CREATIVE SOLUTIONS FOR REAL PROBLEMS
AN INDUSTRY-UNIVERSITY PARTNERSHIP
Projects are displayed in the Student Union Memorial Center Grand Ballroom and on the UA Mall south of the Student Union. The awards ceremony is held in the Student Union Grand Ballroom.
Welcome to Engineering Design Day 2018

This is the best day of the academic year! Today, our engineering students will showcase two semesters of design and development of solutions to technical and societal problems that will improve our quality of life. The capstone design experience in the University of Arizona Engineering Design Program integrates multidisciplinary teams of seniors with real project needs that are identified and sponsored by our industry partners, faculty and student clubs.

This year we have almost 600 students from virtually every degree program offered by the College of Engineering demonstrating 114 projects, some of which will go on to be commercial products.

This capstone experience and event are only possible due to the generous support of our industry sponsors, faculty, student clubs, mentors, coordinators, judges and staff. Together we are witnessing the development and growth of the engineers and leaders of tomorrow.

Our engineering students have worked hard to be ready for this spectacular demonstration, so please enjoy the day and ask the design teams about their projects. University of Arizona engineers are enthusiastic about their work and appreciate opportunities to explain how they intend to help change the world for the better.

Sincerely,

K. Larry Head

Acting Dean, College of Engineering
16 YEARS OF SUCCESS

"We’ve been able to build on the work these student projects have done to develop capabilities for our products."

– Ron Rich
VP Propulsion Systems, Honeywell Aerospace

PROJECTS DISPLAYED
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HIRE THE BEST

“...We need to invest in our future workforce. A lot of engineers are retiring, and it’s going to leave a huge gap in our ability to fill critical roles.”

– Cindy Klingberg
Program Operations Manager, Raytheon Missile Systems
Raytheon Award for Best Overall Design
(1st prize, $5,000)
PayPal Award for Best Overall Design
(2nd prize, $2,500)

While several designs may meet the judging criteria, this award is given to the design that does so the most effectively. The project that receives this award excels in many ways. The design is well-thought-out and its implementation is of high quality. It accomplishes all key design requirements and is supported by rigorous analysis and testing. Its poster and presentation are professional and easy to understand.

Microsoft Award for Best System Software Design
($2,500)
Software has become a critical part of the operation, management and control of complex systems comprising mechanical, electrical, electronic and biomechanical elements and other components and subsystems. As a result, software has become an integral part of the design of complex systems. This award recognizes the best use of software in the process of designing systems for operation, management, control and usability. Teams will be judged on the reliability, robustness, maintainability, reusability, originality and testability of software embedded in their designs.

Frank Broyles Engineering Ethics Award
(1st prize, $1,500; 2nd prize, $750)
Increasingly businesses are adopting cultures that emphasize ethical conduct, driven in part by the dollar value that financial markets place on reputation. Questionable shortcuts to save cost or time can have catastrophic consequences. Similarly, the marketplace can punish a business that ignores or inappropriately resolves conflicts. A team might experience a significant conflict between team members, or between the team and its sponsor or mentor. This award is designed to reward the team that best recognizes and resolves a significant ethical issue, whether that issue concerns a tempting shortcut, a conflict or another factor.

Bly Family Award for Innovation in Energy Production, Supply or Use
(1st prize, $1,500; 2nd prize, $500)

This award recognizes the best project related to sustainable, cost-effective and environmentally friendly energy production, distribution or use. Winning projects could focus on developing new energy sources, reducing energy costs, improving efficiency or reducing cost of energy distribution, adapting existing energy distribution methods to better integrate new energy sources, and increasing efficiency of energy use.

Thorlabs Photonics is the Future Award
($250 per person, up to $1,750)

This award recognizes the most innovative use of optoelectronics and optomechanics in a design.

Andressen Award for Design Above and Beyond
($1,500)

This award recognizes a design solution that goes above and beyond the project design requirements and produces results that may impact and/or be useful for other products and applications. Teams competing for this award must show that they have met all project design requirements and have produced an innovative solution that may lead to other products or applications. Solutions that are sufficiently innovative for a potential patent application and that may form the basis of a new startup will be given special consideration in the selection process.

Rincon Research Award for Best Presentation
($1,500)

This award reflects the quality of the overall verbal and poster presentations. Verbal presentations should be well-structured to describe efficiently the overall problem being solved and the specifics of how the team accomplished its design. Answers to questions should be direct and demonstrate mastery of the project. Presenters should speak in a clear and easily audible voice, making good eye contact with the judging pod. The poster board should be visually interesting and graphically well-organized to tell a standalone story of the project.
VENTANA MEDICAL SYSTEMS AWARD FOR INNOVATION IN ENGINEERING ($1,500)
Innovation may include the novel use of existing components or the creation of entirely new components to meet customer requirements. The most innovative design will not only be a creative solution to a problem but also an effective solution that is well-implemented. This award recognizes the team that has created or made use of components in the most innovative way, or demonstrated excellence in the implementation of innovative design in its project, or both.

MICROSOFT FISH OUT OF WATER AWARD (1st prize, $750)
II-VI OPTICAL SYSTEMS FISH OUT OF WATER AWARD (2nd prize, $500)
The Fish Out of Water award congratulates students for successfully accomplishing a task that was not in their realm of expertise. The projects for senior design require skills from many disciplines, and students must sometimes learn a new subject or skill in an area outside of their major to help the team succeed. A student who not only learns this new subject or skill, but also uses it to effectively help the team thrive, shows dedication and initiative, traits that will continue to help in an engineering career.

ACSS/L-3 COMMUNICATIONS AWARD FOR MOST ROBUST SYSTEMS ENGINEERING ($1,000)
This award goes to the team that most robustly addresses all aspects of the project from the systems perspective. Criteria include requirements capture and flow down, technical risk identification and mitigation, manufacturability, integration and test plan. Judges will look holistically at the program to determine overall effectiveness of the systems process.

TECHNICAL DOCUMENTATION CONSULTANTS OF ARIZONA AWARD FOR BEST DESIGN DOCUMENTATION ($1,000)
Successful implementation of any innovative design requires that all members of the design and production team communicate effectively. Design intent must be communicated from the design activity to the rest of the team using design documentation with a clear map for others to reproduce the design based on documentation only. The mechanical portion of the design is evaluated on the use of drawings with geometric dimensioning and tolerancing, solids models, illustrations, and presentations that can be used to manufacture and inspect design hardware. Software and other systems are evaluated on the use of documentation that clearly and fully describes the system.
Regardless of whether a design project is sponsored, who is sponsoring it, or what is being designed, analog integrated circuits are often required. Teams using three or more TI analog ICs in their designs are invited to enter the TI Analog Design Contest. Projects are judged on originality of design, quality of design, creativity of design, level of engineering analysis and a written description of how each TI analog chip benefited the design.

The design project is executed using a flexible and incremental approach. Final project outcome is achieved through several test and evaluation iterations in collaboration with the customer. The project team should continuously review and assess results, and quickly adapt to any changes or problems encountered.

This award recognizes the team with the strongest strategy, implementation and documentation of analyses supporting its design. Analyses vary from project to project, but may include market research and analysis, analysis of prior solutions to the design problem posed, trade studies that justify the final design selected from alternatives considered, system modeling to demonstrate that the final design is sound and should perform as desired, analysis of potential reasons for failure and a mitigation plan, and economic or other analysis of the benefits of the final design in its intended application. Criteria for judging include the completeness of the project analysis based on the above categories, thoroughness of the analyses, application of sound engineering principles and practice, a demonstrated understanding by team members of any tools or models used, reasonableness of all assumptions, and the quality of the documentation of the analyses.

This award is given to the team that displays the most innovative new or modified manufacturing method. Projects could include introducing a new technique for manufacturing, an innovative use of an existing technique, or new techniques that significantly reduce the cost of manufacturing and improve the quality of the product.

Issues and roadblocks always occur during the engineering design process. Although they cause panic and distress, they also represent great opportunities to learn and often lead to designs that would otherwise be impossible to conceive. This award recognizes a team’s ability to learn and to overcome issues or roadblocks encountered during the design process. The award is judged based on the ingenuity of solutions to problems caused by issues or roadblocks and the features in the final design that contribute to recovery from them.

This award goes to the team that best uses a physical prototype model to understand and study the fit, form and function of the device or system designed. Teams are judged on the appropriateness of the prototyping technology used, how effectively prototyping is used to improve design, and how effectively the use of prototyping is communicated. Prototypes can be made using rapid fabrication technology, traditional manufacturing, or can be hand-built.
ENGINEERING DESIGN DAY 2018 AWARDS

- **RBC Sargent Aerospace & Defense Voltaire Design Award ($1,000)**
  The French philosopher Voltaire is credited with the saying “Le mieux est l’ennemi du bien,” which means “the best is the enemy of the good.” Similarly, Leonardo da Vinci is credited with the saying “Simplicity is the ultimate sophistication.” This award recognizes the design team that best emulates these ideals and resists the temptation to overly complicate the design to yield a clean, simple, elegant, lowest-cost design that simply works well.

- **W.L. Gore & Associates Award for Most Creative Solution ($1,250)**
  This award honors the student team that has implemented a unique and creative solution within its project. It recognizes outside-the-box thinking that pushes boundaries and hands-on approaches to creative solutions. Projects are judged on the elegance and creativity of the technical solutions and their implementation. Teams should be able to communicate effectively their design and the processes they use for creativity.

- **II-VI Optical Systems Award for Best Use of Optical Design and Technology ($500)**
  This award is given to the team that demonstrates the most thorough approach to the design and engineering of its optical system. This award recognizes complete understandings of the optical design, system requirements, tolerance analysis and optical component usage. Important criteria are integration of optics into the overall system, novel use of optical components, creative use of commercial off-the-shelf items, verification of optical components, meeting system requirements, use of standard optical design software, and manufacturability of optical design and components.

- **Dataforth Corporation Award for Best Design Using a Data Acquisition and Control System ($500)**
  This award recognizes the design team that best implements a modern data acquisition and control system. Recognition is given for the use of the system to collect data that characterizes project performance and assists in project optimization and, ideally, uses the same data acquisition system to perform feedback and control operations.
HONEYWELL AWARD FOR EXCELLENCE IN AEROSPACE ELECTRONIC SYSTEM DESIGN ($500)
This award recognizes excellence in overall system design in a project that has an aerospace emphasis. Verbal presentations should be well-structured to describe effectively the overall system and the specifics of how the team implemented its design project. A key feature of the presentation must be representative data that demonstrate how the system was thoroughly tested. Answers to questions should be direct and demonstrate a high level of team competency about the details of the electronic system for the project. The presentation should demonstrate how all members have contributed to the project to exhibit core values of teamwork and professionalism.

HONEYWELL AWARD FOR EXCELLENCE IN AEROSPACE MECHANICAL SYSTEM DESIGN ($500)
This award recognizes excellence in overall mechanical system design in a project that has an aerospace emphasis. Verbal and written presentations should be well-structured to describe effectively the overall system and the specifics of how the team implemented its design project. A key feature of the presentation must be representative data that demonstrate how requirements were analyzed, documented, designed against and tested. Answers to questions during the presentation should be direct and demonstrate a high level of team competency about the details of the mechanical system for the project. The presentation should demonstrate how all members have contributed to the project to exhibit core values of teamwork and professionalism.

LATITUDE ENGINEERING AWARD FOR BEST PHYSICAL IMPLEMENTATION OF ANALYTICALLY DRIVEN DESIGN ($500)
Some engineering problems are straightforward: Optimal solutions are found through the application of engineering best practices. Sometimes, however, the best design choices are not obvious and only reveal themselves after a thorough analysis of the underlying physical principles. This award recognizes a design that could only have been arrived at after careful study and creative application of physics.

HONEYWELL AWARD FOR TEAM LEADERSHIP
(two individuals at $250 each)
This award recognizes students who best exemplify teamwork skills, including the ability to work cooperatively with others to produce high-quality work, to take initiative, to support and respect the opinions of fellow team members, to give and receive feedback, to demonstrate effective leadership, to keep their team focused, and to elevate the work of their fellow team members. Nominees for this award are selected by their teammates.

PROTOTRON CIRCUITS AWARD FOR BEST PRINTED CIRCUIT DESIGN ($500)
This award recognizes the team that has designed or used the most elegant and efficient electronic circuits in its project. Priority is given to best PCB designs or applications. Originality and manufacturability of the design are key criteria in selecting the winning team. Any team that has used circuitry in its project is eligible for consideration. In the absence of any original designs, the originality of the use of off-the-shelf products and the manufacturability of the overall design are used as selection criteria.

CYBER WARRIOR AWARD FOR BEST CYBERSECURITY DESIGN ($500)
Cybersecurity is quickly becoming one of the most challenging and threatening issues that we face in the 21st century. Evaluating and designing security into the products that engineers and computer scientists build is essential to providing a cyber resilient solution, along with the other capabilities and attributes of any given product or system. As a result, cybersecurity has become an integral part of the design of complex systems. This award will be given to the team that either: 1) develops tools and/or products that can be used to ensure that cybersecurity is factored into the development of any given system/subsystem, or 2) designs cyber resiliency into the product that they are developing.
REAL-WORLD ENGINEERING

“It’s something we use, not put in a drawer. We wanted a complete project – we’ll actually use it right away in manufacturing.”

– Daniel Dittmar
VP Production, Wittenstein North America

PROJECT DESCRIPTIONS
MOBILE RESIDENTIAL REFUSE CONTAINER CLEANING SYSTEM

TEAM 17001
SPONSOR MENTOR: Gary Wonacott

PROJECT GOAL: To expedite the cleaning of residential refuse cans by designing an automatic wash-dry cycle that is compact, self-contained, efficient and sustainable.

Removing residue from these containers provides many benefits to the community and reduces media for flies and other disease-spreading vectors.

The rotary union designed distributes hot pressurized water about the can’s interior and uses the water’s velocity to drive a rotating mechanism. The process that cleans the can exterior was designed to contain all water within the system while maximizing the contact between the water and the can walls. Water pressures and flow rates were modeled using WaterCAD. A prototype system was fabricated and tested. Optimal water flow rates, nozzle sizes, and pipe lengths were selected through several iterations of testing.

TEAM MEMBERS:
Kassandra Bracamonte  Mechanical Engineering
Andrew Cervantes  Mechanical Engineering
Joseph Young Chang  Chemical Engineering
Tess Clara Degginger  Biosystems Engineering
Melissa Margret Elkadi  Engineering Management

COLLEGE MENTOR: Brian O’Cain

OPTICAL SYSTEM FOR SUPER RESOLUTION IMAGES

TEAM 17002
SPONSOR MENTOR: Steve Harford

PROJECT GOAL: To apply compressive sensing theory to the field of optics to create a nominal four times improvement in X and Y image resolution from the detector.

High-resolution images are highly sought after in many commercial and military optical systems because they can store large amounts of information, but detector costs increase significantly with pixel count.

The Super Resolution Imager SRI design incorporates a coded mask, which complicates the point spread function of the optical system. The mask pattern can then be exploited to acquire improved image resolution. To meet the Shannon-Nyquist sampling criterion, the design incorporates a piezoelectric translation stage on the mask to allow multiple image samples to be captured with different mask positions. Representing the samples as a Toeplitz matrix presents them as an undetermined linear system, allowing them to be solved by computer compressive sensing algorithms such as the two-step iterative shrinkage/thresholding, or TwIST, algorithm.

TEAM MEMBERS:
Michael Keith Crowe  Optical Sciences & Engineering
Kyle Steven Davis  Mechanical Engineering
Matthew J. Filiberti  Electrical & Computer Engineering
Ryan Jeffrey Hamilton  Optical Sciences & Engineering
Matthew Ryan Noyes  Optical Sciences & Engineering

COLLEGE MENTOR: David Gilblom
LOW-COST UNMANNED AIRCRAFT-BASED LIDAR SCANNING SYSTEM

TEAM 17003
SPONSOR MENTOR: Kamel Didan

PROJECT GOAL: To design a low-cost drone attachment capable of using lidar to create a sub-five centimeter resolution model of a selected area.

This system easily mounts to an unmanned aircraft and, by programming a simple flight path, is capable of flying over a designated area to create a high-resolution 3-D model of the scanned area. The system uses three low-cost lidars scanning simultaneously while the unmanned aircraft is on autopilot slowly flying across a field. A custom-designed interface board allows microcontrollers to log the data from each lidar. An ultra-high-resolution GPS using real-time kinematics was selected to get a global positioning accuracy of less than one centimeter. Custom software running on a supercomputer was used to process the millions of data points collected and return a 3-D model of the scanned object with a final resolution accuracy of five centimeters or less.

TEAM MEMBERS:
Hamad Alqabandi Industrial Engineering
Lane Elizabeth Breshears Biomedical Engineering
Richard A. Herriman Electrical & Computer Engineering
Daniel Inigo Gamiz Optical Sciences & Engineering
Benjamin Mark Weaver Optical Sciences & Engineering
Isaak Maxwell Willett Biosystems Engineering

COLLEGE MENTOR: Mike Nofziger

REGENESIS WASTE AIR RECAPTURE

TEAM 17004
SPONSOR MENTOR: Perry Martens

PROJECT GOAL: To design test procedures to investigate the relationship between the power captured by Regenesis and the Regenesis system’s effect on an HVAC unit.

Regenesis is the concept of generating electrical power from the discharged airflow of a heating, ventilation and air conditioning, or HVAC, system. The first procedure determines the baseline efficiency of an HVAC with and without the sponsor-provided high-efficiency fan and Regenesis fan blade. The second test restricts different amounts of airflow to find similarities in this simulation and how Regenesis restricts the airflow and affects HVAC pressure. Finally, a test is run to determine the relationship between the placement of the system above the HVAC and the power captured by Regenesis. The tests determine the placement of Regenesis where power is optimized, and if the HVAC is running to factory specifications.

