: any and all analyses, documents, applications, fees and submissions required to obtain, federal, state, and local environmental permits for the project. This shall include compliance with EPA, TVA, U.S. Army COE, FEMA, Metro Public Works, and Metro Parks & Recreation requirements or permits.
4. Development of two preliminary bridge concept designs for Owner's approval before proceeding to final design. Concept should show treatment of connections to pedestrian trails at each end of the bridge. Connection points at either end can be taken from existing GIS information.
5. Design should include the deep foundation members.
6. Prepare final engineering drawings to convey the design of the bridge.
7. Develop a cost estimate based on the final design of the pedestrian/bicycle bridge

Metro-Nashville Traffic Safety Study and Improvements

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Team Members:
Samuel Betten
Denise Smith
Lucas Muller
Oliver Kuntz

Client:
RPM Transportation Consultants, LLC
www.rpmtraffic.net

Project Adviser:
Amy L. Burch, P.E.

PROJECT DESCRIPTION

A detailed crash study is requested to evaluate four intersections in Metro-Nashville with known safety concerns. The four study intersections are as follows:

1. 20th Avenue and Terrace Place
2. 21st Avenue and Church Street
3. Church Street and 18th Avenue
4. 21st Avenue and Acklen Avenue

The project scope should include the following for each intersection:

1. A detailed evaluation of crash data (data provided by RPM).
2. Determine intersection crash rates and crash trends.
3. Collision diagrams should be provided.
4. Peak hour traffic counts should be conducted.
5. Capacity analyses using Synchro & SimTraffic software tools should be conducted to evaluate existing conditions.
6. Conduct site visits as necessary to confirm roadway and intersection geometrics, traffic control, signs, sight distances, and other pertinent roadway/intersection characteristics.
7. Provide feasible countermeasures to mitigate the crash trends and improve safety at each intersection. Countermeasures should be based on FHWA data.
8. Schematics should be provided illustrating the existing conditions and countermeasures.
9. Prepare preliminary cost estimates for each improvement.
10. Prioritize the improvements based on benefit vs. cost. A methodology for evaluating the benefit of each improvement should be developed based on typical crash modification factors.
11. Prepare a written technical memorandum outlining the results of the crash analyses conducted, conclusions, and recommendations for each intersection.

Civil and Environmental Engineering students display the American Society of Civil Engineers (ASCE) 2010 Concrete Canoe.

Smartphone Robot Controller

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Team Members:
Daniel Hasday
Matthew Maggiore
Muhamad Shahmi Muhamad Shokri
Muhammad Zulhelmi Iskandar

Project Adviser:
Jeffrey Black, Research Associate Professor of Electrical Engineering

PROJECT DESCRIPTION

The goal of this project is to be able to control an iRobot Create and peripheral devices with multiple Android smartphones. Each phone is able to control an aspect of the robot, such that users can work together to complete tasks. Control is spread over multiple devices to accommodate for the limited space on the screen and the intuitive feel of controlling a single device as if you were actually operating it.

Through a common user interface, the phones can gain access to a part of the robot through a Master controller phone. Each role has a unique view, which includes streaming live video of what the robot or the additional device is seeing, and other information pertinent to that role. All of the robot's duties are controlled by an on-board netbook, which interfaces with the robot and the peripheral devices to filter each command received from the smartphones and passing along the proper response to the system. We hope that this proof of concept shows how multi-manned robotics can be useful and easily configured in future applications, including health care and military settings where a degree of oversight is necessary in the control system.

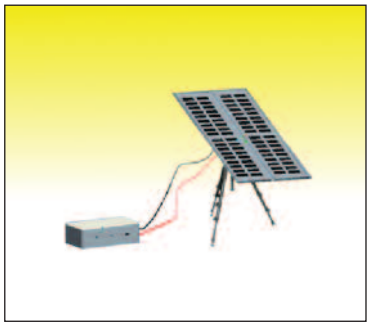
Solar Powered Cell Phone Charging Station

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Team Members:
Noor Abdullah Abdule Ramli
Edwina Jones **(ME)**
Terrance Henning

Project Adviser:
Jeffrey Black, Research Associate Professor of Electrical Engineering

PROJECT DESCRIPTION



In today's society, cell phones have grown to be an integral part in most Americans' daily lives. Aside from standard voice communication, today's cell phones include features that aid in the organization and management of everyday life. It is fairly common for cell phones to come equipped with a calendar, camera, and a GPS tracking system, all of which play a role in maintaining one's social and professional life. As the number of features included on cell phones increases, its power consumption grows as well. With dependence on cell phones growing and with environmentally friendly energy usage becoming more of a concern, it is becoming more important to find alternative ways to power these devices.

For these reasons, the Solar Powered Charger Team (SPCT) is proposing the design of a cell phone charging station that efficiently utilizes abundant solar power as the main source of energy. This design will feature the capability of being able to charge multiple cell phones in an array of settings including outdoor environments. To extend the time of usage, the system will include a back-up battery that will double the charging time of the system. The lightweight and portability of this system will allow anyone to transport this system and use it in any place that has sunlight.

