CRAIG M. BERGE

ENGINEERING

DAY 2020

THE UNIVERSITY OF ARIZONA

Virtual Design Day will take place on May 5, after which project video presentations can be viewed at **page.video/UADesignDay2020**.

THE UNIVERSITY OF ARIZONA
COLLEGE OF ENGINEERING

Craig M. Berge Engineering Design Program

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Welcome to Craig M. Berge Design Day!

Nowhere is the ingenuity and resolve of College of Engineering students more pronounced than in this year's Design Day projects.

Design Day is one of the most memorable events for Wildcat engineers. This year for the first time, seniors are using videos to showcase their designs. While the presentation format is different, the tradition of excellence is as strong as ever.

These projects are a testament to the technical agility of our students and mentors. With just weeks remaining to complete yearlong projects, Interdisciplinary Capstone teams had to adapt to unprecedented COVID-19 restrictions -- social distancing, university facilities closures and online instruction. Final deliverables for a number of projects shifted. One team even pivoted to a 3D-printing process for protective face shields.

This Craig M. Berge Design Day is the story of remarkable student success.

Seniors are eager to share their videos, available at **page.video/UADesignDay2020** after the virtual awards ceremony on May 5. Cash prizes totaling $45,250 include the inaugural Craig M. Berge Dean's Award for Most Outstanding Project and the longtime award for Best Overall Design. Teams are recognized for developing the best systems for aerospace, biomedicine, sustainable manufacturing and energy production. Also honored are cyber warriors, exceptional leaders and champions of drone safety.

Design Day is a key part of the Craig M. Berge Engineering Design Program, in which all students get meaningful, hands-on experience throughout their undergraduate years.

We are grateful for the dedication and flexibility of program mentors, sponsors, judges, and staff – and tremendously proud our students' adaptability and perseverance.

Please join us in recognizing the incredible accomplishments of our seniors and celebrating all the good that engineers do. Bear Down, and support our Wildcat engineers!

David W. Hahn
Craig M. Berge Dean, College of Engineering

P.S. Because students prepared their project summaries prior to COVID-19 restrictions, some descriptions in this booklet may differ from the actual outcomes.

2020 FAST FACTS

115 DESIGN TEAMS

22 BIOMEDICAL PROJECTS

$45,250 IN PRIZES

625 STUDENTS

60 CORPORATE & UA SPONSORS

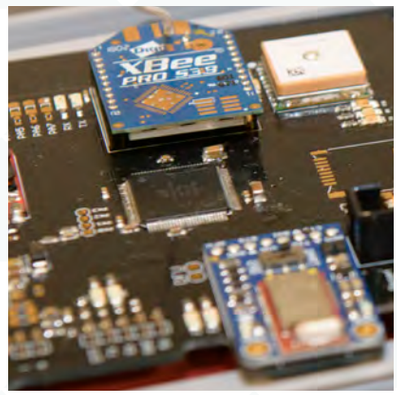
82 TECHNICAL JUDGES

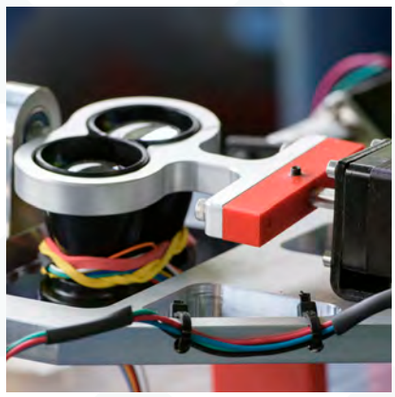
4 SPACE-RELATED PROJECTS

14 RENEWABLE ENERGY & ENVIRONMENTAL PROJECTS

> “These kids do such a good job, and it’s great value for the money.”
>
> – Frank Broyles, *Design Day project and prize sponsor*

PROJECTS





“We get students to solve real-world, applicable problems.”

– Jay Crossman, *Aviation Communications & Surveillance Systems*

AWARDS

Craig M. Berge Dean's Award for **MOST OUTSTANDING PROJECT**

($7,500)

This award recognizes the project that embodies the best attributes of engineering design and the engineering profession. The winning project shall have an outstanding design approach and implementation, excellent system modeling and/or analysis that support the design, comprehensive system testing that verifies system requirements, and a superior presentation of results to Design Day judges. Team members of the winning project shall present themselves professionally and clearly demonstrate engineering knowledge of the design. The winning project shall clearly be the best project at Design Day.

Raytheon Award for **BEST OVERALL DESIGN**

($5,000)

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 video presentation are professional and easy to understand.

Ball Aerospace 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. 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.

ACSS, an L3Harris and Thales Joint Venture Award for **MOST ROBUST SYSTEMS ENGINEERING**

($2,000)

The systems engineering perspective is based on systems thinking. When a system is considered a combination of elements, this thinking acknowledges the primacy of the whole in relation to those elements. This award goes to the team that most robustly addresses all aspects of the project from the systems perspective.

RBC Sargent Aerospace & Defense **VOLTAIRE DESIGN** Award

($2,000)

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.

Thorlabs and II-VI Optical Systems Award for **BEST OPTICAL SYSTEMS DESIGN**

(1st prize $1,500; 2nd prize $500)

This award recognizes the most innovative use of optoelectronics and optomechanics in a design and is given to the team that demonstrates the most thorough approach to the design and engineering of its optical system. 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.