TEAM MEMBERS:
Jude Alawadhi Industrial Engineering
Madison Eich Mechanical Engineering
Lorin Thomas Greenwood Mechanical Engineering
Logan Christopher Tober Systems Engineering
Irene Cathy Tran Electrical & Computer Engineering

COLLEGE MENTOR: Gary Redford
FLEXIBLE SENSITIVE PARTS EVENT  
DATA TRANSPORTATION RECORDER

TEAM 17005
SPONSOR MENTOR: Scott Rowland

PROJECT GOAL: To design a device that records data from transportation events that could affect flightworthiness of sensitive parts.

The sponsor needs a device to determine whether the parts it ships have been subjected to transportation events that exceed design or demonstrated limits, which could render them unflightworthy. The device needs to record and present evidence of any shipping events that exceed the specified control limits set before shipping.

The flexible event data recorder houses three internal sensors to monitor six degrees of freedom motion, triaxial acceleration, temperature and humidity. The flexibility of the device allows the user to record data from numerous sources, including external ports designed for three variable capacitance accelerometers, six strain gauges, and two type-T thermocouples. The data recorder continuously monitors all sensor channels for trigger conditions, which are set before shipment via a built-in USB interface with a custom Windows application. When a trigger event is detected, the recorder saves pretrigger and posttrigger sensor data to separate files, which can be extracted after shipment through the same Windows application.

BALANCE AND COGNITION FALL  
INTERVENTION APPLICATION

TEAM 17006
SPONSOR MENTOR: Jane M. Mohler

PROJECT GOAL: To design and test a smartphone application to make balance exercises easily accessible, to help improve balance in adults 60 or older by providing evidence-based motor-cognitive dual-task exercises.

Age-related poor balance results from diminished neuromuscular feedback, and often leads to an increased risk of falling. Studies show that motor-cognitive dual-task performance exercises can enhance proprioception and neuromuscular control, which improve balance and gait speed and reduce the risk of falling in older adults.

A simple and age-appropriate smartphone application was developed in accordance with the requirements of Android and iOS mobile operating systems. The design includes a goal-configurable instructional audio feature that guides users through their exercises, and a system of motivational notifications, goals and progress tracking to keep users engaged at a level of practice with which they are comfortable.
ADVANCED MINING MACHINE CONCEPT
TEAM 17007-17008
SPONSOR MENTOR: Brian Weller

PROJECT GOAL: To provide a machine concept capable of replacing the electric rope shovel as the primary method for surface mining excavation.

The primary requirements were to achieve a material-loading rate of 200 tons per minute, machine geometry providing a 70-foot horizontal and 30-foot vertical digging reach, and material selectivity greater than that provided by the electric rope shovel.

Extensive research, trade study analysis, and CAD modeling narrowed the concept ideas to a final design designated the “bucket-scraper.” The design maximizes the amount of time the machine spends extracting material by removing the swing cycle that plagues existing power shovels, and by implementing continuous mining methods. The system architecture of this new machine was broken down to the component level, where functional requirements were specified and confirmed through analysis. CAD modeling of structural components with 3-D printed models was used to verify machine geometry requirements. Calculations and theoretical analyses were performed to confirm the excavator’s loading rate. Less detailed analysis and design was performed on the machine’s hydraulic system, power system, control system, propulsion system, conveyors, and structural components.

TEAM MEMBERS:
Matthew Hilton  Mechanical Engineering
Nathaniel Matesich  Mechanical Engineering
Owen David Pierce  Mechanical Engineering
Gaurav Sathish  Mechanical Engineering
Don C. Uvindra Sirimanne  Mechanical Engineering
Brian C. Cebrynski  Engineering Management
Maximilian Garber  Mechanical Engineering
Dylan Arthur Guenther  Mechanical Engineering
Ivan Llancas  Systems Engineering
Duy Trong Van  Mechanical Engineering

COLLEGE MENTORS: Brian O’Cain, Mike Nofziger

SOLAR-POWERED MEDICAL REFRIGERATOR
TEAM 17009
SPONSOR MENTOR: Robert Futch

PROJECT GOAL: To design improvements to the SunDanzer BFRV15 battery-free vaccine refrigerator that reduce production costs and address environmental concerns.

Analysis included researching alternatives to the current phase change material, testing the input voltage, evaluating autonomy time and temperatures, analyzing heat transfer data, and performing analyses to understand the required battery size for the system to function properly with the longest lifetime.

World Health Organization standards require the internal chamber temperature to remain between 0 and 8 degrees Celsius. No suitable phase change material that froze in the desired range was found. Water was chosen as the phase change material, but a way was needed to keep the chamber from dropping below 0 degrees Celsius. Insulation to form a physical barrier between ice and the vaccine chamber was incorporated, as was a battery-powered heater to heat the ice when the chamber reaches a specified minimum temperature. Testing and analysis proved the viability and cost effectiveness of the modified system.

TEAM MEMBERS:
Jake Howard Glatting  Industrial Engineering
Timothy Alan Gust  Mechanical Engineering
Megan S. Lubbers  Electrical & Computer Engineering
Dustin Robert Rhodes  Systems Engineering
Wang Sun  Mechanical Engineering

COLLEGE MENTOR: Cathy Merrill
PIEZOECELEROMETER TEMPERATURE CHAMBER

TEAM 17010

SPONSOR MENTOR: Nitin Patel

PROJECT GOAL: To design and build a testing apparatus that provides a safe environment in which to bring piezoaccelerometers up to 260-600 degrees Celsius while vibrating 100 Hz at ±1.0g of acceleration.

Caterpillar’s quality control procedures include vibration testing on its equipment using piezoaccelerometers, which export test data to a data acquisition system for subsequent analysis by Caterpillar engineers. Piezoaccelerometer manufacturers, however, do not provide testing or calibration data for some of the temperatures at which Caterpillar operates its equipment, which means that the exported test data might be unreliable.

The apparatus designed contains the heat around the accelerometer while keeping delicate electronics from overheating. Combined heat transfer and vibrational analyses provided the correct conditions for the inside of the testing apparatus, and heat transfer calculations determined the amount of insulation required to make the outside surface safe to work with.

AUTOMATED NAVAL RESUPPLY SYSTEM

TEAM 17011

SPONSOR MENTOR: Huy Le

PROJECT GOAL: To design a resupply system that autonomously identifies, lifts and stores a 300-pound cylindrical tube aboard a ship following underway replenishment.

The U.S. Navy’s ability to remain at sea relies on underway replenishment, a method of transferring cargo and supplies from ship (or aircraft) to ship. These supplies are then moved to their storage location. The process is risky and jeopardizes personnel, especially in extreme weather conditions.

The designed system replaces human labor and includes an easy-to-use electronic interface. A key component of the design is the end effector, a software-controlled mechanical design that integrates with a robotic arm to locate and move objects to a specified storage area. The end effector has been tested to withstand harsh marine environmental conditions, such as salt-water exposure, extreme temperatures, humidity, rainfall and ice accumulation. Analysis was conducted to ensure the equipment’s reliability and safety.
3-D PRINTED CONFORMAL ANTENNAS FOR HIGH-POWER L-BAND APPLICATIONS

TEAM 17012

SPONSOR MENTORS: Jay Crossman, Tyler Hilt

PROJECT GOAL: To design, build and test an L-band antenna using 3-D printing.

As aviation platforms become smaller, more complex and increasingly cost-averse, a market is being created for novel antenna designs that use manufacturing technologies like 3-D printing.

The design was created using a high-frequency electromagnetic simulation software tool, and required development of a custom process for copper plating. Design iteration produced a cost-effective process for building directional and omnidirectional antennas that operate in the L-band frequency range. After 3-D printing and electroplating, the antennas were lab tested within a range of 1.0–1.2 GHz. The resultant antennas use less expensive materials and significantly decrease the cost of manufacturing. The next phase will involve connecting the antennas to a frequency transceiver and mounting them on an aircraft.

TEAM MEMBERS:
Noe Arroyo-Williams  Mechanical Engineering
Brett Allan Fagerheim  Systems Engineering
Carson Lenard Hines  Materials Science & Engineering
Vincent Wong  Electrical & Computer Engineering

COLLEGE MENTOR: Claude Merrill

TOUCH-FREE CONTROL AND LATCHING SYSTEM FOR AIRLINE PASSENGERS

TEAM 17013

SPONSOR MENTOR: Ian Frost

PROJECT GOAL: To develop touch-free access to all storage spaces inside a super first class airline suite.

Super first class passenger amenities are a competitive market for modern commercial airlines, and passengers in this class are always looking for newer, more convenient options.

This multistorage compartment system uses a custom-designed latch that meets safety regulations, including double latching and manual override. Latch actuation is performed with an electric relay and a solenoid. The design explores two sensor solutions: an infrared-based gesture sensor and a capacitive sensor. For esthetic reasons, the sensors are concealed behind infrared-permissive acrylic or Ultraleather fabric material already in use by the project sponsor.

All of these components are controlled by an Arduino processor that interprets data from the sensors and controls the electric relays that power the individual latches. The operating current is kept under 2 amps and 24 volts AC at all times.

TEAM MEMBERS:
Amro Mohammed Alharbi  Systems Engineering
Krystal Lynn Kolakowski  Mechanical Engineering
Stephanie A. Marcellin  Electrical & Computer Engineering
Joseph George Ornellas  Mechanical Engineering
Tam Tran  Electrical & Computer Engineering
Zhaoyi Yang  Mechanical Engineering

COLLEGE MENTOR: Elmer Grubbs
FORGOTTEN ITEM DETECTION SYSTEM FOR SUPER FIRST CLASS SUITES
TEAM 17014
SPONSOR MENTOR: Ian Frost

PROJECT GOAL: To design a forgotten item detection system for the storage spaces in super first class airplane suites.

When passengers forget to remove their belongings from the wide variety of storage compartments in super first class airplane suites, the result is cost and inconvenience for passengers and airline operators alike.

The system is designed to detect items in six different compartments using a visible light detection system. Each compartment has LEDs and phototransistors mounted on line replacement units that are integrated with an Arduino microprocessor and a display to notify when an item is detected. The optical and electrical performance of the components was analyzed to find the ideal number of LEDs and phototransistors needed to detect an item left in any location, while minimizing the power drawn by the system. In addition, tests and inspections were performed to ensure system stability during inflight and storage conditions.

MEDICAL DEVICE DETECTION SYSTEM FOR IMPLANTABLE PORTS
TEAM 17015
SPONSOR MENTOR: Andre Chanduszko

PROJECT GOAL: To design, build and test a handheld wireless device that locates implantable ports.

Implantable ports are surgically placed inside the chest and assist in the administration of large volumes of medications, such as chemotherapy agents and contrast materials for medical imaging. The designed implantable port detection device will aid medical personnel in locating the port without relying on the typical palpation method, which requires the practitioner to feel around for the port on the patient’s chest. The device will interface with the port within the patient. The data received from the port will then be translated into physical coordinates, allowing the device to locate the port. Once the port is located, medical personnel can then access the port and administer therapeutic agents.
LOW-COST AUTONOMOUS MOBILE
TELEMETRY PLATFORM

TEAM 17016
SPONSOR MENTOR: Nick Keehn

PROJECT GOAL: To design a robot that autonomously navigates Microsoft data centers to collect temperature, humidity and Wi-Fi signal strength telemetry data.

The compact autonomous telemetry system uses a purpose-built robot that incorporates various transducer load-outs such as anemometers, humidity sensors, radiofrequency identification scanners, thermal optics, and thermos probes to measure data center parameters. The robot travels without contacting any surfaces or colliding with any obstacles in its path as it navigates using onboard optical sensors. The low-cost telemetry system can run independently without posing a threat to humans, other objects or itself, and uses easily sourced parts while being scalable for small-scale production.

TEAM MEMBERS:
Clarissa Kay Morse Hill  Systems Engineering
Justin Loera  Electrical & Computer Engineering
Ciaran James McGirr  Electrical & Computer Engineering
Swati Munjal  Electrical & Computer Engineering
Brandon Sipos  Electrical & Computer Engineering

COLLEGE MENTOR: Sharon O’Neal

INDUSTRIAL WAFER-TYPE KNIFE GATE VALVE

TEAM 17017
SPONSOR MENTORS: Micah Davenport, Daniel Soria

PROJECT GOAL: To design and build an 8-inch nominal pipe size wafer-type knife gate valve.

The design is scalable to sizes in the product range of 2–24 inches. Research of existing valves identified the differences between valve designs. Stress analysis testing verified that the material chosen could withstand design requirements provided by the sponsor. Although a new valve body design was created, the design used the same actuators and hand wheels used by the sponsor in an existing knife gate valve. The valve prototype was built as a two-piece model, but will be cast as a single piece if the sponsor decides to put the valve into production.

TEAM MEMBERS:
Nathaniel Justin Henry  Mechanical Engineering
Yuri Vladimir Lopez  Industrial Engineering
Garrett Levi Morrison  Biosystems Engineering
Michelle Nguyen  Mechanical Engineering
Kyle Senes  Engineering Management

COLLEGE MENTOR: Greg Ogden
Radar-Based Vehicle Location and Navigation System

Team 17018
Sponsor Mentor: Cassie Kammerman

Project Goal: To design a navigation system that is not reliant on GPS technology and can be easily attached to the hitch of a vehicle.

The success of autonomous vehicles hinges upon accurate GPS signal reception. Loss of signal makes it nearly impossible for autonomous vehicles to navigate their surroundings, which means they do not always function well in parking garages, tunnels and canyons.

A GPS-independent navigation system using the Doppler effect was designed. The system is equipped with two radar modules that collect data while the vehicle is in motion, and all hardware is packaged to survive in standard automotive environments. Custom software was developed for the microprocessor that collects the sensor data. A MatLab algorithm analyzes the data collected and infers vehicle location based on the vehicle’s last known GPS coordinates.

Mobile Telemetry and Communications Console for Baja Racing Team

Team 17019
Sponsor Mentor: Michael Marcellin

Project Goal: To design, build and test a portable base station for receiving, parsing and recording telemetry data.

The portable base station enables a pit crew to monitor vehicle conditions live during a race, and design engineers to analyze events leading up to a component failure.

The system is housed in a ruggedized case rated for full submersion while closed. A liquid-cooled computer runs custom software that acquires data from multiple sources. A multithreaded analysis engine analyzes the data for trends and anomalies. The data is displayed on a 23.8-inch LCD screen in a customizable format suitable for technical and nontechnical users. The graphical interface is built on wxWidgets and a custom graphics library. A removable keyboard and trackpad, a 900 MHz wireless transmitter, and the core of a carrier-grade gigabit IP-based network complete the system components. The system can record over 1,000 hours of data for later review and is capable of displaying up to four hours of data at a time.
ARCHIMEDES SCREW PUMP FOR ALGAE REACTOR RECIRCULATION SYSTEM

TEAM 17021
SPONSOR MENTOR: Pete Waller

PROJECT GOAL: To design, build and test an advanced Archimedes screw pump to recirculate algae in a raceway.

The Archimedes screw pump, once used to irrigate the Hanging Gardens of Babylon, has a potential efficiency of 70 percent and can be used to recirculate algae within an algae raceway, the track through which algae circulates.

The sponsor currently uses paddle wheels with 25 percent efficiency to recirculate algae. The pump designed for this project incorporates modularity in the form of multiple screws and individual screw controls for an operator to set desired flow rates. The sustainably designed screw pump converts solar energy from photovoltaic cells into DC power for two motors, which individually turn two 12-inch-diameter screws. The screws are housed in a PVC casing and draw water up as they turn, releasing it to the original elevation so that it can recirculate in the raceway. Each pump is individually controlled using a calibrated Arduino microprocessor with potentiometers that allow the operator to set the flow rate. The system is designed to run autonomously, turning on in the morning and shutting off at night, and is capable of storing enough energy to operate for two days without optimal sunlight.

TEAM MEMBERS:
Catalina Fernandez-Moores  Biosystems Engineering
Luis-Alejandro Garcia-Ramirez  Biosystems Engineering
Tina Thao Nguyen  Systems Engineering
Brandon B. Preciado  Electrical & Computer Engineering
Hailey Alixandra Stock  Biosystems Engineering

COLLEGE MENTOR: Greg Ogden

CUSTOMER-OPTIMIZED POWER USE AND COST

TEAM 17022
SPONSOR MENTOR: Christopher Lynn

PROJECT GOAL: To design a system of devices to track home energy use at the appliance level, calculate the corresponding cost and identify money-saving opportunities.

The system design incorporates an appliance current-measurement device and a method for transmitting the energy data to a central computer for analysis. Current draw of the appliance is measured continuously using a current transformer. An analog-to-digital converter sends the collected data to a microcontroller collocated with the transformer. The microcontroller processes the data and transmits the data via Wi-Fi to the main computer located at TEP.

Tucson Electric Power offers homeowners several different rate plans, including reducing power cost during nonpeak usage hours. Custom-designed software for the main computer manipulates data from the database, estimates energy cost using TEP rate plans, and presents information on a computer monitor with a graphical user interface.

TEAM MEMBERS:
Hadi Naief Almakaiel  Mechanical Engineering
Dylan Carlson  Electrical & Computer Engineering
Kendall Jane Collier  Systems Engineering
Daniel G. Miranda  Electrical & Computer Engineering
Liam P. Spinney  Electrical & Computer Engineering

COLLEGE MENTOR: David Gilblom
REMOTE LIVESTOCK WATER TANK SENSORS

TEAM 17023
SPONSOR MENTORS: Kitt Farrell-Poe, Mitch McClaran

PROJECT GOAL: To design and implement a remote water-flow monitoring system on an open range and send flow data to a website.

Cattle ranchers cannot afford to waste water, especially in arid environments. The vast network of plumbing to supply tanks with the water needed by large herds cannot be interrupted, so they must be inspected often.

The data from the remote sensors is of interest to researchers and ranch owners, and the project includes developing a website to display the acquired flow data. This removes or reduces the need for manual inspections by the rancher or ranch hands. The system monitors water flow via sensors placed throughout the plumbing system between tanks to detect leaks or stoppages. The solar-powered system communicates through a series of mesh network radios to a central location that uploads the data to an internet server. Data can be viewed on a website or via a mobile notifications.