Triage Interactive Nurse Assistant (TINA)

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Team members:
Taylor Wood **(BME)**
Troy Brown **(EECE/BME)**
Rueben Banalagay **(EECE/BME)**
Adil Ismail **(ME)**

Project Advisers:
Karen Miller, RN, MPA, CCRP

Kazuhiko Kawamura, Ph.D

Mitch Wilkes, Ph.D

Erdem Erdemir

Client:
Vanderbilt University Department of Emergency Medicine

PROJECT DESCRIPTION

Emergency rooms can be very hectic these days, especially with the initial triage process all non-urgent patients have to go through. Right now a nurse has to triage each patient by taking their blood pressure, heart rate, oxygen saturation and temperature as well as ask them basic personal information. This can be very time consuming, especially with a large amount of patients cycling through.

Our goal was to create an early prototype for a Robot Triage Nurse Assistant to create more efficient patient care in the Vanderbilt University Emergency Department. In order to do this we designed a device that would combine a touch screen monitor, a blood pressure cuff, a pulse oximeter and a scale. The patient would initially sit down at the device and through our created Graphical User Interface on the computer answer all of the personal and historical questions normally asked. They would then have their blood pressure, weight, oxygen saturation and pulse read by the integrated automated devices. A camera on the computer will be linked to an outside source to monitor the patient.

Small Satellite Payload Experiment

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Team Members:
Steven Ho
Laura Manley
Ryan Millay
David Zheng

Project Advisers:
Jeffrey Black, Research Associate Professor of Electrical Engineering

Robert Reed, Associate Professor of Electrical Engineering

PROJECT DESCRIPTION

Vanderbilt University Institute for Space and Defense Electronics (ISDE) has developed advanced prediction techniques for estimating electronic memory upsets due to interactions with radiation particles. Due to the nature of space particles and the fact that they cannot be fully duplicated in ground-based particle accelerators, the prediction techniques need to be validated with space flight data. The main effort was to build an experiment payload equipped with test memory devices to determine the rate at which the memory bits upset. The prototype payload board utilized non-volatile memory to store data and was programmed to prepare a data stream that can be transmitted to the ground once in flight. The team selected the payload components carefully to ensure that the payload did not become the experiment.

3D Printer

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Team Members:
Kyle Thomas
Kimberly Collins **(BME)**

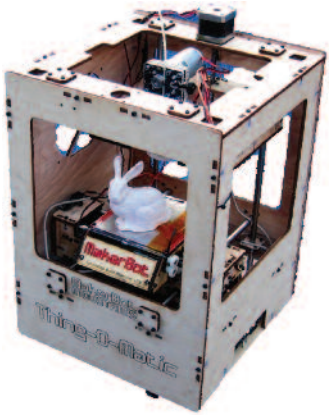
Project Advisers:
Jeffrey Black, Research Associate Professor of Electrical Engineering

Todd Giorgio, Chair of Biomedical Engineering

PROJECT DESCRIPTION

Biomedical engineers frequently design new medical devices that must be prototyped during the testing process. These designs are usually sent to a commercial prototyping company that can take weeks and thousands of dollars to produce just one model. However, small do-it-yourself three dimensional printer kits have become widely available in the past decade and can make cheap prototypes in a matter of hours. 3D printers create physical models by stacking many thin layers of melted plastic on top of each other.

We constructed one of these 3D printer kits and demonstrated its effectiveness in rapid, cheap, in-house prototyping of biomedical devices. We chose the Thing-O-Matic® printer to construct based on its reasonable price, resolution and available online support. At the request of a doctor from the Vanderbilt University Medical Center, we designed a smaller resuscitation mask for infants. Similar masks for adults allow doctors to determine a patient's status during resuscitation given the amount of CO2 they expel. But when a child breathes into one of these larger masks, the volume of their breath is too low to measure CO2 levels in. A mask scaled down to appropriate dimensions for pediatric patients provides doctors with accurate readings from the respiratory monitor.



The Thing-O-Matic® 3D Printer comes in a do-it-yourself kit. It can print in plastic almost any design within a 96x108x115mm build volume.

Conference Room Display

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Team Members:
David Hamrick
Cameron Hill
Craig Verzosa
Mohammad Mulla

Project Advisers:
Lewis Saettel, Building Manager

Jeffrey Black, Research Associate Professor of Electrical Engineering

PROJECT DESCRIPTION

Our senior design project is to create a display that will be placed on the window of conference rooms that will display the schedule of that room for the day. Throughout Featheringill Hall, there are a number of conference rooms that can be booked by faculty members for meetings, classes, or other purposes. It is difficult for the faculty to know when the room is available. These displays will be connected to the central scheduling system used by the administration and display the latest scheduling information. Instead of using custom built hardware we will be using the Amazon Kindle e-reader as the platform for delivering this information.