IMAGING PYROMETER FOR FURNACE TEMPERATURE MONITORING

TEAM 17024
SPONSOR MENTOR: Sean Ashley

PROJECT GOAL: To develop software for a noncontact imaging pyrometer in the visible spectrum.

Current imaging pyrometers for furnace temperature monitoring operate in long-, mid- or short-wave infrared spectra. This project could lead to technology that reduces the cost of noncontact pyrometers and allows anyone to find the temperature of an object with a standard digital camera.

The team derived a radiometric calibration constant relating temperature to camera response. Software and a proprietary algorithm were developed to calculate blackbody source temperatures of 1,100–1,700 degrees Celsius. Using data acquired from a commercially available visible-light camera, the algorithm developed enables the system to calculate temperature to within 40 degrees Celsius. The graphical user interface allows furnace monitoring for materials, such as molten copper, at comparable temperatures of known emissivities. Thermal analysis and a full-system verification process proved that the system can operate in extreme ambient temperatures of 90 degrees Celsius.
EXTERNAL FIREFIGHTING TANK FOR S-70 FIREHAWK HELICOPTER

TEAM 17026
SPONSOR MENTOR: Mike Slattery

PROJECT GOAL: To develop a new firefighting water tank design for the S-70C Firehawk helicopter.

The team explored alternative functional design concepts for firefighting techniques, and created a new system for a more efficient drop pattern. The new tank incorporates a door with a simple gear mechanism that ensures a more dependable output of water. The tank’s doors also use a funneling system that increases the boundary layer for the water, allowing a greater head pressure. The Firehawk pilot can select specific drop durations and rates from the cockpit depending on the targeted fire.

The new tank, which will be used by the Los Angeles Fire Department, allows more reliable surface area coverage than the previous version, and enables the Firehawk to deliver water quickly and efficiently to a fire in terrain inaccessible by ground personnel.

TEAM MEMBERS:
Cameron M. Campbell  Electrical & Computer Engineering
Nicole Marianne Gefrides  Systems Engineering
Peter Gonzales  Mechanical Engineering
Audrey Nicoline Mayger  Mechanical Engineering
Nicholas Forrest Vandivort  Mechanical Engineering

COLLEGE MENTOR: Doug May

AUTONOMOUS SELF-DRIVING SOLAR RACE CAR

TEAM 17027
SPONSOR MENTOR: Larry Head

PROJECT GOAL: To design, build and test a kit that gives a solar powered go-kart autonomous capability.

The design integrates a servomotor for steering, electric actuator for braking, and GPS and lidar for control and position updates. All components are controlled by an Arduino Mega microcontroller. The variable voltage output from the Arduino allows control of the throttle. The pure pursuit algorithm is used as the control loop, which uses a goal point found along the path and steers the kart toward it with updates from GPS. The lidar was integrated for collision avoidance, stopping the kart whenever it recognizes something in its path.

A modified go-kart was tested at the Musselman Honda Circuit in Tucson, Arizona. The developed kit can be used in the Racing the Sun competition, and it is hoped that high school students will start building autonomous go-karts in 2019.

TEAM MEMBERS:
Ian Andrew Aguilar  Mechanical Engineering
Alejandro Apodaca  Electrical & Computer Engineering
Kyle C. Arechiga  Electrical & Computer Engineering
Joshua Marks  Systems Engineering
Seth Jordan Sanasac  Electrical & Computer Engineering

COLLEGE MENTOR: Mike Nofziger
TURBINE ENGINE FRANGIBLE BEARING SUPPORT DESIGN

TEAM 17028
SPONSOR MENTORS: Jeff Guyman

PROJECT GOAL: To design a frangible bearing support that will withstand higher fatigue loads.

Stricter Federal Aviation Administration regulations require that new propulsion turbine engines be able to withstand more severe icing conditions. On these engines, the No. 1 bearing support is designed to break in the event of fan blade separation. This “blade-out” event causes a severe rotating shaft imbalance. To reduce the load that would be transferred to the engine, the bearing support is designed to break away from the engine frame and allow the engine shaft to whirl.

The bearing support was modified from having six individual fuse ligaments to using a solid rim ligament around the entire circumference. This design reduces stress concentrations, thus decreasing fatigue from icing conditions. Stresses calculated using finite element analysis software were used to determine ligament thickness and surrounding fillet radii that would fulfill the breaking load and fatigue life requirements. To validate the FEA results, a physical test was performed using a simplified test specimen. Custom tooling was used to simulate the in-engine mounting conditions and radial loads were applied via a hydraulic press. Deflection and strain data were collected to compare with the finite element analysis model.

PRESSURE SENSOR AND DATA-ACQUISITION SYSTEM

TEAM 17029
SPONSOR MENTORS: Darrell Horner

PROJECT GOAL: To design, integrate and test a pressure sensor and data-acquisition system to be used in testing equipment for aircraft products controlling cabin pressure.

The easy-to-use-and-install system consists of a 6-by-3-by-10-inch box containing two absolute pressure sensors, one differential pressure sensor, and one water differential pressure sensor. The box also includes an Arduino Mega 2560 microcontroller, communication wiring between the sensors and Arduino, and other design materials to protect the components.

The device displays sampled pressure values via a graphical user interface using software programmed in C# that is compatible with Windows 10. The software allows data to be saved in a spreadsheet file. The device provides the user with various sensor readings at different capture rates ranging from 0.05 seconds to 10 seconds for all four sensors. The detection accuracy of the absolute pressure sensors is ± 0.1% (with 0.001 resolution). Accuracy of the differential pressure sensors is ± 0.25% (with 0.01 resolution).
ADDITIVE HEAT EXCHANGER CHARACTERIZATION AND OPTIMIZATION
TEAM 17030
SPONSOR MENTORS: Keith Sangston & Dave Oman

PROJECT GOAL: To design a heat exchanger using additive manufacturing.

The heat exchanger of an auxiliary power unit maintains the oil running through the unit at the appropriate operating temperature. The design includes a lattice fin to dissipate heat from the working fluid. Direct metal laser sintering 3-D printing is used to create a one-piece lattice fin to reduce production cost and eliminate assembly time. Modular features are incorporated in the final design to allow easy scalability and a wide range of geometric configurations. Heat transfer characterization and optimization were analyzed extensively using finite element methods and experimental tests verified the results obtained.

TEAM MEMBERS:
Nathan David Fier  Mechanical Engineering
Jaydon Michael Flori  Mechanical Engineering
Theodore Joseph Hastings  Mechanical Engineering
Mark Lopez  Mechanical Engineering
Jamie Vail  Systems Engineering

COLLEGE MENTOR: Mark Brazier

TEST RIG FOR PRESSURIZED BOLT JOINT ASSEMBLIES
TEAM 17031
SPONSOR MENTORS: Melissa Bush, Kevin Schwab

PROJECT GOAL: To design a modular flange that can be used to detect leakage at bolted joints.

The test rig allows designers to test proposed bolted joint assemblies at a smaller scale and enables revisions to be made at earlier stages of engine design. It also provides criteria for leakage when running computer analyses.

Three modular flange assemblies were designed and built to demonstrate three cases: leakage through the bolt holes, leakage between the bolt holes, and no leakage. Assemblies differ in the amount of space between bolt holes in the three sets of interchangeable flanges. Once secured, flanges can be tested using a water pump and a specifically designed test rig, which simulates engine flight conditions and allows the user to check for leakage and quantify displacement. The displacement of the flanges during testing can be measured and the leakage status recorded. After testing, the displacement with corresponding leakage status can be compared to the bolt hole spacing. After multiple tests at different loadings and bolt patterns, a database can be built to provide qualifiable analytical criteria. The database will allow the sponsor to determine the amount of leakage based on the displacement, loads and number of bolts without running any subsequent physical tests.

TEAM MEMBERS:
Luis Bustamante  Mechanical Engineering
Reagan Loree DeVoe  Mechanical Engineering
Lisanne Hagens  Mechanical Engineering
Alexander Ellis Heydt  Systems Engineering
Bradley David King  Mechanical Engineering
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COLLEGE MENTOR: Brian O’Cain
DUST FILTRATION SYSTEM FOR AIR BEARINGS
TEAM 17032
SPONSOR MENTORS: Melissa Bush, Kevin Schwab

PROJECT GOAL: To identify, prototype and test a filtration system that can reduce dust intake by filtering out large particulates.

The sponsor is developing air bearing technology for 131-9 auxiliary power units, or APUs, used in narrow-body commercial airliners, which use pressurized air generated by the APU to operate. In areas such as the Middle East and American Southwest, dust particulates from the environment can enter the air bearing housing and cause premature wear to the air foil.

After conducting trade studies, the team selected a lightweight reverse-pitot tube design, which uses inertial separation to isolate clean air from dust without any moving parts. The filtered air is drawn through a tube by a pressure differential, so no additional transport systems are necessary. The design is virtually maintenance-free and can operate for the life of the APU.

Testing of various pitot tube prototypes involved a design of experiments and construction of an airtight fabricated flow chamber that could simulate key APU conditions (Mach 0.1 velocity) and accommodate different pitot tube geometries. A measurable amount of dust was passed through the flow chamber, and filters were fitted to catch dust entering a simulated bearing housing and dust continuing through the main flow. Filter efficiency and particulate size could be verified by this method, and the prototype design that met or exceeded all requirements was deemed to have met the project goal.

DUST FILTRATION FOR GAS TURBINE COOLING SYSTEM
TEAM 17033
SPONSOR MENTORS: Dave Jan, Ifeanyi Umunna

PROJECT GOAL: To design a dust filtration system that stops particles entering turbine cooling passages, preventing the plugging that leads to hot corrosion of turbine components.

The sponsor’s auxiliary power units, or APUs, experience severe dust ingestion in areas such as the Middle East. These units operate on the ground, and fine particles from dust and sand storms enter through the engine inlet and obstruct the cooling system within the gas turbine. The components most affected are the first-stage nozzle vane cooling passages and the turbine rotor cooling circuit.

The designed system is designed to increase APU life expectancy while decreasing premature failure in the field. It incorporates two filters, cyclonic and barrier, which work together to trap the incoming dust particles. Tradeoffs in weight, size, reliability, cost and performance were performed to determine an optimal configuration. The final design of the filtration system was analyzed and tested to capture data for the sponsor, and the system was designed as a line replaceable unit to allow easy access for simple maintenance.
REACTOR DESIGN FOR NASA OXYGEN RECOVERY

TEAM 17034

SPONSOR MENTORS: Amanda Childers & Charles Lo

PROJECT GOAL: To develop a methane pyrolysis reactor to increase oxygen recovery aboard the International Space Station.

On the International Space Station, carbon dioxide and hydrogen are run through a Sabatier reactor that produces methane and water. An electrolysis reactor splits the water into oxygen and hydrogen, and the methane is vented overboard. The reactor will close the resource loop in the air revitalization systems and reduce the need for hydrogen resupply.

The methane pyrolysis reactor designed for this project uses waste methane from the current system to increase percentage oxygen recovery. The reactor takes in methane gas and heats it by induction to over 1,000 degrees Celsius while using a vacuum pump to keep the pressure below 300 torr. This combination of high heat and low pressure facilitates pyrolysis, which splits methane molecules into their constituent atoms, carbon and hydrogen. The carbon adheres to a porous substrate designed by the sponsor, and the hydrogen continues through the oxygen recovery system, starting the cycle over again.

TEAM MEMBERS:
Geoffrey Angle Biosystems Engineering
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Gerardo Yasser Perez Mechanical Engineering
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Zachary James Zalzalah Engineering Management

COLLEGE MENTOR: Mark Brazier

AUTOMATED FUEL AND FLUID MANAGEMENT

TEAM 17035

SPONSOR MENTOR: Shawn Roberts

PROJECT GOAL: To design, test and build an automated system to record fuel consumption at the sponsor’s Tucson Proving Ground, where equipment testing uses thousands of gallons of diesel per week.

The system replaces the current manual method of data collection with a mobile application that uses a tablet to collect and store fueling data, which is then sent to a sponsor server. A fabricated bracket allows the Windows tablet to be transported safely during data acquisition, after which reports are merged and produced automatically, and checked for quality using a custom application developed using Python and Visual Basic for Applications. The script then produces a final report that goes to billing and a report that identifies quality issues.

TEAM MEMBERS:
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Ali Mohamed Talaat Engineering Management
Raymond Gafu Tang Electrical & Computer Engineering

COLLEGE MENTOR: Brian O’Cain
SMART MUSEUM DISPLAY CABINET
TEAM 17036
SPONSOR MENTOR: Tony Gleckler

PROJECT GOAL: To create a modern museum display cabinet that improves the protection and display of valuable items.

Museum cabinet technology has remained fairly stagnant since its origin. In addition to protecting valuables from wear, dust and theft, contemporary museum cabinets must also consider factors such as temperature and lighting.

The smart cabinet design incorporates wireless communication to control and monitor cabinet parameters. Using an advanced thermal model, a temperature-based thermal control system was designed. High-quality illumination is provided by LEDs with a high color-rendering index. The systems also incorporate a purpose-built power supply and a wireless entry notification system. Using an embedded microcontroller in the cabinet itself, the user is able to wirelessly control protective-action temperature thresholds and individual shelf lighting levels through a graphical user interface. This graphical user interface also displays entry notifications to the user when a cabinet door is opened.

LANDING GEAR BEARING TEST MACHINE
TEAM 17037
SPONSOR MENTORS: Ryan Gleason, Chris McDade, Andrew Loutzenheiser

PROJECT GOAL: To design, build and test a bearing test machine to determine bearing service life.

Journal bearings used in aircraft landing gear absorb radial and axial loads during landing and takeoff. Being nonserviceable and costly to replace, the service life of the bearings must be predictable and adequate for their application.

The test machine uses off-the-shelf and fabricated components to move a shaft linearly through a bearing while a radial load of 3,000 pounds is applied. The team used SolidWorks to design the fabricated parts, conducted finite element analysis and motion simulation tests, and followed design for manufacturability practices to produce geometric dimensioning and tolerancing drawings. The linear shaft induces wear of the polytetrafluoroethylene liner, which is measured using a linear variable differential transformer sensor capable of detecting 0.0001 inches of displacement.

Signals from the sensors are sent through the data acquisition system and into LabVIEW, which displays and records data. If any information received from the sensors exceeds safety criteria, the machine shuts off and removes load from the test piece. By gathering data on the wear characteristics of bearings smaller than those used in aircraft, it is the sponsor’s goal to create a scalable benchmark that will help establish industry standards regarding bearing service life.
INLINE SWIRL PARTICLE SEPARATOR III
TEAM 17038
SPONSOR MENTORS: Melissa Bush, Kevin Schwab

PROJECT GOAL: To optimize a device from a previous design team that reduces air contamination in engine bleed lines and compressed air ducts without significant loss of air velocity or pressure.

Turbine engines, used primarily in aircraft, operate in many environments and are expected to perform nominally, but contamination due to harsh environments has always been a problem.

The inline swirl particle separator uses swirl vanes and air flowing through compressed air lines to create a helical airflow that exerts centrifugal force on particles and moves them to the outer perimeter of the flow. At this point, a diffuser incorporated into the flow separates cleaner air from particle-laden air, which is ejected from the engine. Filter boxes located at this intersection capture any remaining dust. To optimize this process, the team determined effectiveness and efficiency by using varying pipe lengths, swirl vane rotations and diffuser gaps.

TEAM MEMBERS:
Emily Dolbeck Mechanical Engineering
Kevin Alexander McCarville Mechanical Engineering
Jack William Odell Mechanical Engineering
Steven Edward Pack Mechanical Engineering
Rafael Quintero Industrial Engineering
Huy Gia Tran Mechanical Engineering

COLLEGE MENTOR: David Gilblom

ROTATING CONNECT/DISCONNECT UNDER LOAD
TEAM 17039
SPONSOR MENTORS: Tom Phielix, Quinn McIntosh, Dan Jan

PROJECT GOAL: To develop a prototype mechanism to mechanically connect and disconnect a gas turbine auxiliary power unit from the load compressor on large commercial aircraft.

A review of existing mechanisms indicated that some type of clutch system would be required, and trade studies led to the selection of a design based on a synchromesh blocker ring. The first generation of the rotating connect/disconnect was developed and tailored to the sponsor’s torque, centrifugal and thermal load requirements and dimensional constraints.

The first-generation mechanism was then evaluated under worst-case scenarios using a combination of manual and finite element analysis. Design aspects that did not meet performance requirements were identified and then iteratively modified and re-evaluated until all performance requirements were met. Through this process a final-generation mechanism was created and a 3-D printed demonstrator unit produced.

TEAM MEMBERS:
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Andrew Getman Aerospace Engineering/Mechanical Engineering
Bradley Hawk Mechanical Engineering
Blake Nicholas Nolette Mechanical Engineering

COLLEGE MENTOR: Mark Brazier
OIL SPRAY COOLING ON ROTATING MACHINES

TEAM 17040

SPONSOR MENTORS: Melissa Bush, Kevin Schwab

Honeywell

PROJECT GOAL: To design and build a simplified version of the end turn region of an oil-cooled high-power-density aerospace generator and test for the most effective cooling configuration.

The test fixture had to be built at full scale, be flexible enough for multiple configurations, and have a way to determine how well it was being cooled. The oil circulation system of the test fixture allows for the manipulation and measurement of the oil pressure, temperature and flow rate. It provides a constant source of oil to the nozzles that apply the cooling oil to the test item.

Effective cooling of the end turn region is critical for proper generator performance. Oil pressure, temperature and flow rate were tested, as were nozzle type, configuration and quantity. Cooling effectiveness was determined using an infrared camera mounted within the system. The most effective configuration was determined using a design of experiments model.

TEAM MEMBERS:
Sherif Samir Ghoneim  Engineering Management
James Patrick McHugh  Mechanical Engineering
Daniel C. Pearce-Walker  Mechanical Engineering
Shichen Wu  Mechanical Engineering

COLLEGE MENTOR: Gary Redford

MULTIFREQUENCY ANTENNA MAST SYSTEM FOR LARGE MINING TRUCKS

TEAM 17041

SPONSOR MENTOR: Joseph Tabor

CATERPILLAR

PROJECT GOAL: To design, build and test a multifrequency antenna mast for large mining trucks.

The sponsor needed to update its antenna mast configuration to better interface its large mining trucks with the data and communication arrays used in its international markets. Design requirements stressed safety, dependability and durability.

3-D modeling was used to limit obstruction of the truck operator’s field of view and to verify that the antennas could be lowered to a safe working height. Finite element analysis modeling was performed to ensure that the antenna mast system’s natural frequency would not couple with the truck’s vibration spectrum; if the frequencies were too close, the resulting resonance would destroy the mast system. Finite element analysis was also used to verify that the antenna could withstand forces of 3 Gs.

The antenna mast system is reinforced with a steel frame and fitted with a rack and pinion system that uses an electric motor to raise and lower the antenna. The system has an enclosed housing to cover moving parts and prevent damage by flying debris. The sponsor plans to attach up to five antennas to the mast system to improve communications and data accumulation.

TEAM MEMBERS:
Faisal Dawood  Mechanical Engineering
Timothy Daniel Murphy  Engineering Management
Michael Paul Richardson  Mechanical Engineering
Alejandro Serrano  Mechanical Engineering
Kevin Wassenberg  Electrical & Computer Engineering

COLLEGE MENTOR: Steve Larimore
HARDWARE ENVIRONMENTAL PROTECTION FOR AUTONOMOUS LARGE MINING TRUCKS

TEAM 17042
SPONSOR MENTOR: Adam Hales

PROJECT GOAL: To redesign an enclosure for the autonomous control hardware on the sponsor’s mining trucks.

Primary requirements were to provide sufficient cooling, to control dust intrusion, to remain close to the existing enclosure’s footprint, and to extend the service interval to 500 hours. The primary challenges of the project were the extreme heat and dust conditions in which the trucks operate.

Many of these vehicles are in use around the world, so a retrofit design was chosen to allow simple field deployment on active vehicles. Blown air cools the electronics in the enclosure, so the cooling profile and temperatures were optimized using temperature and flow modeling in MatLab. Dust intrusion is managed three ways. First, the blower creates positive pressure inside the enclosure, which prevents dust ingress through cracks or holes. Second, a standard automotive filter was chosen for its low profile and wide cylindrical shape to fit the size constraints of the project while maximizing surface area to provide the longest life. It was determined a higher-level HEPA filter was not needed as the target air quality within the enclosure was ISO 9, or standard room air quality. Third, two cyclone prefilters were used to prevent the air filter from becoming saturated, allowing 500 hours of service before needing to be changed. The design is compact, protruding only one inch beyond the original cabinet’s footprint, and compatible with the sponsor’s vehicle lines.

TEAM MEMBERS:
Jeffrey Walter Breed  Mechanical Engineering
Alexander Gerwe  Mechanical Engineering
Charles R. Steinke  Electrical & Computer Engineering
Zhizhou Yang  Mechanical Engineering
Bryan Zittlosen  Mechanical Engineering

COLLEGE MENTOR: Gary Redford

COMPACT POWERED DOOR OPENER

TEAM 17043
SPONSOR MENTOR: Eric Zuercher

PROJECT GOAL: To design and build a door operator concealed in the door frame of a wheelchair lift in compliance with applicable ANSI/BHMA standards.

The doors on wheelchair lifts are not automatic and require wheelchair users to operate them manually. The team designed and built a door operator, concealed in the door frame of an Ascension Protégé wheelchair lift, in compliance with applicable standards of the American National Standards Institute and the Builders Hardware Manufacturers Association. The opener enables a person in a wheelchair, or someone without use of their arms, to control their own lift entry and exit. The design consists of a mechanical actuator to move the door and software to regulate speed and operating procedure.

A mechanical override, activated by pushing on the door, accounts for emergencies and power outages. In the event of obstructions, the software resets the current operation or allows the obstruction to be removed if there are multiple failed attempts. The system is also designed to be compact and modular for easy maintenance and implementation in other lifts.

TEAM MEMBERS:
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Jesus F. De la Cruz  Mechanical Engineering
Jesse Deffenbaugh  Mechanical Engineering
Allison Beth Katz  Mechanical Engineering
Adriana Parra  Systems Engineering

COLLEGE MENTOR: Gary Redford
UNMANNED AIRCRAFT SYSTEM FOR RESCUE MISSIONS

TEAM 17044
SPONSOR MENTOR: Mark Meadows

PROJECT GOAL: To create software to read and manipulate data from two commercial off-the-shelf unmanned aircraft.

The unmanned aircraft follow a flight path and gather photographs of the surrounding area. Open source flight-control software ArduPilot is used to program waypoints into the unmanned aircraft using GPS coordinates. The team edited the software to handle directions for two unmanned aircraft, and modified it to output a data log.

ArduPilot transfers the gathered imagery and unmanned aircraft statistical data to a mission planner software program coded in C++. The mission planner software displays aircraft velocity, elevation, battery life and photos via a graphical user interface, and generates a report for subsequent analysis and processing by proprietary software provided by the sponsor.

SHALLOW GROUND NATURAL GAS AERATION IMPROVEMENT

TEAM 17045
SPONSOR MENTORS: Philip James Ciuffetelli, Dominique Mitchell, Josh Spivey

PROJECT GOAL: To design and build a more efficient and cost-effective system for aerating natural gas from saturated soil.

Underground natural gas leaks cause the surrounding soil to become saturated with gas. If a gas leak occurs at a facility owned by the sponsor or one of its customers, the sponsor can remove the natural gas safely with aeration equipment.

The aeration ejector uses the Venturi effect to force compressed air through an inlet nozzle designed to choke the flow and cause a pressure drop, which draws the natural gas out of the ground and into the second-stage nozzle before it is ejected through the diffuser to the atmosphere.

To ensure the new design improved the efficiency of the old design, the current system was modeled in SolidWorks and complex flow simulations were conducted. Pressure gauges were used on the current system to validate the accuracy of the simulations. Simulations of the new design were used to optimize the internal geometry. The new system will save time, money and energy because it extracts the natural gas more efficiently.
TISSUE THICKNESS ANALYZER
TEAM 17046
SPONSOR MENTOR: Dianne Pistone

PROJECT GOAL: To design and implement a tool for measuring the thickness of histological tissue sections on a microscope slide.

Tissue samples in a given protocol are processed in an identical fashion, but their thickness might vary. This inconsistency could influence the final staining results and, therefore, the resulting diagnosis. Mitigating this inconsistency requires determining variations in thicknesses by directly measuring the samples before they are processed.

The design uses near-infrared reflectance confocal microscopy. A near-infrared laser is focused on the tissue section as it moves through the beam. Movement is tracked using a differential micrometer paired with a rotary encoder. As the index of refraction changes, particularly at the top and bottom interfaces of the section, the laser is reflected onto a photodiode. Microscope objectives and a spatial filter are used to reduce noise, increasing sensitivity and signal-to-noise ratio. The thickness of the section is calculated by tracking how far the stage has moved between the strong signals corresponding to the bottom and top of the section.

TEAM MEMBERS:
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Zachary Garrett  Optical Sciences & Engineering
Meagan Jennifer Holmes  Systems Engineering
Jillian Nguyen  Optical Sciences & Engineering
Kenneth Edward Schackart  Biosystems Engineering

COLLEGE MENTOR: David Gilblom

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MICROFLUIDIC-BASED SYSTEM FOR MIMICKING HUMAN ORGANS
TEAM 17047
SPONSOR MENTOR: Yitshak Zohar

PROJECT GOAL: To develop a lung-on-a-chip that mimics the blood-gas exchange that occurs in the alveoli found in human lungs.

The microfluidic-based lung-on-a-chip provides researchers with a cost-effective device that enables real-time ex vivo assays of foreign agent effects on human lung tissue with an air-liquid interface.

Microfabrication techniques were used to create a device made of a clear, flexible and inert polydimethylsiloxane polymer. The device is composed of two stacked flow chambers separated by a porous membrane, which creates an air-liquid interface that mimics the lung’s alveoli. Epithelial lung cells on the top channel of the device are subjected to air flow, which recreates breathing motions, while the endothelial cells opposite the membrane are subjected to nutrient flow (that is, blood flow).

A system that achieved real-time monitoring of the lung tissue was tested and demonstrated an application of the lung-on-a-chip. This involved the introduction of e-cigarette aerosol particles to the air chambers and subsequent analysis of the cell characteristics. It was confirmed that the system design sustains a tissue monolayer in the microchannel under regular air and liquid flow for an extended period.

TEAM MEMBERS:
Fernando Daniel Albela  Biomedical Engineering
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Apoorva Bhaskara  Biomedical Engineering
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Adolfo Herrera  Mechanical Engineering
Meagan Thuy Tran  Biomedical Engineering

COLLEGE MENTOR: Brian O’Cain

WITH SUPPORT FROM:
ENTERAL FEEDING LOW-PROFILE GASTROSTOMY TUBE MEDICAL DEVICE

TEAM 17048

SPONSOR MENTORS: Ariana Lamanda, Meghan McGovern, Paul Melnychuck

PROJECT GOAL: To modify an existing low-profile gastrostomy tube system to include a reflux valve.

The primary function of a gastrostomy tube is to transfer liquid food and nutrients directly into the stomach through a stoma.

A new injection mold plate, core pins and cap molds were designed in SolidWorks and fabricated using silicon injection molding. Durometer analysis determined the optimal hardness of silicon needed to maintain the correct flexibility, sturdiness and biocompatibility that would ensure complete medical functionality.

The team designed a hub to house the sponsor-provided cross-slit petal reset valve, a cap that securely closes access to the stoma, and a set of core pins used to fabricate gastrostomy tubes of varying internal diameters. Pressurized leak tests and tensile strength tests were performed in accordance with Federal Drug Administration and medical device regulatory compliance standards. The testing was designed to verify that the new device is substantially equivalent to the existing device for future FDA regulatory approval and commercial viability.

TISSUE-REPLACEMENT CONTROL SLIDES

TEAM 17049

SPONSOR MENTOR: Dianne Pistone

PROJECT GOAL: To develop a material that can absorb tissue stains at an intensity less variable than human tissue, and that can withstand the physical and chemical processes encountered in staining equipment.

A limitation of histological staining technologies is the inherent variability in human tissue, which can cause deviation in staining results and introduce difficulties in cancer diagnoses.

The team developed a material that can absorb stains more consistently than human tissue. The lower variability of the material means that it functions as a control slide to identify instrument-induced stain intensity variation in diagnostic assays. The design incorporates polymers and cellulose compounds tested to be compatible with the acidophilic and basophilic properties of hematoxylin and eosin stains. These materials are adhered to glass microscope slides in sections under 100 microns thick in order to allow cover-slipping.

The assembled slides were tested in the HE 600 staining instrument to confirm their ability to withstand the various temperature and chemical conditions throughout the staining process. After staining, the material was subjected to image analysis to verify that the stained final product was less variable than the current control slides using human tissue.
EMBEDDED PLATFORM WEB SERVER OPTIMIZED FOR SECURITY

TEAM 17050

SPONSOR MENTOR: Glen Uehara

PROJECT GOAL: To create and run an embedded web server and HTML5 host on a small cyber-hardened “internet of things”-style device.

The proliferation of devices connected to the “internet of things” presents numerous security challenges. The team developed a web server and host on cyber-hardened device using components found in the Gumstix Autonomous Kit for Overo, including a Caspa VL camera, a Pre-GO GPS, an accelerometer and a gyroscope. The designed system gathers data relevant to an unmanned aircraft system application and transmits it securely to the client over Wi-Fi using authentication procedures and a secure communication protocol.

The device pushes data from the camera, GPS, accelerometer and gyroscope in real time, without the browser polling for this information. The client can use the web page to remotely view the output and status of each sensor and individually turn on and off data communication from each sensor. The system has been penetration-tested for security.

TEAM MEMBERS:
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Su Ean Lim Electrical & Computer Engineering
Qing Sunny Zhong Electrical & Computer Engineering

COLLEGE MENTOR: Sharon ONeal

WEB-BASED INTERFACE FOR DIGITAL MARITIME DISTRESS

TEAM 17051

SPONSOR MENTOR: Glen Abousleman

PROJECT GOAL: To eliminate the United States Coast Guard’s reliance on expensive proprietary software for digital distress signaling.

Digital selective calling is an international standard paging system used by the United States Coast Guard to automate distress and safety alerts sent over terrestrial medium-frequency, high-frequency and very-high-frequency marine radio systems. Most digital selective calling systems rely upon commercial off-the-shelf products with proprietary interfaces. The proprietary nature of these systems limits the ability for maintenance contractors to perform technology refreshes and improvements on Coast Guard systems.

The system designed uses an open standard radio interface for processing packetized digital selective calling data. The design incorporates a web-based graphical user interface that can send, receive and acknowledge digital selective calling messages. Processed messages are displayed in real time with a sortable 30-day message history. Archiving capability is included to allow the storage and retrieval of messages through an automatically generated file format.

TEAM MEMBERS:
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Michael P. Harmon Electrical & Computer Engineering
Derek McMullen Electrical & Computer Engineering
Carlos Perez Electrical & Computer Engineering
Muhammad Bilal Rao Systems Engineering

COLLEGE MENTOR: Claude Merrill
SECURE WIRELESS PROTOCOL

TEAM 17052

SPONSOR MENTOR: Glen Abousleman

PROJECT GOAL: To create a system of wireless transceivers that communicate with a fast, consistent stream to transmit acceptable quality audio.

The designed system consists of a microphone, computer and two speakers, each with its own wireless transceiver. The transmission is secured by use of an Advanced Encryption Standard protocol compatible with the transceivers. The intended system application is simplification of a dispatch center setup by reducing the wiring used for audio equipment. With this system’s integrated encryption, sensitive information can be transmitted securely.

To secure the transmission the design requires insertion of a physical encryption key to begin transmission. Using a physical rather than digital key eliminates wireless exchange of keys, reducing the likelihood of any transmission being compromised. Off-the-shelf components were modified to fit the requirements of the design. Testing of the system verified data transmission speeds and encryption methods. Additional testing quantified wireless transmission range and audio quality.

ADVANCED VOICE FILTERING USING MACHINE LEARNING

TEAM 17053

SPONSOR MENTOR: Michael Scott

PROJECT GOAL: To expedite cleaning of maritime distress signals without manual filtering.

Maritime distress transmissions received by the U.S. Coast Guard are subject to environmental noise and communication channel distortion, and must be filtered manually using current Rescue 21 software, which can be time consuming and imprecise.

This project uses deep learning to improve signal filtration. The core of the software is a denoising recurrent autoencoder, a machine learning model that recognizes and removes distortion from input audio files. Noisy distress signals are input into the team’s software and automatically filtered by the autoencoder, which generates a coherent, noiseless version of the input signal.

Testing required the software to process a 5-minute audio segment in under a minute while using less than 2 GB of local memory. The software is compatible with all operating systems used by the Coast Guard, including the existing Rescue 21 software.
CYBERSECURITY RISK PLANNER
TEAM 17054
SPONSOR MENTOR: Michael Taylor

PROJECT GOAL: To develop a cybersecurity risk-modeling tool that combines national standards to frame an original mathematical algorithm.

Cybersecurity risk can be difficult to anticipate and plan for, which is driving demand for more quantitative, repeatable and comprehensive methods of cybersecurity risk estimation.

The team developed a cybersecurity risk-modeling tool that combines the principles of National Institute of Standards and Technology Risk Management Framework and the Open Group Standard Risk Taxonomy to frame an original mathematical algorithm. The tool uses empirical data and a Monte Carlo simulation that runs more than 10,000 iterations to quantify the cybersecurity risk based on user-defined threat sources. It also defines predisposing conditions and countermeasures for a given system, a time frame for evaluation, and a potential monetary impact of exposure. The tool combines Python scripting and an SQL database to store data, run the simulation, and interface with the user. The report produced gives data on realistic impacts and likelihoods of risk and vulnerabilities, as well as risk-mitigation recommendations, in a format suitable for nontechnical users.

TEAM MEMBERS:
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COLLEGE MENTOR: Sharon ONeal

PRECISION DIAGNOSTIC REAGENT PACKAGE
TEAM 17055
SPONSOR MENTOR: Dylan Miller

PROJECT GOAL: To design, build and test a single-dose reagent package and corresponding table-sized dispensing equipment.

The package design requirements included ensuring proper volume for each dispense and maintaining material compatibility with the company’s proprietary chemical reagents. Pressure sensors in the dispenser confirm the presence of the reagent package and send a notification to the touch screen on the front of the product. The user can then start running the equipment.

The dispensing system consists of a roller on a conveyor that applies force to the top of the inserted reagent package. When the reagent package has been emptied onto the tissue slide, the graphical interface displays a status update and a green LED light to indicate that the system has finished. The dispenser, coupled with a simple reagent package, will help the sponsor evaluate the benefits and restrictions of using a single-dose package versus rather than its current bulk packaging.

TEAM MEMBERS:
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Max Fitzgerald Electrical & Computer Engineering
Estefania Cynthia Hurtado Systems Engineering
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COLLEGE MENTOR: Steve Larimore
CONTINUOUS FLOW SINGLE SLIDE HANDLING SYSTEM

TEAM 17056

SPONSOR MENTORS: Kenyon Kehl, Dianne Pistone

PROJECT GOAL: To design an automated system for placing slides in staining equipment.

Currently, microscope slides are removed from their containers and placed into staining equipment manually. This repetitive motion decreases efficiency over time and increases possibility of contamination and improper slide placement.

The design of this system focuses on integration and communication between the sensor system and the mechanical transfer system. Off-the-shelf components were used to build a sensor system to detect slide containers and microscope slides, and to read the barcode on each slide. Microscope slides within the working range are picked up by a gripper mechanism on a Cartesian-gantry robot system. Because the system is handling delicate objects, the gripper system is designed so that it does not damage the microscope slides or the tissue samples.