The Kindle provides a built in WiFi unit, a CPU, and a web browser capable of displaying the scheduling information. The Kindle also features an e-ink display. This display consumes very low power and only using power to change the contents of the screen. In order to receive the scheduling data, the Kindle will use the built-in web browser to view a web page with the current days schedule on it. Since that data may change throughout the day, it will periodically update itself to receive the latest information. The page will automatically reload itself using javascript to asynchronously fetch new scheduling information. The Kindle itself will be placed inside of a locked box that is secured against the window of conference rooms for maximum security.

GOALS

- Create a functional prototype of the conference room display
- Successfully interface with the existing scheduling system
- Create a hardware enclosure that will protect the device from theft

Conference Room Laser Pointer System

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

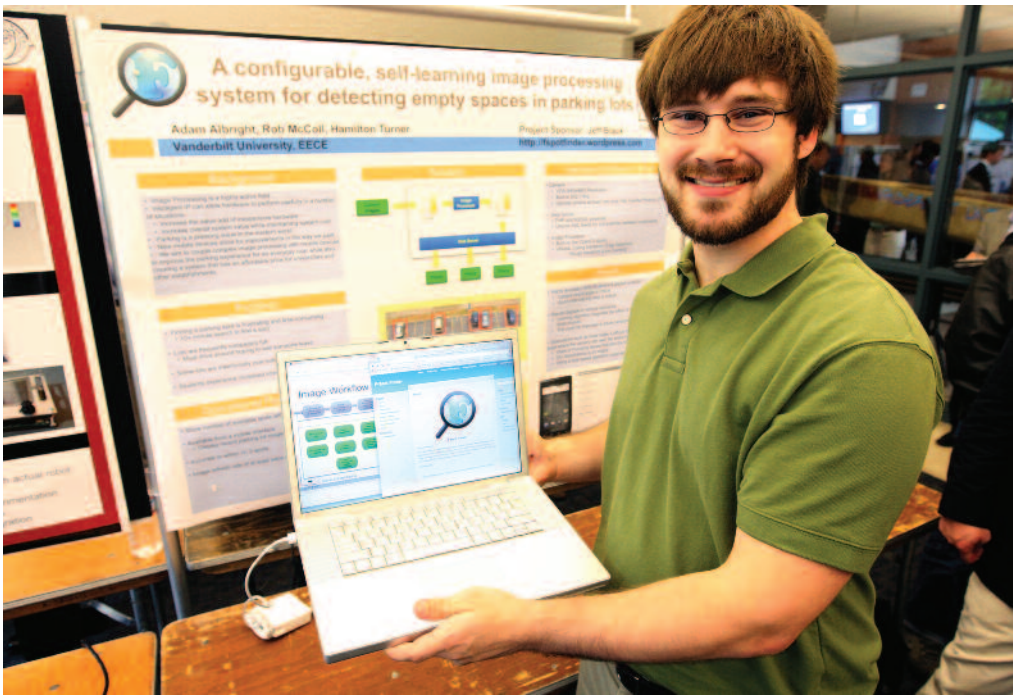
Team members:
Anna Goncharova
Brent Hoover
Alex Mendes

Project Adviser:
Jeffrey Black, Research Associate Professor of Electrical Engineering

PROJECT DESCRIPTION

This figure demonstrates how the laser beam detection algorithm locates the laser pointer position (indicated by the lavender square).

In large conference room presentations when the slides are shown on multiple screens, there is no good solution for pointing a laser at one screen and having it shown on the other(s). This project uses a webcam to monitor a large conference projection screen and look for a laser pointer beam. When a beam is detected, another laser is turned on to the other screen. This second laser beam points to the same spot on the screen as the corresponding location where the first laser is directed. The location of the primary laser beam is determined by applying image processing algorithms to the webcam data. These algorithms are run on a laptop computer to which the webcam is connected. The second laser is mounted on a pan and tilt system which is controlled by servo motors. The motors are controlled from the laptop via USB. The secondary laser is turned on and off by a relay, which is also controlled from the laptop via USB.



Former engineering student Hamilton Turner displays his team's F-Spot project. The system monitored the number of available parking spots in the student parking lot (F-Lot), and made that information available via mobile phone.

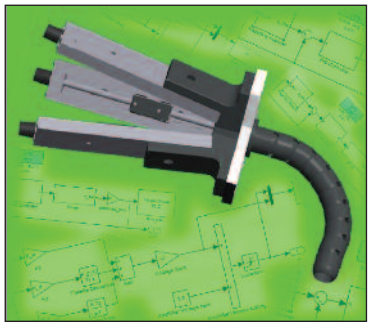
A Tendon Actuated Channel for Upper Airway Surgery

DEPARTMENT OF MECHANICAL ENGINEERING

Team Members:
Mohammed Rahman
Hilmi Mohd Mustafah
Nicholas Pappalardo
Kemar James

Client:
Advanced Robotics and Mechanisms Applications Laboratory

PROJECT DESCRIPTION



Robots are quickly infiltrating the medical field bringing gifts for patients and surgeons. Medical robots give patients a minimally invasive surgery and they assist physicians in performing medical procedures with greater accuracy. The medical robot that is being presented is a tendon-actuated channel that is specially designed for upper airway surgeries. The robot is remotely actuated deep into the patient's oral cavity and locked into place once it reaches the desired location. The surgeon can then safely deploy medical instruments through the locked channel and perform the operation. Since the robot enters through the natural opening of the oral cavity, the patient will not be left with visible scars following the operation. The function of this tendon-actuated channel is twofold: it assists surgeons to accurately and safely deploy surgical tools into the upper airways, and it provides the patient the option of a more comfortable and less invasive surgery.