TABLETOP LASER FOUNTAIN

TEAM 17058

SPONSOR MENTOR: Colette DeHarpporte

PROJECT GOAL: To design a tabletop laser fountain to show additive color mixing in real time by using red, green and blue laser sources routed through a laminar flow water fountain.

The laser light travels through the water streams as though they are optical fibers and combines in a 3-D printed bowl that demonstrates the additive color-mixing properties of light.

The design uses laser diodes that are modulated using electronic driver boards to alter the amount of electrical current supplied to each laser diode. By altering the amount of electrical current, the perceived brightness of each laser changes and allows selective color mixing according to the color gamut created by the wavelengths of each laser source. Control of the color in the fountain is managed by manual slider switches that control the brightness of each laser, and via an Android app with digital sliders that send signals to a microcontroller running on an Arduino microprocessor.
LOW-COST MULTIFUNCTIONAL BENCHTOP TOOL FOR ELECTRONICS INSTRUMENTATION

TEAM 17059

SPONSOR MENTOR: Paul Frost

PROJECT GOAL: To design a benchtop tool that consolidates the functions of several different pieces of lab equipment.

Testing electronic equipment requires multiple instruments and a lot of bench space, so the team designed a benchtop tool that eliminates the need for so many instruments by consolidating the functions of several different types of common lab equipment into one benchtop enclosure.

The benchtop tool consists of a microcontroller and five submodules. The submodules operate as static and variable power supplies, a digital multimeter, a function generator, and a digital logic analyzer. A printed circuit board was designed for the circuitry of the individual submodules and microcontroller so that individual components of the submodules were electrically connected to each other. The benchtop tool connects to a computer, which allows the user to interact with the benchtop tool via a graphical user interface created using LabVIEW.

TEAM MEMBERS:
Alexander J. Barber  Electrical & Computer Engineering
Jero D. Delos Santos  Electrical & Computer Engineering
Chad Lacy  Electrical & Computer Engineering
Mikael Nocos  Electrical & Computer Engineering
Kathleen Spencer  Electrical & Computer Engineering

COLLEGE MENTOR: Elmer Grubbs

MODULAR PAYLOAD BAY FOR UNMANNED AIRCRAFT SYSTEMS

TEAM 17060

SPONSOR MENTOR: Dana Cordova

PROJECT GOAL: To design and build a cylindrical modular payload bay for a generic unmanned aircraft system.

The payload bay accommodates three different but interchangeable payload modules that each use a different communication protocol and have individual functions. This modular system allows the operator to quickly change the configuration to match mission requirements.

The design required trading material selection and design concepts to create a payload structure that can survive the shock of a hard landing while being as light as possible. Use of finite element analysis optimized the weight and strength of the structure. The software written allows the payload bay computer to recognize which slots in the payload bay have modules and which communication protocol each module is using. The payload bay computer communicates with each module individually or with all three simultaneously. A prototype bay was built and tested.

TEAM MEMBERS:
Nelson Alexander Alfaro  Mechanical Engineering
Benjamin Honea  Mechanical Engineering
Riley Kechely  Mechanical Engineering
Michael Floyd Mellen  Systems Engineering
Julian L. Ramirez  Electrical & Computer Engineering
Nicholas D. Wohlleb  Electrical & Computer Engineering

COLLEGE MENTOR: Steve Larimore
VIRTUAL REALITY SYSTEM FOR ANALYZING HUMAN BRAIN NEURONAL NETWORKS

TEAM 17061
SPONSOR MENTOR: Nan-Kuei Chen

PROJECT GOAL: To integrate high-resolution magnetic resonance imaging scans into a virtual reality platform.

Visualizing high-resolution MRI scans of white matter tracts in the brain via a virtual reality platform allows students and researchers to learn about and interact with 3-D imaging data.

The virtual reality platform provides an immersive visualization of fiber tract maps acquired by diffusion tensor imaging, and provides interactive tools for education and research to develop a better understanding of brain regions. The educational modules feature a dynamic menu that displays information on the brain regions as the user moves through the simulation. This platform comes with a Python-based file-conversion tool that allows users to load new MRI scans. The design uses the Unity game engine, which allows the platform to run the full version using the Oculus Rift headset, and a smaller streamlined version as an Android mobile application.

MACULAR DEGENERATION EVALUATION SYSTEM

TEAM 17062
SPONSOR MENTOR: Robert Snyder

PROJECT GOAL: To design a perfusion system for the dynamic culture of retinal pigment epithelial tissue that allows protein quantification.

Age-related macular degeneration is the leading cause of blindness among older adults in the United States. The designed system will contribute to a better understanding of cell behavior and function, and could lead to preventative treatment.

The system built allows liquid media to feed retinal pigment epithelial cells growing inside a customer-furnished perfusion chamber. The design uses a flow-rate model to determine optimal pumping rate based on tubing specifications, and incorporates an automated collection carousel to gather hourly samples of proteins emitted from the perfusion chamber. Proteins are sampled using a microcontroller to rotate a collection plate mounted upon a stepper motor shaft. The user can control how often protein samples are collected by modifying the software read by the microcontroller. The proteins can later be quantified from the liquid samples to provide more in-depth information about tissue-substrate interaction.
AUTOMATED INTELLECTUAL PROPERTY PROTECTION OF OPEN-FRAME PRINTED CIRCUIT BOARDS

TEAM 17063

SPONSOR MENTOR: Dan Reid

PROJECT GOAL: To design a new manufacturing tool to automatically dispense encapsulating epoxy onto open-frame printed circuit boards.

Manufacturers are concerned about protecting intellectual property, or IP, which can be compromised by reverse engineering of electronic hardware. The team developed an encapsulating device that protects IP quickly and economically.

The design combines two industry-standard technologies into one easy-to-operate system: a precision x-y translation stage and a bulk-adhesive pressurized delivery vessel. The x-y translation stage allows customizable shapes and areas of epoxy application onto the printed circuit boards, while the dispensing pressure vessel brings uncured epoxy to the printed circuit boards at flow rates that can keep up with the manufacturing line. The machine’s versatility yields additional manufacturing cost savings by eliminating the need to fill syringes or move the boards to custom trays.

TEAM MEMBERS:
Gabrielle Casini  Biomedical Engineering
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Duncan A. Reed  Electrical & Computer Engineering
Wei Ren  Mechanical Engineering
Guillermo Silva Rosas  Mechanical Engineering

COLLEGE MENTOR: Claude Merrill

AUTOMOTIVE SENSOR FUSION COLLISION-AVOIDANCE SYSTEM

TEAM 17064

SPONSOR MENTORS: Jacob Freet, Anthony Vaughan

PROJECT GOAL: To design and test a lidar and sonar collision-avoidance system for vehicles.

The main components of the design include a Texas Instruments Hercules microcontroller, a TI time-to-digital converter, a Hall effect sensor, optical components for the lidar system, and an off-the-shelf sonar sensor. The distance is measured from the car to an obstacle and the car stops to avoid any possible collisions. The system determines the speed of the car by analyzing the duty cycle of the frequency created by magnets connected to the drive shaft of the car passing by a Hall effect sensor. The system uses this speed and the distance from the object to calculate when the brakes need to be applied in order to avoid collision with the object. Information from the car, including the distance from obstacles and speed of the car, is transmitted via Bluetooth to a PC that displays the information on a graphical user interface.

The system has been tested using a remote-controlled car. The test system can detect objects within 10 feet of the front of the car and 3 feet of the back of the car. Using the information collected from the sensors, the system can stop the car within 5.2 inches of the obstacle, with a tolerance of half an inch. This system is scalable for a real-world application and will be taken to automotive trade shows.
HYBRID QUADROTOR UNMANNED AIRCRAFT AERODYNAMIC AND PERFORMANCE ANALYSIS

TEAM 17065
SPONSOR MENTORS: Justin Armer, Aaron Farber, Michael Balthazar,

PROJECT GOAL: To obtain experimental data for lift, drag and 3-axis moments of inertia for one quadcopter rotor at various motor speeds, air speeds and angles of attack.

The team designed a test apparatus for a single rotor of the quadcopter and tested it in the University of Arizona subsonic wind tunnel. Design requirements included size, vibration frequencies to avoid, cost, and wind tunnel compatibility. Thrust testing conducted inside the wind tunnel determined the position and size of the model. Data was recorded using a load cell and analyzed using a Microsoft Excel model.

To understand the vibration that the model would experience at various motor speeds and to ensure the safety of the wind tunnel equipment, accelerometers were mounted on the test model, which was mounted to a sturdy grounded beam. MatLab was used to analyze the data and provide wind tunnel personnel with the information they needed to approve use of the equipment. The sponsor will use data recorded by the wind tunnel balance to optimize autopilot control algorithms for smoother and safer transition events.

INSTALLATION DESIGN OF PHASE CHANGE MATERIAL IN RESIDENTIAL HOMES

TEAM 17066
SPONSOR MENTOR: Kyle Yamamoto

PROJECT GOAL: To evaluate the performance of a phase change material and develop a set of design options for installation in pre-existing residential homes.

The design incorporates the phase change material into a multipiece interior design concept, allowing flexibility for Salt River Project and its customers. Unlike traditional thermal modeling, special software was used to simulate the phase change material transitioning between solid and liquid states. A small-scale physical model was built to collect and compare data to that from the thermal analysis model. The physical model simulates a life-size residential room and a room within the thermal analysis model. Through specific designs or combinations of pieces, the results have shown the quantity of phase change material required to shift electrical loads to nonpeak hours, which will enable Salt River Project and its customers save energy and costs.

TEAM MEMBERS:
Nofal Najeeb Alkhunaizi  Engineering Management
Nicolas Balda  Mechanical Engineering
Tyler Michael Fraley  Industrial Engineering
Alexander Gill  Mechanical Engineering
Tanya Cheyenne Turner  Mechanical Engineering
Lorelei Mei Wong  Industrial Engineering

COLLEGE MENTOR: Steve Larimore
BLAST VIBRATION MODELING WITH RADAR
TEAM 17067
SPONSOR MENTORS: Seth Gering, Johnny Lyons-Baral

PROJECT GOAL: To evaluate the capability of the IBIS-FB radar in predicting vibrations during blasting.

A secondary objective was to develop a centralized data interface system to handle data from seismographs and the IBIS-FB. Data was collected using the IBIS-FB and seismograph concurrently at a local mine. Because the radar transmits unidirectionally and seismographs read tridirectionally, the radar and seismograph were aligned in the radial direction. Analysis was done by creating regression curves plotting peak particle velocity against scaled distance for the radar, the seismograph, and a set of combined radar and seismograph data. The database created was used to build a heat map of the propagation of blast vibrations using seismographs or radars, or both. Blasting parameters were run through empirical models based on the developed regression curves and target digital terrain model to generate peak particle velocity versus scaled distance predictive heat map overlays.

COLLEGE MENTOR: Rodger Elkins

ROBOTIC ARM FOR FIBER-OPTIC COUPLING MANIPULATION IN VACUUM
TEAM 17068
SPONSOR MENTORS: Michael McCraig, Vishnu Reddy

PROJECT GOAL: To develop a system that allows autonomous fiber-optic cable exchanging within a vacuum environment, and to develop fiber-optic pass-through that allows the system to exchange signals through a vacuum wall.

Accurate angular positioning of light-collection fibers relative to both source and sample had to be established so that light from the source reflecting off the sample was properly characterized. The team designed an autonomous data-collection system to measure spectral reflectance for recovery of a sample’s bidirectional reflectance distribution function, or BRDF. A fiber-caddying system was designed to allow the programmed arm to select one of the system’s three data-collection fibers. The fiber was moved to precise locations to facilitate measurements of the sample’s reflection across the fiber’s effective spectral region. The used fiber was remounted and the next fiber selected for use.

A custom CF flange (a type of industry-standard vacuum flange) containing fiber-connection points and epoxy-sealed windows was designed, and two ThorLabs CF flanges were purchased to maximize outgoing transmission without compromising the vacuum seal. Tests were performed on the designs for the autonomous BRDF vacuum-measurement system to ensure reliable fiber interchange and maximal spectral reflectance recovery.

TEAM MEMBERS:
Julian Xavier Avitia  Systems Engineering
Juan Carlos Burrola  Mining Engineering
Pulmi Pudara Jayasinghe  Engineering Management
Megan Patrice Kittredge  Mechanical Engineering
Kolton Paul McMahon  Mining Engineering
James David Nekoliczak  Mechanical Engineering
Chimezie Okorod Odike  Mining Engineering

COLLEGE MENTOR: Doug May

TEAM MEMBERS:
Justin Carlson  Electrical & Computer Engineering
Erin Nicole Clark  Optical Sciences & Engineering
Christopher Class  Mechanical Engineering
Nicolas Colon  Mechanical Engineering
Ramsey Lawrence Hastings  Mechanical Engineering
Chris McCarthy  Mechanical Engineering

COLLEGE MENTOR: Rodger Elkins
INFRARED MEASUREMENT SYSTEM FOR VISIBLY OPAQUE FREEFORM WINDOWS

TEAM 17069

SPONSOR MENTOR: Jake Beverage

PROJECT GOAL: To test visibly opaque windows by flexible optical ray metrology using an infrared camera with a thermal source, to improve test usability by automating test window positioning, and to quantitatively characterize test subsystem performance.

Flexible optical ray metrology measures complex aspheric windows in transmission. The transmitted wavefront error and surface quality of these windows are determined by measuring off-nominal deflections of a known patterned source.

Tightly tolerated spatial control of the optic in pitch, yaw and roll was achieved by designing a kinematic optical mount for the freeform optic under test. A software package and graphical user interface were created in LabView to automate spatial positioning of the optic and subsequent image acquisition. Mechanical performance of the motorized optic mount was characterized with a laser tracker, and an infrared modulation transfer function test was designed and implemented to verify optical performance modeled in Zemax. The improved flexible optical ray metrology system overcomes challenges associated with freeform window metrology, and could lead to higher-quality fabrication processes for visibly opaque conformal windows.

TEAM MEMBERS:
Lucas Heppner Electrical & Computer Engineering
Lennon Reinhart Optical Sciences & Engineering
Lucas Sanchez Electrical & Computer Engineering
Andrew Steuer Mechanical Engineering
Karen M. Ward Optical Sciences & Engineering

COLLEGE MENTOR: Mike Nofziger

ACTIVE VIBRATION CONTROL FOR IMAGING SYSTEMS

TEAM 17070

SPONSOR MENTOR: Jim Bakarich

PROJECT GOAL: To design an active vibration control system using inertial measurement units to detect motion changes of the camera.

Active vibration control is designed to remove the small pixel blurs on the detector of a camera system when imaging an object. When the system is mounted on a vehicle and a camera is imaging an object far away, image blur is more likely because sensitivity increases with distance. Conventional active vibration control systems use passive gyroscopic means to eliminate the imaging errors.

The inertial measurement unit sends binary code to a motor-control unit, and a control loop algorithm pushes commands to the three individual motors. A fabricated three-axis gimbal is used to mechanically account for image stabilization. The camera itself allows for some built-in optical image stabilization, and the inertial measurement units facilitate an electronic approach to mitigate vibrational errors in the system. The active vibration control system mounted on an unmanned aircraft will correct for pitch, yaw and roll to allow imaging of an object 300 meters away with a standard digital camera.

TEAM MEMBERS:
Cesar A. Aguirre Acuna Electrical & Computer Engineering
Feibien Cheah Optical Sciences & Engineering
Asa Edwin Farrington Mechanical Engineering
Aaron C. Kwan Mechanical Engineering
Ashley Nied Optical Sciences & Engineering

COLLEGE MENTOR: Doug May
NONINTRUSIVE HUMAN DETECTION SYSTEM

TEAM 17071

SPONSOR MENTOR: Jim Bakarich

PROJECT GOAL: To design, build and test a standoff noninvasive system to detect people hidden in vehicles.

The system uses an ultrawideband radar sensor to detect the minute movements of the human chest caused by breathing or a beating heart. The radar sensor operates at a frequency of 6–10 GHz with a 60-degree arc and a maximum sensing distance of 9 meters. The returned signal is processed by an on-sensor advanced reduced instruction set computer machine processor with Doppler signal-processing algorithms.

These processed signals are sent to a microcontroller that looks at the baseband amplitudes to determine respiratory or heartbeat spikes that would indicate human presence. Once processing is completed, the number of detected presences is shown on a touch screen display. The touchscreen display also allows users to control the system, which is water-resistant, portable, easy to train on and use, and capable of working on cars, pickup trucks and sports utility vehicles.

TEAM MEMBERS:
Casey M. Anderson  Electrical & Computer Engineering
Matthew J. Burrell  Electrical & Computer Engineering
Keeli Ginsbach  Systems Engineering
McKenzie Diane McDaniel  Mechanical Engineering
Daniom Tecle  Biomedical Engineering
Spencer J. Valancius  Electrical & Computer Engineering

COLLEGE MENTOR: Bob Messenger

SOFTWARE-CONTROLLED DIGITAL OSCILLOSCOPE

TEAM 17072

SPONSOR MENTOR: Patrick Edwards

PROJECT GOAL: To design, build and test a lightweight and portable oscilloscope in a price range suitable for both hobbyists and engineers.

Oscilloscopes are essential for circuit analysis, but their bulk, expense and reliance on a power outlet often confine their use to the laboratory. The product designed, called the µScope, has two subassemblies: the simplified hardware and a graphical user interface to display its voltage readings. A printed circuit board was created to implement the input-phase circuitry for adjusting voltage readings to ranges readable by the analog-to-digital converter.

All conversion was then performed via the firmware and sent to the microcontroller using serial peripheral interface protocols. Measurements are read by connecting the µScope to a computer via USB cable and signals are viewed in a graphical user interface, which was designed in LabVIEW because of its high compatibility with other system components.

TEAM MEMBERS:
Adam Ali Awale  Electrical & Computer Engineering
Yogesh Budathoki  Electrical & Computer Engineering
Hanlin Chen  Electrical & Computer Engineering
Jian Jiao  Electrical & Computer Engineering
Andrew Miller  Electrical & Computer Engineering
Merium O. Morell  Electrical & Computer Engineering

COLLEGE MENTOR: Elmer Grubbs
ACTIVE DRONE DENIAL
TEAM 17073
SPONSOR MENTOR: Jim Bakarich

PROJECT GOAL: To design and build a prototype system to disable unmanned aircraft.

The Federal Communications Commission has begun regulating unmanned aircraft but they can still cause harm in the wrong hands. The system designed disables communication between the remote controller and the unmanned aircraft and aims to prevent this potential harm. Communication is disabled using a high-powered router that emits the same frequencies as unmanned aircraft that operate at 2.4–5.8 GHz. The frequency is amplified and transmitted by a high-power directional antenna. Amplification ensures that the frequencies overpower the controller’s transmissions and that path loss is reduced throughout the transmission. The design includes a control system with an LCD screen, which is used to direct the transmission toward the unmanned aircraft and for active amplification of waves via mechanical switch. Once the amplifier is activated, the unmanned aircraft is unable to register the controller’s commands, causing it to fall from the sky or return to its user.

PORTABLE DEVICE TO MEASURE MUSCLE FORCE
TEAM 17074
SPONSOR MENTOR: David Margolis

PROJECT GOAL: To create a neurodiagnostic research suite to study nerve recovery and repair in animals.

The system enables a repaired nerve and the corresponding muscle it innervates to be characterized by studying two parameters: nerve conduction velocity, the speed at which the action potential propagates down the nerve; and muscle contraction in response to different frequencies, durations and amplitudes of stimulation.

A force sensor is attached surgically to the subject’s severed tendon at the insertion end of the muscle. Muscle contraction generates a force that is amplified and transmitted to a computer. Electrodes connected to an oscilloscope are placed in the subject’s muscle to study electrical stimulation. A surgical stage, which includes a heating pad and sensor to control the subject’s temperature, holds three different subject sizes in place while testing.

Data collected is processed by an Arduino and displayed on a computer via a graphical user interface that allows the user to control the subject’s temperature and stimulation characteristics. The system was not tested on animals, but on models that replicated what would occur during actual use.
**THERMOGRAPHY AUTOMATION FOR ELECTRIC POWER DISTRIBUTION**

**TEAM 17076**

**SPONSOR MENTOR:** Andy Griffis

**PROJECT GOAL:** To design, build and test a prototype of a low-cost monitoring system to provide 360-degree thermal and visual field surveillance of an electrical substation.

High-resolution thermal imaging is an informative yet expensive imaging technique to monitor electrical substation performance. The designed system provides security and monitors high-voltage equipment life to prevent component failure.

The system transmits visual and thermal video data to a server, and a graphical user interface displays the two video feeds and graphical thermal data. The design allows the camera system to operate with a cost-effective long-wave infrared system that output an improved resolution in long-wave infrared up to 640 by 480 pixels, and dual camera long-wave infrared/visible feed for security and thermal data purposes.

**TEAM MEMBERS:**
- Abdalrahman A. Albthali Electrical & Computer Engineering
- Dallon Dray Lines Electrical & Computer Engineering
- Matthew N. Mardesich Optical Sciences & Engineering
- Micaehla Rachel May Optical Sciences & Engineering
- Phillip McCann Material Science & Engineering

**COLLEGE MENTOR:** David Gilblom

**WITH SUPPORT FROM:**

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**ROBOTIC CADAVERIC GAIT SIMULATOR**

**TEAM 17077**

**SPONSOR MENTOR:** Dan Latt

**PROJECT GOAL:** To create a gait simulator to study how changes in foot alignment resulting from surgery or fractures affect pressure in foot joints.

Realistic gait is achieved by simulated muscle contractions created by linear actuators attached to each of four tendons. The system consists of the material testing system, the actuator assembly, and the computer software program that controls actuator sequencing. The material testing system provides axial loading on the foot during the simulated gait cycle. The system includes a graphical user interface that creates flexibility by allowing changes to amplitude of force applied by actuators, speed of actuator loading, and synchronization of the gait simulator and actuator control systems.

**TEAM MEMBERS:**
- Sara Marie McMahon Biosystems Engineering
- David William Norris Mechanical Engineering
- Michele Minh-Yen Tang Biomedical Engineering
- Thinh Quoc Tran Mechanical Engineering
- Austin Stephen Vedder Biomedical Engineering

**COLLEGE MENTOR:** Rodger Elkins

**WITH SUPPORT FROM:**
COMMERCIAL UNMANNED AIRCRAFT PARACHUTE SYSTEM
TEAM 17078
SPONSOR MENTOR: Pete Lauderdale

PROJECT GOAL: To design a fully autonomous parachute system for an unmanned aircraft system in distress.

The design required tradeoffs between material and system performance. Iterative testing established the most effective ejection method, and mathematical models determined the appropriate parachute size to meet the requirement for descent rate. Microcontroller firmware was written to filter and analyze the real-time sensor data. If the unmanned aircraft system exceeds manufacturer-specified flight envelope limits, the spring-loaded system rapidly ejects a parachute. The electronics package uses off-the-shelf sensor components and a commonly used microcontroller. The parachute is made of thin ripstop nylon strung with a combination of nylon and paracord. The entire system is contained in a custom plastic enclosure mounted to the unmanned aircraft system.

A functioning prototype was built using 3-D printed components. The design is based on the commercially available DJI Phantom, but is scalable for larger and heavier models and differing impact speeds.

LASER-GUIDED ANKLE POSITIONING FOR TOTAL ANKLE ARTHROPLASTY
TEAM 17079
SPONSOR MENTORS: Frank Barmes, Frank Bono, Shane Burnside, Daniel Lee

PROJECT GOAL: To design and construct an alignment guide for use in preliminary positioning and fixation of a surgical resection guide during total ankle arthroplasty procedures.

Alignment of the resection guide to the mechanical axis of the patient’s leg is crucial to proper bone removal for the implantation of an ankle prosthesis. Incorrect placement and malalignment of an ankle prosthesis can lead to severe complications in postoperative ambulation due to improper load bearing of the joint.

This device has been developed to be more accurate and less invasive than other products currently available. The mechanical alignment guide system consists of several custom-designed parts making up many common mechanical systems, such as a modified rack and pinion, hinge joint, and slider. Alignment of the system is completed about six degrees of freedom with tolerances of 2 mm and 2 degrees of three anatomical axes. A compact, easy-to-use design capable of withstanding multiple forms of sterilization has been implemented and proper use of the alignment guide is detailed in a surgical technique to be used by physicians.
CELESTIAL GLOBAL POSITIONING SYSTEM ANTI-SPOOFING

TEAM 17080

SPONSOR MENTORS: Jaime Lara, Daniel Okiyama

PROJECT GOAL: To design, build and test a celestial GPS antispoofering system to detect whether a satellite GPS signal has been spoofed.

The system must perform at night in an ocean environment without communication to offboard systems in order to avoid providing potentially biased results to the operator.

The antispoofering system uses images from an onboard camera, celestial mapping software, and image comparison software. All components, including a microprocessor to store the software, are housed in a custom waterproof case that can be mounted to the sponsor’s autonomous aquatic rescue craft, EMILY, which stands for Emergency Integrated Lifesaving Lanyard. The celestial mapping software produces an image of the celestial bodies that should appear overhead for a given time and location, while the image processor makes a comparison with the predicted celestial map to detect the presence of spoofing.

Test images of the night sky were captured over several months and a variety of weather conditions, and used as tools for the development and functional validation of the image processing software.

TEAM MEMBERS:
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Zachary Waters Optical Sciences & Engineering
Cameryn Yow Optical Sciences & Engineering

COLLEGE MENTOR: Greg Ogden

MOTORIZED RESCUE REEL

TEAM 17081

SPONSOR MENTOR: Daniel Okiyama

PROJECT GOAL: To design, build and test a motorized reel system that allows rescuers to bring the EMILY unit and drowning survivors back to shore.

A shortcoming of the Emergency Integrated Lifesaving Lanyard, or EMILY, developed by the sponsor for rapid deployment to save people from drowning, is that it cannot bring survivors back to shore.

Research, testing and data analysis were performed to determine the loads that the reel system would experience during a water rescue. Sponsor requirements included that the system weigh no more than 50 pounds and be portable by one person, and that it can operate in extreme heat and salt-water environments, which limited the materials that could be used. Evaluation of the selected materials’ thermal resistance, corrosion resistance and overall tensile strength was conducted to determine the best option. The information obtained was used to select a motor and develop the variable-speed controller, which maintains a constant speed during retrieval. The tests showed that as the rope is winched in, the increase in reel diameter increases the speed by more than two miles per hour. Limited system tests were performed to verify performance requirements.

TEAM MEMBERS:
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Ryan Bristow Mechanical Engineering
Yu-Hao Chang Electrical & Computer Engineering
Tyler Dean Mettey Electrical & Computer Engineering
Johnathan Rothpletz Mechanical Engineering

COLLEGE MENTOR: Steve Larimore
IPAD POINT-OF-SALE HARDWARE, FIRMWARE AND IOS APPLICATION

TEAM 17082

SPONSOR MENTOR: Kenneth North

PROJECT GOAL: To create a new USB point-of-sale hub that interfaces with existing peripherals and an iPad through a microprocessor.

The peripherals consist of a card reader, scanner, display, printer and cash drawer. The system translates the data collected from the scanner or card reader and displays it on the iPad. The system also takes data from the iPad and outputs it to a display or printer. The entire system meets the requirements of Apple’s Made for iPhone/iPod/iPad licensing program, and the app serves as an iOS demonstration program for the testing of the four peripherals.

SYSTEM FOR OPTIMIZING EFFICIENCY OF SOLAR SYSTEMS

TEAM 17084

SPONSOR MENTOR: Patrick Lee Kelley

PROJECT GOAL: To design, build and test a device to maintain the ideal temperature range of a solar panel and display the efficiency data on a remote device.

Solar panels potentially produce the most power during summer but heat decreases their efficiency as panel temperature climbs above optimal operating range.

The cooling system design uses a Peltier module to distribute a temperature difference across the panel, which enables the cooling system to increase the heat rate through the panel and accelerate heat ejection to its surroundings. While monitoring the changes in power efficiency and temperature, sensors relay data to a cloud-based server. This data is then presented to the user for review on a mobile application, which allows the user to view stored data, control system power, and monitor sensor errors.
COLLABORATIVE ROBOT VISION SYSTEM INTEGRATION

TEAM 17085
SPONSOR MENTOR: Carlos Ramos

PROJECT GOAL: To design, build and test a robotic quality-assurance system to streamline the sponsor’s manufacturing process.

The team designed a collaborative robot vision system integration consisting of a robotic arm integrated with visual part recognition, quality assurance, data logging, and part packaging. Each part being analyzed has a barcode that is scanned and logged in the packaging history. The designed system verifies, using 3-D analysis point clouds, that part pin dimensions and spacing meet the sponsor’s design parameters.

The system chooses parts from an incoming supply, inspects them for quality assurance, and places them in either a packaging carton or a disposal bin. Continuous processing is achieved by a gravity-fed chute system. Empty input containers and full output containers are pushed aside by the robot arm to make way for fresh containers. The system is ready for implementation in the sponsor’s factory.

TEAM MEMBERS:
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COLLEGE MENTOR: David Gilblom

CAPACITY-PLANNING SYSTEM OPTIMIZATION AND AUTOMATION

TEAM 17086
SPONSOR MENTOR: Oliver Koehler

PROJECT GOAL: To automate the sponsor’s capacity-planning system by implementing an accessible and user-friendly web-based form.

The sponsor runs an error-prone manual capacity-planning system using Microsoft Excel. The designed system includes backend and laser-marking capacity planning. An analysis of the sponsor’s current method was done in MatLab, and a simulation of the capacity planning was produced. The simulation was used to learn how to convert, process and interface the required information into a website. The designed web form consists of hypertext markup language graphic interfaces, C# backend computation, and an Oracle database that manages the data storage and interfaces with the web form using Structured Query Language. The web form allows multiple departments, such as human resources and sales, to enter data directly into the system within a certain time frame before a supervisor is notified via automated message. The system also checks if the input values fall within acceptable bounds.

TEAM MEMBERS:
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Julieta Alexandra Valenzuela Mechanical Engineering

COLLEGE MENTOR: Steve Larimore
SMARTPHONE-BASED STRESS MANAGEMENT AND INTERVENTION

TEAM 17087
SPONSOR MENTOR: Janet Wang-Roveda

PROJECT GOAL: To create a smartphone application with a graphical user interface that communicates with an external heart-rate sensor.

Stress negatively affects physical, mental and behavioral health. This heart-rate sensor can detect when a user is stressed and help lower their stress level via music therapy. The device designed employs an electrocardiogram sensor on the user’s chest to measure heart rate variability and transmit the data via Bluetooth to the application, which determines the user’s stress level. High heart-rate variability correlates to relaxation, while low variability indicates stress. If the application determines that the user is stressed, it will access an open-source third-party music application that will start playing music corresponding to the user’s musical interests to achieve quick and efficient stress management. The device quickly lowers stress and provides quantitative data that should further prove the effectiveness of music therapy for stress management.

MOBILE PROPELLANT-DENSIFICATION UNIT FOR ORBITAL CLASS LAUNCH VEHICLE

TEAM 17088
SPONSOR MENTORS: Jeremy Harrington, Alex Rodriguez

PROJECT GOAL: To design a mobile propellant-densification unit to provide support for the sponsor’s Vector-R launch vehicle.

Large, stationary propellant coolant units are commercially available but as space missions using compact satellites and launch vehicles become more viable, the need increases for ground support equipment that is small and mobile.

A full-scale system was designed. It was verified by a prototype that confirmed analyses and demonstrated functionality. This design used liquid nitrogen as the primary coolant, resulting in a compact heat exchanger and less process equipment. Analysis of the design was completed using Aspen, chemical process-modeling software, and SolidWorks simulations to verify that heat transfer and process calculations were accurate. The subscale prototype cools water while demonstrating the ideas and methodologies of the full-scale design. The prototype regulates using thermocouples, logic and variable frequency drives, allowing the system to operate autonomously.
WEARABLE SYSTEM FOR DETECTING EXTREMITY SWELLING

TEAM 17089

SPONSOR MENTOR: Marvin J. Slepian

PROJECT GOAL: To develop a wearable medical diagnostic device to measure reaction to venom injection, such as snakebites.

The designed system is a band that incorporates temperature sensors, infrared bead sensors, and strain gauges to measure body temperature, swelling and band tension. Measured parameters are sent via Bluetooth to a user-configured smartphone. All the metrics are displayed through a general user interface on the smartphone using the Swift 4 software application. The designed product, named SwellSense, provides a real-time monitoring system for victims of venom injection that will reduce costs and optimize patient treatment.

TEAM MEMBERS:
David Johnson  Biomedical Engineering
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Jacob P. Toman-Ibarra  Electrical @ Computer Engineering
Jacob Wait  Engineering Management
Gregory Wheeler  Biomedical Engineering

COLLEGE MENTOR: Rodger Elkins

WITH SUPPORT FROM:

OPTIMIZING PERFORMANCE OF WIND ENERGY POWER-ENHANCER SYSTEMS

TEAM 17090

SPONSOR MENTOR: Brett Krippene

PROJECT GOAL: To design a system that improves current wind energy technology.

Current technology was examined and analysis conducted to determine improvement areas. Fluid flow analysis provided understanding of how to manipulate wind coming from any direction. A model was created of the sponsor’s Windgrabber system that included the improved design. A rudimentary two-dimensional computational fluid dynamics analysis of the system identified the ideal design for the improved system. Through the fluid dynamics visualization, the deflector plates were positioned for optimal airflow to the turbine. A static computational fluid dynamics analysis was used to determine the pressure differentials of the turbine airfoils, and a similar analysis was performed to see how the air would flow in the Windgrabber scoop.

TEAM MEMBERS:
Jesus Alberto Casillas  Systems Engineering
Jesse Z. Chen  Mechanical Engineering
Mitch Delparte  Aerospace Engineering
Kyle Richard Gordon  Mechanical Engineering
Purna Kafley  Mechanical Engineering

COLLEGE MENTOR: Bob Messenger
NONCONTACT DETECTION OF BIOELECTRIC FIELDS

TEAM 17091
SPONSOR MENTORS: Gary Schwartz, Russell Witte

PROJECT GOAL: To design, build and test a noncontact bioelectric field detector that can display, record and monitor a person’s electrocardiogram.

The design uses an ultrasensitive shielded capacitor to detect the subtle change in voltage from the heart through air and skin. The capacitor analog output is converted to a digital output, filtered for noise, and then relayed to a computer to display the final electrocardiogram, or EKG, on the screen. The design allows two live electrocardiogram signals to be simultaneously displayed on the computer from two individual hearts. The device operates with a separation distance of 10 centimeters from the chest to the detector. Applications could include monitoring vital signs of pilots, a less intrusive test for children, and measurement of cardiac changes without affecting the patient under study.

MARKETING APPLICATION FOR THE INDEPENDENT BAKING INDUSTRY

TEAM 17092
SPONSOR MENTOR: Kay Diggs

PROJECT GOAL: To develop a web-based application to visit, browse, search and purchase baked goods, and to create accounts for vendors to advertise and sell baked goods.

Home and independent bakers struggle with visibility and have to compete with big businesses that spend millions on advertising. Tappetite, a virtual marketplace, allows bakers to build their shop digitally and acquire customers at a fraction of this cost.

The front-end development of the web application uses Hypertext Markup Language with Cascading Style Sheets. Data management is handled by JavaScript and Structured Query Language queries. The database is hosted on Google cloud servers, where much of the custom Tappetite code will be stored. Some third-party services will be used, such as Stripe, a payment processor to securely and seamlessly handle payment transactions and offload any liability for cybersecurity risks associated with handling client financial information. The system will use a third party in-application chat service called pubNub to ensure secure and confidential communication between vendor and consumer. Google application programming interfaces will be used to bring location-based services to the website, such as location-relevant search results and customer-delivery information.
DESIGN OF TAILINGS STORAGE FACILITY FOR AN OPEN PIT COPPER MINE
TEAM 17094
SPONSOR MENTORS: Chris Hatton, Brad Rastall

PROJECT GOAL: To design a new tailings storage facility for an Arizona open pit copper mine capable of holding 750 million tons of tailings produced in the next 50 years.