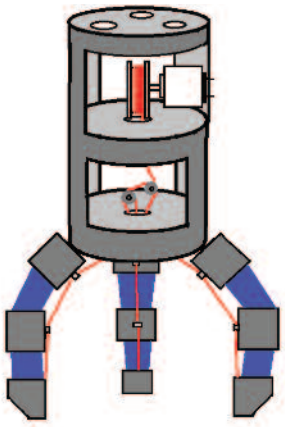
Flexible Automated Robotic Gripper

DEPARTMENT OF MECHANICAL ENGINEERING

Team Members:
Brad Wolfson
Byron Tyler
Tariq Adnan
Mafazi Shamsuddin
Salman Ruslan

Client:
DENSO, Inc.

PROJECT DESCRIPTION



We have designed and constructed a prototype of a robotic picking mechanism. The mechanism is designed to be adaptable to a large variety of small to medium sized parts, and robust enough for factory settings. It is designed to be attached to six-axis DENSO Manufacturing robotic arms, replacing the currently used purpose built picking mechanisms that can only manipulate one specific component. The long-term objective of the research is to cut costs by allowing the production line to rapidly adapt as the parts comprising a Denso alternator evolve over time.

Capturing Wind Energy from Exhaust Stacks

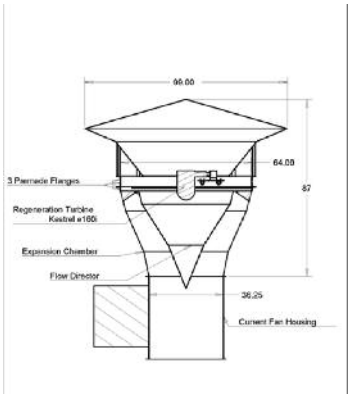
DEPARTMENT OF MECHANICAL ENGINEERING

Team Members:
Jordan Croom
Cameron Thomas
Nabil Yahaya
Philip Ingram

Client:
DENSO, Inc.

PROJECT DESCRIPTION

With the current thrust in energy, most industries are looking towards optimizing energy usage, or even regenerating energy from wastes whenever possible. This project examines the feasibility of generating wind energy from the gases leaving the exhaust vents at the DENSO automotive parts manufacturing plant in Maryville, Tenn. The design challenge is the requirement that the stack height and the volumetric throughput be preserved, and that the load on the existing exhaust fans be not increased. By examining the energy flow, the team has designed an innovative kinetic energy preserver, which when mounted upstream of the turbine, can recover a substantial portion of the flow energy. The validity of the design is demonstrated with a functioning scale model.



Final Assembly Drawing of the Stack Regeneration Design

Sustainable Power for Rural Village in Guatemala

DEPARTMENT OF MECHANICAL ENGINEERING

Team Members:
Troy Probst
Tyler Steier
Will Colmer
Eppa Rixey V

Client:
Lipscomb University

Advisers:
Caleb Rucker
Philip Swaney

PROJECT DESCRIPTION

The goal of our project is to provide a cost effective source of power to a small village in the Ulpan Valley of Guatemala. The people of the valley are mostly indigenous descendants of Mayans and speak Q'eqchi, a language only spoken by a few worldwide. The valley is home to 16 villages and is located in a remote, mountainous region with few roads, which are mostly comprised of mud and rocks. This project is focused on providing sustainable, repeatable, electricity to power small appliances for the native communities. To do this, we are planning on installing a bicycle-powered generator in one of the villages. This generator will charge a 12V car battery that outputs to a standard 110V outlet. This system will allow the users to generate power that will then be stored in the battery for use with any small electronic device at a later time, with the most important being cellular telepones. In addition, the generator needs to be both simple and affordable for the low income inhabitants who have very little technical experience.

On the November surveying trip, our team interacts with and learns from the local villagers.

Reducing Power Dependency at Arnold Engineering Development Center

DEPARTMENT OF MECHANICAL ENGINEERING

Team Members:
Pearce Branthover
Douglass Carlock
Stephen Dolan
Thiago Olson
Anthony Vila

Client:
Arnold Air Force Base

PROJECT DESCRIPTION

A major problem with research centers around the country is the massive power demand produced by their test cells. To meet the high demand of research and testing, the center has to notify the power company on a monthly basis how much power the site plans to use, so that the power company can meet the massively increased transient demand. Also, to reduce the cost of power consumption, the testing is usually conducted at night when the demand on the grid is low.