In the copper mining industry, about 98 percent of the material processed is considered tailings, or waste. A tailings storage facility is required to hold all of the waste material, which is saturated with processing solutions. Through analysis of the tailings material and the area’s hydrologic and geologic conditions, it was shown that centerline construction provides the required stability while remaining cost-effective. The design focused on stability and safety of the tailings, particularly under the most adverse weather and seismic conditions. This tailings storage facility used cyclone deposition and a cross-valley layout to further contribute to its stability and sustainability.

TEAM MEMBERS:
Priscilla Thalia Mendoza  Mining Engineering
Alexandra Katherine Nathe  Mining Engineering
Brody Margaret Rastall  Mining Engineering

COLLEGE MENTOR: Brad Ross

MINE PLAN FOR THE SAN XAVIER MINING LABORATORY
TEAM 17095
SPONSOR MENTOR: Brad Ross

PROJECT GOAL: To provide designs and plans for direction of the activities at the San Xavier Student Mine for the next 3 years.

The objective of the San Xavier Student Mine is to produce experienced engineers who are familiar with working in and around a mine site. The design reflects the limitations and freedoms provided by a student-run mine that operates 4 days a month and is not constrained by an ore body.

The excavation design used the 3-D computer-aided design program MineSight to project advances per month over the 3-year time period. The team conducted extensive geomechanical testing and monitoring of the mine site. Ventilation designs were created in VentSim using the 3-D edit model of pre- and postexpansion. Environmental controls were implemented to Mine Safety and Health Administration standards. Cash flow and production scheduling of proposed equipment and personnel were also considered.

TEAM MEMBERS:
Ian William Althoff  Mining Engineering
Elizabeth Ann Ehrlich  Mining Engineering
Patrick Fahrenbach  Mining Engineering
Corbin King  Mining Engineering

COLLEGE MENTOR: Brad Ross
SOCIETY OF MINING, METALLURGY & EXPLORATION STUDENT MINE DESIGN COMPETITION

TEAM 17096
SPONSOR MENTOR: Brad Ross

PROJECT GOAL: To take raw borehole data and design a mine based on given constraints, such as time and man-hour restrictions.

Borehole data was converted into a geologic block model, complete with ore grades. Using advanced 3-D modeling software and the block model data, pit pushbacks were designed and a life-of-mine plan was developed. Concurrently, a wash-plant upgrade and crusher overhaul were designed by analyzing the overall tons mined per hour. The final part of the design included coordination and design of haulage paths, recommendations for fleet upgrades and purchases, and design of waste storage dump piles. The final design resulted in a mine life of 71 years.

This project was submitted for the 2017-2018 Society for Mining, Metallurgy and Exploration/National Stone, Sand and Gravel Association Student Design Competition. The team placed within the top six teams internationally.

CLOSED-LOOP CONTROL SYSTEM FOR WING STABILITY

TEAM 17097
SPONSOR MENTOR: Eniko Enikov

PROJECT GOAL: To design, build and test a detailed control system within a wing model to discover the wing’s aerodynamic characteristics, such as frequency and flutter.

A closed-loop system was designed and implemented that would allow the wing to correct itself and remove any unnecessary flutter while optimizing flight conditions. The objective of this design is a closed-loop control system that stabilizes the wing section when the angle of attack is disturbed from its desired position. Sensors were placed on the top and bottom surfaces to measure the free stream velocity. Sensor data is sent to a proportional integral derivative controller, which generates the desired values.

TEAM MEMBERS:
Garrett Troy Anderson  Mining Engineering
Daniel James Challenger  Mining Engineering
Christopher Kelly Deuel  Mining Engineering
Sean Matthew Klasen  Mining Engineering
Nathan Luke Kraft  Mining Engineering
Jorge Enrique Loya Lopez  Mining Engineering
Miguel Angel Pugmire  Mining Engineering

COLLEGE MENTOR: Brad Ross

COLLEGE OF ENGINEERING
Aerospace & Mechanical Engineering

TEAM MEMBERS:
Eugenia Anane-Wae  Aerospace Engineering
Deepika Devaraj  Aerospace Engineering
Yahia Mahmoud Ghannoum  Aerospace Engineering
Matthew Austin Meschberger  Aerospace Engineering
Ryan Paul Richard  Aerospace Engineering
Kharan Singh  Aerospace Engineering
Ricardo Vega  Aerospace Engineering

COLLEGE MENTORS: Jules Garot, Robert Jacobi
PROJECT GOAL: To design a radio-controlled aircraft to AIAA requirements that helps simulate a cargo and passenger aircraft with fully integrated line-replaceable units.

The American Institute of Aeronautics and Astronautics Design/Build/Fly is an annual competition that provides students with real-world experience by giving them the opportunity to validate their analytic studies.

The objective of the 2018 competition reflects a demand in the aeronautical industry for line-replaceable units, which are components of an assembly that, upon failure, can easily be replaced to bring the assembly back to full functionality. Normally, any failed component means grounding the aircraft and shipping it to a repair facility for extensive and expensive repair. Line-replaceable units can be easily replaced on the line (airport) and the aircraft recommissioned, saving money, frustration and time. The team competed in Wichita, Kansas, in April 2018 against national and international schools in a competition that featured ground and air missions to demonstrate the capabilities of the aircraft.

TEAM MEMBERS:
Forrest William Carlton  Aerospace Engineering
Nathan Bradford Goss  Aerospace Engineering
Philip Bruce Lacovara  Aerospace Engineering
Zachary James Morrett  Aerospace Engineering
Timothy Morris  Aerospace Engineering
Dean Michael Sanderson  Aerospace Engineering
Steven Douglas Smith  Aerospace Engineering

COLLEGE MENTOR: Jeff Jepson

PROJECT GOAL: To merge the best aspects of fixed-wing aircraft and rotorcraft into a single unmanned aircraft system that can efficiently perform the roles of both types of aircraft.

In emergency search and rescue, fixed-wing aircraft conduct high-pass surveys over a large geographical area to locate injured people. Rotorcraft are then called in to provide aid or assess injuries in greater detail.

The unmanned aircraft system designed can hover and take off and land vertically while still being able to travel long distances efficiently. It has an aerodynamically optimized flying wing lifting-body geometry with a carbon composite construction. Four central ducted fans produce the majority of thrust during vertical flight and are assisted by two thrust-vectoring wing pods, one on each wing tip. During horizontal flight the wing pods rotate to provide forward thrust. The design reduces total system weight by 35 percent when compared to previous design iterations, while still providing increased overall performance. Flight-testing demonstrated that implementing an autopilot system made the aircraft more stable and easier to control.

TEAM MEMBERS:
Andrew David Getman  Aerospace Engineering
Austin Patrick Lara  Aerospace Engineering
David Charles Russell  Aerospace Engineering
Charles Edward Schied  Aerospace Engineering
Jesse Carlos Talamantes  Aerospace Engineering
Abduralhman A. Turkistanly  Aerospace Engineering
Bohdan Osyp Wesely  Aerospace Engineering

COLLEGE MENTOR: Sergey Shkarayev
VERTICAL TAKEOFF AND LANDING UNMANNED AIRCRAFT SYSTEM FOR TERRESTRIAL CLIFF EXPLORATION

TEAM 17100
SPONSOR MENTOR: Jekan Thangavelauthum

PROJECT GOAL: To design, build and test a high-endurance, low-cost unmanned aircraft system to explore and map difficult or remote terrain without disturbing wildlife or the environment.

The final design selected is a vertical takeoff and landing unmanned aircraft that can adjust the motor power distribution to fly as a fixed-wing aircraft. While soaring at cruise, the aircraft uses its carbon-fiber airframe and airfoil to maximize lift coefficients, plus a high-capacity lithium polymer battery for a flight time of 30 minutes. After arriving at its destination, it transitions to a quadcopter, and produces high-resolution photographs and first-person view video through an onboard flight computer system. Three different iterations of the aircraft, with increasing stability and performance, were designed, built and tested.

LARGE-SCALE UNMANNED AIRCRAFT DESIGN TESTBED

TEAM 17101
SPONSOR MENTOR: Sergey Shkarayev

PROJECT GOAL: To design a large-scale unmanned aircraft system to support flight-testing of newly designed parachute-recovery system.

To help mitigate the costs arising from failure of large-scale unmanned aircraft systems, the team designed the testbed to flight-test the autonomous parachute system designed by Team 17078.

A four-foot-diameter hexacopter was designed and built using mostly existing hardware. The structure was designed to protect essential, and costly, components from damage while allowing the inexpensive and easily replaceable frame to absorb the impact. Structural integrity was analyzed using finite element analysis. Motor testing was performed to validate the thrust outputs of all six motors to ensure accurate performance capabilities. Control configuration and system integration were finalized before flight-testing. The hexacopter design satisfied the requirements for parachute flight-testing.
DYNAMICALLY SCALED RESEARCH TESTBED

TEAM 17102

PROJECT GOAL: To design and construct three sets of 35-degree swept wings with varying flexibility that are compatible with the X-56A MUTT fuselage.

Although wings with high aspect ratios increase aerodynamic efficiency, the resulting large wingspans amplify the magnitudes of torsional and bending moments. The Dynamic Scaled Research Testbed is a one-third dynamically scaled fuselage modeled after the Lockheed Martin X-56A MUTT used to test these dynamic interactions.

Analytical methods are used to determine the required geometric and material properties of three different sets of spars, which dictate the stiffness of the corresponding wing. These analytical methods are then verified using numerical finite element analysis and ground testing. Sensors and additional avionics were designed and installed to record telemetry and flow conditions over the wing during flight-testing. Following extensive structural and electronic ground testing, flight tests were performed to validate the design and gather data for research. The upgraded testbed will allow researchers to gather flight data and contribute to the safe and effective use of flexible wings with high aspect ratios.

TEAM MEMBERS:
Mark Eugene Bowen  Aerospace Engineering
Jeremy Rey Correa  Aerospace Engineering
Joseph Scott McBroom  Aerospace Engineering
Cole Alexander Pedersen  Aerospace Engineering
Nathan A. Reiland  Aerospace Engineering
Gregory James Wilburn  Aerospace Engineering
Blake William Young  Aerospace Engineering

COLLEGE MENTOR: Hermann Fasel

EXPANSION OF THE GREENFIELD WATER RECLAMATION PLANT

TEAM 17103

SPONSOR MENTOR: Kim Ogden

PROJECT GOAL: To almost double the capacity of the Greenfield Water Reclamation Plant to 30 million gallons of reclaimed water per day, and 16 million gallons of biosolids per day.

The aim of the project is to expand the current capacity of the Greenfield Water Reclamation Plant from 16 to 30 million gallons of Class A+ reclaimed water per day annual average day flow, or MGD AADF. At the same time, the project investigated an increase in Class B biosolids from 8 to 16 MGD AADF. The expansion maintains the plant’s current Arizona Department of Environmental Quality standards, and does not disrupt existing operations.

Historic flow and wastewater characteristic data were analyzed, as were the processes in the plant to reduce energy and chemical usage. The designed process treats the influent wastewater using a combination of screens, grit removal, hydrocyclone separators, clarifiers, aeration basins, disk filters, and ultraviolet disinfection to remove microbes from the effluent. The sludge is treated using centrifuges and anaerobic digesters, then the Class B biosolids are sent to the landfill. The methane produced during this process is used to heat the boilers, which generate steam to heat the sludge. The excess methane is burnt off in flares. Chemicals used in the process include sodium hydroxide and sodium hypochlorite.

TEAM MEMBERS:
Mohammed Ismail Alsomali  Chemical Engineering
Stephen Jongwon Lee  Chemical Engineering
Emily Ester Ramirez  Chemical Engineering
Samantha Morgan Swan  Chemical Engineering

COLLEGE MENTOR: Kim Ogden
ARSENIC REMOVAL FROM GROUNDWATER IN THE BLACK CANYON CITY AREA

TEAM 17104
SPONSOR MENTOR: Kim Ogden

PROJECT GOAL: To design a process for removing arsenic from groundwater in the Black Canyon City area to meet maximum EPA contaminant limit standards.

Arsenic occurs naturally in groundwater but is especially prevalent in areas near mining operations. Long-term arsenic exposure has been linked to severe medical conditions, including cancer. This project creates potable water by removing arsenic from groundwater via four major processes: chlorination, adsorption, desorption and precipitation. Chlorination oxidizes arsenic, disinfects water, and lowers pH for optimal arsenic removal. Adsorption uses granulated ferric hydroxide to remove arsenic from the water, leaving an arsenic content that is below the maximum containment level and safe for human consumption. Desorption is performed when the adsorbent is saturated with arsenic so that the granulated ferric hydroxide can be regenerated and reused. Desorption produces a concentrated arsenic brine that can be further treated to precipitate out the arsenic as a solid to be disposed of as hazardous waste.

TEAM MEMBERS:
Nathan Bradley Arkwright Chemical Engineering
Kristen Culleen Hunn Chemical Engineering
Leah Rose Kaplan Chemical Engineering
Bryce Keller Royball Chemical Engineering

COLLEGE MENTOR: Robert Arnold

QUADRIVALENT FLU VACCINE PRODUCTION

TEAM 17105
SPONSOR MENTOR: Kim Ogden

PROJECT GOAL: To design an expansion to an existing production line that increases production of the flu vaccine by 50 million doses.

A shortage of vaccines with the correct strand predictions has made the 2017-2018 flu season more severe than usual. The vaccine is mass produced by pharmaceutical companies throughout the world using the strains predicted by the World Health Organization.

The new expansion sought to cut the production period in half. The new design allows the quadrivalent vaccines to be produced on eight lines, each including a virus injector, egg incubator, and egg harvester to create the initial vaccine serum, with two lines per strain. The process after the egg harvester involves several filtration techniques, including tangential flow filtration, ion exchange chromatography and size exclusion chromatography, which yield serum standards pure enough to be mixed with an excipient in order to be absorbed fully by a human body. The final 50 million doses will be sent to distributors, clinics and hospitals nationwide to solve the vaccine shortage.

TEAM MEMBERS:
Teagan Ashley Baacke Chemical Engineering
Elijah Blue Foster Chemical Engineering
Marissa Ann Gautier Chemical Engineering
Esteban Jimenez Chemical Engineering

COLLEGE MENTOR: Laura Chin
ARIZONA WASTEWATER TREATMENT PLANT EXPANSION

TEAM 17106

TEAM MEMBERS: Kyle Jordan Christie Chemical Engineering
Joseph Simon Schlosser Chemical Engineering
Erica T. Vanover Chemical Engineering
Brandon Nicholas Velasquez Chemical Engineering

SPONSOR MENTOR: Kim Ogden

PROJECT GOAL: To design an expansion of the Greenfield Water Reclamation Plant that doubles processing capacity, increases efficiency, and minimizes expansion cost while maintaining the quality of the discharged water.

The facility is rated at an average daily flow of 16 million gallons per day, or MGD, with a maximum hourly flow of 48 MGD. The expansion designed will handle an average daily flow of 30 MGD and a maximum hourly flow of 90 MGD. The plant’s current design allows it to meet current water quality standards, but its efficiency was improved during this expansion by making the facility more user-friendly, and by reducing the maintenance costs.

The team used a decision matrix to find an optimum design for each of the three objective areas, and suggested additional water-treatment technologies that could make the facility easier to operate.

TEMPORARY DISASTER-RELIEF HOUSING FROM REPURPOSED CARDBOARD

TEAM 17107

TEAM MEMBERS: Carter James Bakarich Chemical Engineering
Austin Mitchell Reed Chemical Engineering
Camille Afton Runge Chemical Engineering
Cherell Evonne Ward-Rucker Chemical Engineering

SPONSOR MENTOR: Kim Ogden

PROJECT GOAL: To create temporary disaster-relief housing from repurposed postconsumer cardboard.

The design of the shelter includes water- and fireproofing features that can withstand inclement weather and environmental hazards. The construction material is formed via pulping of recycled cardboard, which incorporates the removal of particulates, adhesives and pulp fibers that do not meet strength requirements. After cleaning and refining, the pulp is dried, rolled and formed into new paperboard, which is chemically treated to improve its resistance to water and fire. The paperboard sheets are then laminated into corrugated building blocks for the final shelter design. The engineered product is lightweight and allows rapid and cost-effective transportation to wherever it is needed. The use of postconsumer waste as a building material creates an inexpensive and environmentally benign means of providing shelter to those displaced by natural disasters and conflict.
SOLID-STATE FUEL CELL ENERGY PRODUCTION

TEAM 17108

SPONSOR MENTOR: Kim Ogden

PROJECT GOAL: To design a distributed generation fuel cell system to replace the fraction of energy that the University of Arizona currently purchases from Tucson Electric Power.

The design reacts methane and hydrogen in a reformer to produce hydrogen for the fuel cells’ feedstock and carbon dioxide as a byproduct. The hydrogen and carbon dioxide are fed to a pressure-swing adsorption column, which removes carbon dioxide, and the pure hydrogen is fed to the fuel cells. The process uses a solid-oxide fuel cell that reacts oxygen and hydrogen across a cadmium cathode to produce water and electricity, which is then fed to the University of Arizona’s power grid. Heat from the carbon dioxide is recovered by heating up the air feed to the fuel cell using a heat exchanger.

The addition of fuel cells around campus allows the University to be powered by green energy while reducing its electricity bill. The water produced as waste is reused in the heating and cooling system for the fuel cells.

ALKYLATION PROCESS DESIGN

TEAM 17109

SPONSOR MENTOR: Kim Ogden

PROJECT GOAL: To design an alkylation unit that produces 5,000 barrels of alkylate per day from a common olefin feedstock found in oil-processing plants.