To help alleviate some of these issues, Arnold Engineering Development Center has asked our design team to produce a feasibility study on implementing alternative energy strategies to help reduce their dependency on external power. Due to the availability of a large area of land inside the base, a large number of possible options exist, including solar cells and nuclear power, among other options. The electricity from these energy sources must be highly reliable and easily maintained, requiring little oversight when running. Reducing Arnold's dependency on external power will allow Arnold to not only control the cost of their power consumption but also potentially allow for more flexibility in testing times.

User Controlled Dynamic Center-of-Gravity Wheelchair

DEPARTMENT OF MECHANICAL ENGINEERING

Team Members:
Chet Gromley
Derrick Kemph
Samantha Lawrence
Muhamad Shah
Ashley Simakas

Additional Adviser:
Thomas Withrow

Client:
MAX Mobility, Antioch, TN

PROJECT DESCRIPTION

The mobility for those disabled and constrained to a wheelchair is of greater importance than the general public is aware. Cities, schools and communities' terrain is comprised mostly of inclines and cross-slopes. Both are major obstacles for wheelchair users. This team is partnering with MAX Mobility to design a wheelchair which enhances the user's ability to travel comfortably in their everyday lives.

The mission was to build a device for MAX Mobility's Hi-Roller Wheelchair design that would change the user's center-of-gravity with respect to the wheel axle. The user's ability to move the center-of-gravity in this way will help to overcome the difficulties that are involved in traveling on a hill or cross slope. Additionally, this design will promote efficient pushing techniques and decrease the risk of shoulder injury.

Our team developed a mechanism comprised of a linear actuator and control knob connected to the bottom of the chair's two-piece frame, the seat of the wheelchair will move relative to the wheels. The knob will act as a user input to the actuator, allowing the person sitting in the chair to adjust their location as they feel necessary.

Establishing Parity between Cruising Airplane Flight and Low-Altitude Rocket Flight

DEPARTMENT OF MECHANICAL ENGINEERING

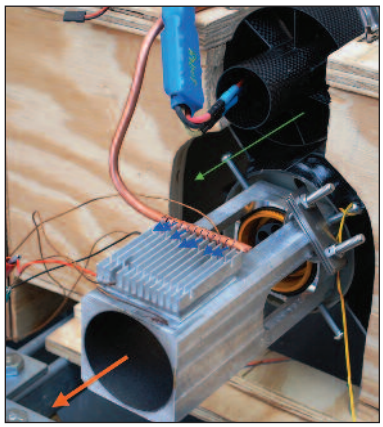
Team Members:
Ben Chociej
Christopher Cameron
Jennifer Frankland
Jonathan Hoke
Kyle Bloemer
Ryan Taylor
Stephen Malanoski

Project Adviser:
Amrutur Anilkumar, Professor of the Practice of Mechanical Engineering

Client:
NASA Marshall USLI (University Student Launch Initiative)

PROJECT DESCRIPTION

A Boeing 747 cruises at a 35,000 foot altitude, where ambient air temperatures typically hovers around -50 °C. A NASA competition rocket flies vertically to about 5,000 feet, where air temperatures are essentially the same as at ground level. However, for a few seconds, the flight speeds of these two vehicles are comparable. The design challenge involves recreating the ambient conditions around the rocket to mimic the ambient conditions of airplane flight.



Rocket flight experimental simulation setup showing scaled model of TEG engine, J90 rocket motor, cryogenic injection system and high-speed VASA fan for establishing parity between rocket and airplane flight.

The team has designed a novel cryogenic injection system that sprays liquid nitrogen into the near ambient of a surface on the rocket, whose heat transfer characteristics are examined during flight. The effectiveness of the cryogenic injection system is evaluated through a full-scale rocket launch. Detailed temperature and power measurements are used to show that thermoelectric generators mounted at the aft of the rocket extract more thermal energy from the rocket's exhaust when cryogen is injected on the convection fins than under normal flight conditions. In essence, the project aims to prove that, in the context of heat transfer, parity can be established between cruising airplane flight and low-altitude rocket flight and that the latter can serve as an inexpensive test bed for experimentation.

Design of a Hybrid Laser/Ink-Jet Printer System for Lexmark Corporation

DEPARTMENT OF MECHANICAL ENGINEERING

Team Members:
Jonathon Poe
Kira Theuer
Muhammad Omar
Madison Hoelscher

Project Adviser:
Kent Ubellacker

Client:
Lexmark, Inc., Lexington, Ky

PROJECT DESCRIPTION

Lexmark is a manufacturer of printers and printing accessories for use by individuals and corporate clients. Lexmark wishes to expand its printer sales volume to small and medium businesses and requested that the Lexmark Design Team investigate the feasibility of combining certain aspects of laser and ink-jet printers for that proposed market. It was felt that the printing capabilities of the ink-jet system, with the paper manipulation/transport system of the laser printer, would provide a cost-effective alternative for the proposed customers.

Therefore, it was the goal of the Lexmark project to design and test a hybrid printer using an inkjet print head assembly and the paper handling system of a laser printer. The tasks included:

1. Evaluation of the printing and paper manipulation systems of both printer systems.
2. Analyses of the physical configurations of both systems.
3. Evaluation of electrical sensors and controls of both systems.
4. Evaluation of printer control (and related) software.
5. Construction of a working prototype for the proposed hybrid system.
6. Consideration of aesthetic and customer-satisfaction issues.

The tasks described above were performed and the initial proof-of-principle testing indicates that further development of this concept is recommended.

Aerodynamic Model-Testing of a Battlefield Unmanned Aerial Vehicle (AAI RQ-7 Shadow) for U.S. Army Missile Command

DEPARTMENT OF MECHANICAL ENGINEERING

Team Members:
Justin Saunders
Ross Shahinian
Drew Marschner
Tommy Griffith **(EECS)**

Client:
U.S. Army Aviation and Missile Research Development and Engineering Center (ARMDEC), Redstone Arsenal, Huntsville, Ala.

Project Adviser:
Dr. Patrick Taylor

PROJECT DESCRIPTION

The Army Aviation and Missile Research Development and Engineering Center (ARMDEC), a subsidiary of the U.S. Army Missile Command, is interested in the development of small-scale Unmanned Aerial Vehicles (UAV) for battlefield reconnaissance. The specific tasks for the Army Missile Command Team were to:

1. To design and manufacture interfaces between the model chosen for evaluation by the customer (1:10 scale model of the AAI RQ-7 Shadow UAV) and the VUSE subsonic wind tunnel.
2. To design tooling/apparatus necessary to calibrate the VUSE subsonic wind tunnel.
3. To perform aerodynamic testing of the specified model.
4. To nondimensionalize the aerodynamic parameters (Re, Cd, Cl, etc.) obtained in Step 3.
5. To develop user interfaces (GUI) for use by Army personnel to allow further use/aerodynamic-design for future UAV's.

Development of an Improved Chemical Deposition System for Diabetes Sensors for Roche Diagnostics

DEPARTMENT OF MECHANICAL ENGINEERING

Team Members:
Raymond E. Borghi
Quentin Harmon
George Davis Flowers Jr.
Catherine Ruelens **(BME)**
Nor Hafizah Sulaiman
Saadah Ahmad Sowi

Client:
Roche Diagnostics, Indianapolis, Ind.

Project Adviser:
Brandon Wilson

PROJECT DESCRIPTION

Roche Diagnostics is a subsidiary of Roche, Inc. Roche Diagnostics develops diagnostic tests and systems for early detection, evaluating and monitoring of disease. The specific testing system under consideration by the Roche Design Team was a system for monitoring blood-glucose in diabetic patients. The evaluation system works, in part, by sensing a chemical reaction between a solution applied to a test strip (including a plastic substrate and associated circuitry) and the patient's blood.

The Roche Design Team's task was to evaluate the application of the test solution to the test strips (in a continuous, mass-production environment) and suggest changes to the solution-delivery system to improve the uniformity of the chemical's application. Areas of concern included the location (position) of the test chemicals on the test substrate, the width of the applied chemical strip, and the depth/thickness of the applied chemicals.

Test and design activities included a preliminary solution using better pressure and flow control to minimize or eliminate pressure fluctuations that were found to exist in the original system. An additional design effort was to evaluate the overall chemical-application system to optimize the flow control and maximize product quality.

Body-Panel Inspection System for Nissan Motor Manufacturing

DEPARTMENT OF MECHANICAL ENGINEERING

Team Members:
Andrew Friedman
Riley Strong
Justin Schneider
Ali AlRamadan
Muhammad Taufiq Muhammad
Nabil Roslan

Project Adviser:
Ashley Gatlin, Nissan
William Sanders, Nissan

Client:
Nissan Motor Manufacturing Corporation U.S.A. (NMMC), Smyrna, Tenn.

PROJECT DESCRIPTION

Nissan North America, of Smyrna TN, is a major manufacturer of automobiles. A very important aspect of the automobile assembly process is checking and maintaining a high degree of quality concerning the fit (separation) of body panels (hood, trunk, doors, etc.) on Nissan vehicles.

The project was conducted in two main phases. Phase I: The first phase involved selection and testing of commercially available body-panel inspection systems for determination of their applicability to Nissan's inspection criteria. This involved technical interaction with both commercial-system vendors and Nissan engineers. This phase also involved cost/benefit analyses, both from a short-term capital investment perspective and also from a longer-term cost perspective, including labor costs. Areas of concern from a technical perspective included lighting/illumination of the vehicles, spatial resolution of the sensors, calibration of the sensors and vehicle-specific issues such as paint-color and reflectivity. The existing systems involved laser illumination of the vehicles and body panels.