This process converts light hydrocarbons (four-carbon chains) to a heavier hydrocarbon (eight-carbon chain), which is a preferred stock for blending high-octane gasoline to be used in airplanes and automobiles. The reactor and auxiliary units are to be placed in an existing refinery, so footprint and safety requirements are considered in the design. Sulfuric acid is used as a catalyst to run the process at reasonable operating conditions for a large-scale plant. Hydrofluoric acid can also be used, so a cost and safety comparison between the two was conducted.

The first reactant for this process, butylene, is commonly created in the separation of crude oil. Typically, lighter hydrocarbons are unusable in fuel blending due to their low boiling point, so heavier molecules are created to output a higher quantity of valuable product from the refinery. By reacting butylene with isobutane via a sulfuric acid catalyst, the two molecules combine to form an eight-carbon hydrocarbon generally referred to as octane, which is sent to a different area of the plant for blending into a variety of fuels. Most of this process was simulated in Aspen Plus software and checked against best industry practices. The project also analyzed and accounted for economics, safety, and environmental impact.
HIGH-EFFICIENCY BREWERY-DISTILLERY HYBRID

TEAM 17110

SPONSOR MENTOR: Scott Bemis

PROJECT GOAL: To design a high-efficiency brewery-distillery hybrid that produces 10,000 barrels of beer and 3,000 cases of whiskey annually.

The advantages of this hybrid are reduced energy and water consumption. The plant uses novel mash-filtration techniques to achieve nearly 100 percent yield of fermentable sugars from grains, which reduces raw material demand. Water is recycled through a reverse osmosis unit for alcohol production, ensuring quality of product and minimizing equipment downtime. The heat exchanger network is optimized to reduce heat duty requirements. The distillation column is designed to achieve maximum alcohol output while automatically separating the volatiles, products and waste.

The hybrid brewery-distillery process maximizes use of equipment, water and raw ingredients to increase the combined output of beer and whiskey while minimizing environmental impact.

TEAM MEMBERS:
Jacob Lee Gist  Chemical Engineering
Lucas Stuart Henry  Chemical Engineering
Erin Kay Looney  Chemical Engineering
Michael Jeffrey Volk  Chemical Engineering

COLLEGE MENTOR: Kim Ogden

SOLAR THERMAL ENERGY GENERATING SYSTEM

TEAM 17111

SPONSOR MENTOR: Kim Ogden

PROJECT GOAL: To design a solar energy plant that uses directed sunlight to produce electricity with zero emissions.

The plant uses sustainable technology and renewable energy to produce electricity. The design includes solar arrays that direct sunlight to heat molten salt in a closed pipe circuit. The molten salt passes through a heat exchanger that transfers the heat to carbon dioxide. The supercritical carbon dioxide is used to spin a turbine, creating usable electricity. This system does not use water in any form for electricity generation, and can operate during the night due to a storage system that retains the heat of the molten salt.

TEAM MEMBERS:
Braelyn Rose Holt  Chemical Engineering
Brent Tyler Morrison  Chemical Engineering
Eric Bryan Watson  Chemical Engineering
Austin Douglas Ziska  Chemical Engineering

COLLEGE MENTOR: Dominic Gervasio
MUSHROOM GROWTH WITH BIOGAS PRODUCTION FROM USED SUBSTRATE

TEAM 17112
SPONSOR MENTOR: Kim Ogden

PROJECT GOAL: To design a nearly carbon-free application to grow approximately 3 million pounds of mushrooms per year.

Recent developments in the field of medicinal mushrooms have shown that two species, commonly known as turkey tail and lion’s mane, are linked to possible cancer treatments, increased immune system function, and enhanced brain and liver function.

Both mushroom species are grown in a commercial atrium containing a humidifier and drip system to maximize growth. Nearly all the water used in this process goes to the growth of the mushrooms, while any excess is reused and filtered using reverse osmosis. The used mushroom substrate, which is made primarily of straw, is exposed to the cellulase enzyme, which breaks down the substrate into simple sugars that can be fermented into bioethanol. The process has been shown to be sustainable and economically efficient.

HYDRAULIC FRACTURING EFFLUENT TREATMENT SYSTEM

TEAM 17113
SPONSOR MENTOR: Kim Ogden

PROJECT GOAL: To develop a system that can treat effluent wastewater produced by hydraulic fracturing.

Effluent wastewater produced by hydraulic fracturing, or fracking, often contains high levels of salts, toxic metals, and radioactive particles. Treating this toxic wastewater so that it can be responsibly reused or disposed of in a cost-effective and environmentally safe manner is a hurdle that gas companies must overcome.

The design uses membrane distillation and crystallization in a system that can be easily transported and implemented for on-site treatment of fracking effluent. The treatment process will be able to generate 2,000 cubic meters of distilled water daily from effluent containing total dissolved solid levels that often exceed 100,000 parts per million.

TEAM MEMBERS:
Boubacar Diallo Chemical Engineering
Jason Jaruvang Chemical Engineering
Austin Edward Paciora Chemical Engineering
Michael David Rooyakkers Chemical Engineering

COLLEGE MENTOR: Kim Ogden
**MONOCLONAL ANTIBODY PRODUCTION FOR CANCER IMMUNOTHERAPY**

**TEAM 17114**

**SPONSOR MENTOR:** Kim Ogden

**COLLEGE MENTOR:** Roberto Guzman

**TEAM MEMBERS:**
- Karen Maria Leon  Chemical Engineering
- Samantha Louise Louzek  Chemical Engineering
- Jacob George Rischar  Chemical Engineering
- Sara Elizabeth Slosky  Chemical Engineering

**PROJECT GOAL:** To design a facility for large-scale manufacture of cancer immunotherapy drug bevacizumab.

Immunotherapy treats cancer by using the body’s immune system to attack cancerous cells. Monoclonal antibodies such as bevacizumab can stimulate this immune response. Bevacizumab treats glioblastoma as well as colorectal, lung, kidney, cervical and ovarian cancers by inhibiting the growth of new vascular tissue. In the United States, over half a million people are diagnosed with these types of cancer every year.

Bevacizumab is produced in a cascade of bioreactors charged with recombinant Chinese hamster ovary cells that proliferate and produce the antibodies, which are secreted into the extracellular medium. The secreted antibodies are purified using a process that involves centrifugation, affinity chromatography, ion exchange chromatography, and ultrafiltration. The final purified antibodies are freeze-dried and packaged in vials for shipment to healthcare providers.

**DESIGN OF A DIRECT POTABLE WASTEWATER REUSE FACILITY**

**TEAM 17115**

**SPONSOR MENTOR:** Kim Ogden

**COLLEGE MENTOR:** Kim Ogden

**TEAM MEMBERS:**
- Murad Ibrahim Attiah  Chemical Engineering
- Andrew Riley Dunn  Chemical Engineering
- Pablo Andres Espitia  Chemical Engineering
- Adrian Raul Ramirez  Chemical Engineering

**COLLEGE MENTOR:** Kim Ogden

**PROJECT GOAL:** To design a 25,000-gallon direct potable wastewater-reuse system for Biosphere 2.

Directly treating wastewater to produce potable drinking water is known as “toilet to tap” and is the basis of this project, which aims to make Biosphere 2 as close as possible to 100 percent self-sustaining in terms of drinking water.

The equipment was designed to treat the pathogens present in the water and to remove any harmful chemicals, solids or elements. The design incorporates an aerobic plug flow reactor, sludge-removal techniques, reverse osmosis, and ultraviolet and chlorine disinfection to achieve the potable water quality guidelines specified by the Environmental Protection Agency. The process was also designed to be economically feasible for Biosphere 2.
PRODUCTION AND COST ANALYSIS OF DIMETHYL ETHER FOR TRANSPORTATION

TEAM 17116

SPONSOR MENTOR: Kim Ogden

PROJECT GOAL: To design an economically feasible process to produce dimethyl ether for transportation fuel.

When dimethyl ether burns it produces virtually zero particulates and it has been suggested as a possible fuel for slightly modified diesel engines. The process designed feeds methanol through a catalytic reactor to create dimethyl ether, with water as a byproduct. A side-reaction from the catalyst produces methyl formate. Recycling the water produced by the reaction for various on-site uses will help save money and reduce the environmental impact of the process. Methyl formate has various industrial uses, as a blowing agent for foams or as an agricultural pesticide, for example. The economical production of dimethyl ether as a transportation fuel could have significant environmental benefits.

LIQUEFIED NATURAL GAS RECEIVING TERMINAL

TEAM 17117

SPONSOR MENTOR: Kim Ogden

PROJECT GOAL: To design a receiving terminal for large cargo ships carrying liquefied natural gas, or LNG, and a plant to vaporize it back to a gaseous state for distribution via pipeline.

Natural gas has to be liquefied cryogenically for transoceanic transportation by large cargo vessels. It then has to be vaporized so it can be transported in distribution pipelines.

Design optimization and regulatory factors were considered in the design of the LNG receiving terminal. Aspen Plus was used to model and optimize the thermodynamics of the process, which includes cryogenic factors. This allowed the team to determine the economic feasibility of the plant and to decide which vaporization process would be ideal for a plant of this nature. A plant was designed that can accommodate 12 LNG carriers and deliver 1.2 trillion MMBtus per day of vaporized natural gas.
PYROLYTIC CONVERSION OF WASTE BIOMASS TO JET FUEL
TEAM 17118
SPONSOR MENTOR: Kim Ogden

PROJECT GOAL: To design a process for converting guayule waste from biorubber production into biofuel in the form of gasoline, diesel and jet fuel.

The guayule plant, which is used to make biorubber, doesn’t need much water to grow, which makes biorubber an increasingly popular alternative to petrochemical rubber. Much of the waste from biorubber extraction, called “bagasse,” is discarded or reprocessed into low-profit secondary products. This design involves extracting, upgrading and refining hydrocarbons from the bagasse into biofuels.

Hydrocarbons are extracted by fast pyrolysis, which creates char (for fertilizer) and a bio-oil that is rich in hydrocarbons and unwanted oxygen. The oxygen is removed by hydrodeoxygenation using hydrogen gas, and distillation separates the upgraded oil by carbon-chain length to produce output streams of pure gasoline, diesel and jet fuel. Steam reforming the waste products yields hydrogen gas that can be recycled into the hydrodeoxygenation process.

TEAM MEMBERS:
Patrick Joseph Lohr  Chemical Engineering
Abdullah Qasem Matalgah  Chemical Engineering
Alexander J. Hartzog Piatkiewicz  Chemical Engineering
Armon David Tadj  Chemical Engineering

COLLEGE MENTOR: Kim Ogden

AUTOMATED AGRICULTURAL MAPPING SYSTEM
TEAM 17119
SPONSOR MENTOR: Samuel Peffers

PROJECT GOAL: To create a web-based mapping system that meets the needs of agricultural map-making.

Creating, saving and sharing data relevant to agricultural ranches in Arizona’s Yuma County involves multiple software applications and a lot of manual data capture. The data is imported into drafting software to create a map that shows boundaries, layout and information relevant to the agricultural ranch. These maps are then printed.

The Django web framework was used to develop a system incorporating all the current cartographic functions in a single web application that is executable in Windows 10 and on Samsung Android 5.0 and later tablets. Maps are created on a tablet using automated GPS, eliminating the need for multiple software applications in the field. Maps are saved in a MySQL database for registered users to see via the developed website.

TEAM MEMBERS:
Benjamin Lopez  Systems Engineering
Miguel Angel Maldonado  Systems Engineering
Martin Eduardo Martinez  Systems Engineering
Robert Davis Wilson  Systems Engineering

COLLEGE MENTOR: Samuel Peffers
IMPROVED IRRIGATION CANAL WATER-SAMPLING SYSTEM

TEAM 17120

SPONSOR MENTOR: Samuel Peffers

PROJECT GOAL: To minimize hazards, increase sampling location accuracy, and decrease cross-contamination when sampling irrigation canal water for microbial analysis.

Identifying pathogen vectors in commercial food production and supply chains is critical to maintaining food safety.

The designed system is an arm, with an adjustable reach to accommodate different canal widths, mounted on a base that can be positioned over the sampling location, which is scanned by a depth-detection sensor using a dual-beam transducer sonar. Arm and base are fabricated from ASTM A513 Grade B square tubular steel, with a tensile strength of 58 kilopounds per square inch and a flexile strength of 46 kilopounds per square inch. Samples are collected using a 1-liter Nalgene container with a custom closure cap that is 3-D printed in high-density plastic. A bicycle brake was repurposed to build the remote operation assembly, which opens and closes the submerged sample collector.

STEEL BRIDGE

TEAM 17121

SPONSOR MENTOR: Tribikram Kundu

PROJECT GOAL: To design and build a steel bridge with a span of 18 feet able to sustain a load of 2,500 pounds at varying locations along its span.

The bridge designed is the team’s entry in the 2018 National Student Steel Bridge Competition organized by the American Society of Civil Engineers and the American Institute of Steel Construction.

To simulate construction at a smaller scale, the bridge is broken up into members that fit within a box measuring 36 inches by 6 inches by 4 inches. Members are fabricated and assembled over a river on a mock construction site. Structural analysis software is used to model the bridge iteratively before selecting a final design for construction. The strength of the connections was calculated and subsequently verified through strain testing of sample specimens. The bridge, and bridges designed by the other 18 universities in the Pacific Southwest region involved in the competition, is judged according to criteria that include self-weight, stiffness, structural efficiency and construction economy.
ENGINEERING DEGREE PROGRAMS

AEROSPACE ENGINEERING
ARCHITECTURAL ENGINEERING
BIOMEDICAL ENGINEERING
BIOSYSTEMS ENGINEERING
CHEMICAL ENGINEERING
CIVIL ENGINEERING
ELECTRICAL & COMPUTER ENGINEERING
ENGINEERING MANAGEMENT
ENVIRONMENTAL ENGINEERING
INDUSTRIAL ENGINEERING
MATERIALS SCIENCE & ENGINEERING
MECHANICAL ENGINEERING
MINING ENGINEERING
OPTICAL SCIENCES & ENGINEERING
SYSTEMS ENGINEERING
After students are assigned to projects, teams work with their sponsors to generate structured lists of system requirements and metrics to evaluate final designs and prototypes.

Following approval of the Systems Requirements Memo, teams conduct research and brainstorm to produce a preliminary or conceptual design.

Based on feedback from sponsors and mentors at the Preliminary Design Review, teams modify their preliminary designs and generate detailed manufacturable designs to create prototypes for Engineering Design Day.

Following Critical Design Review and approval of the Critical Design Report, teams begin production of their prototypes by purchasing parts and manufacturing custom components in University of Arizona facilities.

During the last phase of the program, teams – in close collaboration with sponsors – assemble and test their prototypes. They also prepare their presentations and demonstrations for Engineering Design Day.

ENGINEERING DESIGN OPEN HOUSE

SYSTEM REQUIREMENTS
4 WEEKS

PRELIMINARY DESIGN
4 WEEKS

DETAILED DESIGN
6 WEEKS

WINTER BREAK

DESIGN CHANGES/ BEGIN BUILD
7 WEEKS

FINALIZE BUILD/ ACCEPTANCE TESTING
9 WEEKS

ENGINEERING DESIGN DAY

SYSTEM REQUIREMENTS MEMO
This structured document defines a sponsor’s requirements for completed projects. All designs, tests and prototypes are gauged against this document.

PRELIMINARY DESIGN REVIEW
This format review allows sponsors and mentors to critique conceptual designs, challenge assumptions and help teams refine their plans. All teams must obtain sponsor approval for their conceptual designs.

CRITICAL DESIGN REVIEW
This important milestone is when sponsors and mentors ensure their teams are meeting all requirements and have a feasible plan to manufacture and test a prototype within budget.

FINAL DESIGN PRESENTATION
This is the final formal opportunity for teams to receive feedback from sponsors and mentors on their projects and any last-minute changes.
STUDENTS
Projects exhibited today are the culmination of a year’s worth of work. Students have applied knowledge from the breadth of their undergraduate education, exercised outside-the-box thinking and spent hundreds of hours producing the best solutions for their sponsors. We applaud your dedication and professionalism and congratulate you on your achievements.

MENTORS
Project mentors apply hundreds of years of collective engineering experience to guide students in the completion of their projects. They ensure the implementation of industry standards in the design process. Their expertise in devising solutions to challenging problems adds a critical dimension to students’ engineering knowledge. Thank you for your hard work, your commitment to excellence in engineering design, and your role in the education of our students.

SPONSORS
Sponsors provide students with real-world questions and allocate funds to the program. They designate technical staff and mentors to steer students through the intricacies and requirements of their projects. Sponsors are a big part of what makes the Engineering Design Program at the University of Arizona what it is today – one of the largest and best-quality programs of its kind in the nation. Thank you immensely for your continued support.

JUDGES
The 120+ external judges who participate in Engineering Design Day supply independent professional assessments of the quality of students’ work. They help maintain the accreditation of undergraduate University of Arizona Engineering degree programs by providing insight and suggestions for improving the Engineering Design Program. Thank you for volunteering your time and applying your knowledge to evaluate students’ capstone projects.

STAFF
Dedicated professionals in the College of Engineering ensure the program’s smooth operation. They spend thousands of hours each year organizing events, communicating with sponsors, operating manufacturing areas, generating marketing materials and news, maintaining budgets and purchasing records, and performing a myriad of other tasks. Thank you all for your invaluable contributions and the excellence you bring to the program.
THANK YOU TO OUR SPONSORS

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From startups to Fortune 500 companies, more than 120 project sponsors have benefited from this outstanding interdisciplinary academic program throughout its 16-year history.

- Try out potential employees
- Explore new technologies
- Move products to market
- Support engineering education
- Boost company profile on campus

TRANSFERRING SKILLS TO THE WORKFORCE

Teams of four to six seniors mentored by industry liaisons and University of Arizona Engineering faculty spend an entire academic year taking your design projects – many of which become patented technologies and commercial products – from start to finish.

KEEP UP WITH DESIGN DAY EVENTS, TIMES AND DEMONSTRATIONS WITH THE APP

UA ENGINEERING DESIGN

Available on the App Store
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