The success of Phase I led to a sufficient understanding of the design criteria for a body-panel inspection system that a second phase of the body-panel inspection process was undertaken. Phase II: A feasibility study of a proposed (by the Design Team) white-light illumination body-panel inspection system was conducted. In this system the laser was replaced by a white-light (ring-light) illumination system, using an off-the-shelf digital camera for the sensing element, and an off-the-shelf image-processing software package for measurement and decision-making (quality evaluation).

The proof-of-principle experiments using the white-light illumination and inspection system indicate that further development of the Phase II system is warranted.

Development of a Water/Soap-Dispensing Shower System for Elderly or Disabled Persons (Product Name: "Sudsy Shower")

DEPARTMENT OF MECHANICAL ENGINEERING

Team Members:
Christopher Drake
Siti Zaleha Baharudin
Muhammed Shazwan Mat Shayuti
Muhammed Syafiq Roslan
Jason Sabourin

Client:
Andrea Coonrod, Entrepreneur

PROJECT DESCRIPTION

Andrea Coonrod, a Nashville-based entrepreneur, requested the design services of what became the "Sudsy Shower" Design Team to develop a product intended for use in showering by elderly persons or those with disabilities. The object was to provide a product which enhances the abilities of those persons to attend to personal hygiene (washing/showering) with minimal assistance.

Design issues for the proposed product concerned safety, functionality (water/soap mixing and dispensing), controls, sensing, manufacturability, cost, and aesthetics. Significant effort was devoted to maximizing user-friendliness of the system since those using it may be physically or mentally challenged.

Both functional and proposed final-product configuration models were built and tested.

A Biomimetic Hovering Micro Aerial Vehicle (MAV) with Flexible Wings

DEPARTMENT OF MECHANICAL ENGINEERING

Team Members:
Nathan Tardiff
Ben Bradshaw
Seyi Senbore
Keith Becker
Muhammad Shafiq Hanif
Mohamad Hamdan
Su Cong

Primary Client/Advisor:
Haoxiang Luo, Assistant Professor of Mechanical Engineering

Secondary Client:
U.S. Air Force

PROJECT DESCRIPTION

Hoaxiang Luo's research interests include theoretical and computational fluid dynamics, computational bio-mechanics, and flow/structure interaction. The specific task of the design team was to design a small-scale wing which simulates the behavior of a biological ornithopter (flapping-wing system) as with a bird or insect. The aerodynamic behavior of small-scale ornithopters is of great interest to both civilian and national security users.

The project involved the design and kinematic analysis of the wing-flapping mechanism from a motion-analysis perspective using a computer (ProE) simulation. The biological system which the project seeks to emulate, biomimetic, is that of the hummingbird.

It also involved material selection and construction techniques for the wing structure. Power source and driving-motor considerations and selection were also part of the project. The project also involved a computational fluid dynamics analysis of the aerodynamic behavior of the flapping wing(s).

Physical-Positioner/Force-Generator for Study of Very-Small-Scale Fluid Behavior

DEPARTMENT OF MECHANICAL ENGINEERING

Team Members:
Anderson Funk
Ryan Lohse
Siti Saleh
Nor Hidayah Shukur (EE)
Mohd Razif

Client and Primary Project Adviser:
Jon Edd, Assistant Professor of Mechanical Engineering, Vanderbilt University

Graduate Student Advisers:
Marc Ramsey
Todd Lagus

PROJECT DESCRIPTION

Jon Edd's research involves experimental studies of the microfluidic behavior of fluids. The particular area of investigation for this project involves high-magnification microscopic studies of fluid behavior under high-deceleration conditions.

The project's objective was to design and test a sample-holding and translating apparatus which will allow acceleration and then deceleration of the fluid sample under controlled conditions in the field of view of a microscope. The apparatus involves four main sub-systems: 1) sample holder cart 2), force cart, 3) actuating system (pneumatic), and 4) bearings and support structure.

The two carts were designed such that variations in system weight and materials will result in a tunable system to provide the desired dynamic performance (high-g-forces). A pneumatic system was chosen to allow maximum adjustability in the initial actuating forces applied to the sample holder and force carts. An air bearing system was chosen to minimize friction in the moving systems. Use of the system will allow observation by microscope of very-small-scale fluid behavior.

Commercialization Strategy for Radiation Effects Simulator

DIVISION OF GENERAL ENGINEERING – ENGINEERING MANAGEMENT PROGRAM

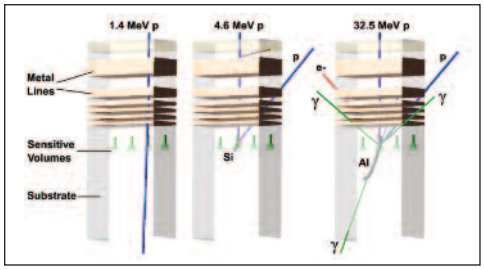
Team Members:
Ekow Ankumah
Moses Morjain

Project Advisers:
Scooter Ball, Vanderbilt Institute for Space and Defense Electronics Staff Engineer

John Bers, Associate Professor of the Practice of Engineering Management

Client:
Vanderbilt Institute for Space and Defense Electronics

PROJECT DESCRIPTION



Events causing single event upsets for 1.4, 4.6, and 32.5 MeV incident protons. The material dimensions have been reduced for illustration purposes.

The Institute for Space and Defense Electronics (ISDE) provides engineering solutions for radiation-specific problems in microelectronic circuits for U.S. space and defense agencies. With the explosion of semiconductors in commercial electronics such as computers, portable communications, medical equipment and automobiles, the effects of radiation on semiconductor performance and reliability must be assessed and resolved quickly and cost-effectively before it is incorporated into a device and put into service. ISDE has developed a unique simulation tool, called MRED (Monte Carlo Radiative Energy Deposition) to predict a semiconductor's susceptibility to radiation.

GOALS

For this project, ISDE is seeking a commercialization strategy for MRED that will address the following key questions:

1. Should MRED be a service or a product? If a product, should it be licensed, where customers can pay per usage of MRED, but do their own analysis?
2. What are the implications of using the open source program at MRED's core?
3. What are the implications of commercializing MRED as part of Vanderbilt University?
4. Are there opportunities in the medical and automotive spaces? How should we enter these markets? Are there additional opportunities in space and defense?

Business Plan for Transductive Access Catheter System

DIVISION OF GENERAL ENGINEERING – ENGINEERING MANAGEMENT PROGRAM

Team Members:
Aaron Ernst
Cody Hall
Jacob Walters

Project Advisers:
Dr. Doug Sawyer
Chairman of Cardiovascular Medicine, Vanderbilt University Medical Center

Ken Russell
Chief Engineer and local angel venture capitalist

Dr. Michael Barnett
Cardiovascular Medicine Fellow, Vanderbilt University Medical Center

John Bers, Associate Professor of the Practice of Engineering Management

TACSx

PROJECT DESCRIPTION

Obtaining accurate access into potential spaces and thin planes of the body is a common problem in medicine. Structures in the human body are often separated by planes of tissue, and it is often desirable to enter into these planes to perform procedures including delivery or removal of fluid/therapeutics. Accurately placing catheters within these dissection planes is difficult because of the very close proximity of the planes – often within 1mm. Currently, this is accomplished by the operator "feeling" resistance to the passage of wires.

Thus a method to accurately place catheters is needed in a wide range of procedures in multiple specialties of medicine. The Transductive Access Catheter System (TACSx) solves these problems by allowing the operator to insert a shallow beveled needle into the space or vascular channel of interest with extreme accuracy. Potential uses include infusion or drainage into pericardial, pleural, peritoneal, joint, and intraocular fluid spaces; amniocentesis; epicardial pacemaker insertion; subdural and epidural infusion; pericardioscopy; and intracranial pressure monitoring.

GOAL

A thoughtful business evaluation of this device, including an innovation strategy, an intellectual property strategy, a financial analysis, business model and business plan for venture funding, a regulatory strategy, an organizational design and a project plan.

Home Health Monitoring & Support for Seniors/Independent Living

DIVISION OF GENERAL ENGINEERING – ENGINEERING MANAGEMENT PROGRAM

Team Members:
Rachel Lanchak
Leah Langdale
Christopher Montes-Sabino

Project Advisers:
A. B. Brill, Research Professor of Radiology & Physics, Adjunct Professor of Biomedical Engineering

John Bers, Associate Professor of the Practice of Engineering Management

Client:
Community Without Walls of Middle Tennessee (501c3 not for profit)

PROJECT DESCRIPTION

Wireless and sensor technologies have demonstrated ability to detect falls and motion patterns, monitor vital signs (pulse, temperature, blood pressure) and generate calls for assistance in response to aberrant signal behavior. Multiple organizations provide home security support and more are offering health monitoring from the home. System requests and interrupts are handled by call centers (such as ADT). The need to extend such systems to support life style and health issues is apparent and many organizations are responding accordingly.

Vanderbilt has conducted pilot telemedicine projects involving home support for patients with selected conditions, e.g. hypertension. Wireless technology supports patient care by faculty and staff. Expansion of aging populations, and funding changes result in increased use of emergency rooms (ER) for non-urgent care. As patient numbers increase and number of general practitioners decrease, increasing utilization of ER resources results in high costs, long waiting times for urgent and non-urgent issues. The ability of doctors and paramedical professionals to respond to and triage sick patients is well established but not for less ill persons. After initial demonstration of effective response by family and neighbor responder intermediaries in demonstration scenarios, we will extend responder response to include professional health care resources in Nashville to test utility of a Virtual Emergence Room (VER) capability.

GOAL

Community Without Walls of Middle Tennessee is seeking a business plan and overall innovation strategy for a VER system, to include system definition and design, competitive analysis, organizational design, financial analysis/business model design, and a detailed project plan.

THANK YOU TO OUR SPONSORS

Our sponsors generously support the senior design program. Thank you for providing your time, experience and financial support that make our program a success.

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TUESDAY, APRIL 26, 2011

3:00-5:00 P.M.

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