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.

Andressen Award for **DESIGN ABOVE AND BEYOND**

($1,500)

This award recognizes a design solution that goes above and beyond the project requirements and produces results that may impact and/or be useful for other products and applications. Solutions that are sufficiently innovative for a potential patent application and that may form the basis of a new start-up 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 video 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 a professional presentation for the judging pod. The video should be visually interesting, and graphically well organized to tell a standalone story of the project.

Roche Tissue Diagnostics Award for **MOST INNOVATIVE ENGINEERING DESIGN**

($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.

W.L. Gore and Associates Award for **LIFELONG INNOVATION**

($1,500)

This award honors a student team that has improved or enhanced the quality of life for individuals through the outcome of their project. It recognizes the improved standard of health, comfort, environment, community, and happiness experienced by an individual or group. Projects are judged on the ability to promote the well-being of humans through togetherness and the practicality of the implementation. Teams should be able to effectively communicate their design and how it will improve lives.

Delta Development Team Award for **SUSTAINABLE MANUFACTURING INNOVATION**

($1,000)

This award is given to the team whose design incorporates the most innovative manufacturing method addressing reduced carbon emissions. Projects could include introducing a new technique for manufacturing or an innovative use of an existing technique that reduces the cost and improves the quality of a product while reducing carbon footprint.

Garmin Award for **BEST USE OF WIRELESS TECHNOLOGY**

($1,000)

Wireless technology is ever-present in our world today. This technology allows products to be used in a wide variety of applications, from streaming movies on the couch to receiving pictures from Mars. With so many wireless technology options available, it's critical for engineers to understand the tradeoffs each provide and how they might be used to expand the capabilities of a design. This award recognizes the team that demonstrates the best utilization of a wireless technology in their design.

Honeywell Award for **EXCELLENCE IN AEROSPACE ELECTRONIC SYSTEM DESIGN**

($1,000)

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**

($1,000)

This award recognizes excellence in overall mechanical system design in a project that has an aerospace emphasis. Verbal and written presentations should effectively describe 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.

Jackson Medical Solutions Award for **BEST BIOMEDICAL SYSTEM DESIGN**

($1,000)

Biomedical engineering is a discipline that advances knowledge in engineering, biology and medicine, and improves human health through cross-disciplinary activities that integrate the engineering sciences with biomedical sciences and clinical practice. This award recognizes the team that has demonstrated excellence and innovation in biomedical engineering design. 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 effectively communicate their design and the processes they use for creativity.

Mensch Foundation Award for **BEST USE OF EMBEDDED INTELLIGENCE**

($1,000)

The Mensch Prize for Best Use of Embedded Intelligence recognizes the engineering innovation team that best integrates embedded intelligence into a potential commercial product. Specifically, the award will be granted to a student team that has built a smart connected prototype that may have a commercial market. Embedded intelligence is characterized as the ability of a product to sense, process, communicate, and actuate (SPCA) based upon information gained from an understanding of both itself and others and for the benefit of many. Preference will be given to designs with SPCA capabilities that can demonstrably surpass human abilities to perform the same function.

Sharon ONeal Cyber Warrior Award for **BEST CYBERSECURITY DESIGN**

($1,000)

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/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.

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. Intent must be communicated from the design activity to the rest of the team using 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 and illustrates the approach to testing.

Trax International Award for **BEST IMPLEMENTATION OF AGILE METHODOLOGY**

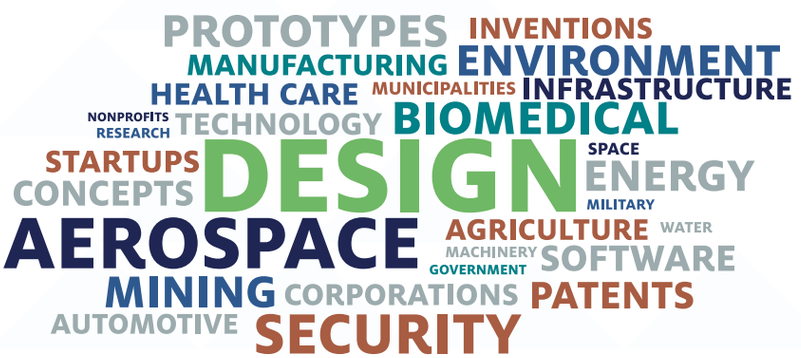
($1,000)

This award recognizes the team that best executes project design 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.

II-VI Optical Systems **FISH OUT OF WATER** Award

($750)

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.



Phoenix Analysis & Design Technologies Award for **BEST USE OF PROTOTYPING**

($750)

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.

SciTech Institute Award for **BEST ENGINEERING ANALYSIS**

($750)

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.

Steve Larimore Award for **PERSEVERANCE AND RECOVERY**

($750)

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 and the features in the final design that contribute to recovery from them.

Southwest Gas **PRACTICAL SOLUTION / APPLICATION** Award

($750)

Prototypes designed and built by engineering capstone teams often require additional development by the sponsors. This award is given to a team that develops a practical solution or application that would require minimal additional redesign/development by the project sponsor before it begins utilizing or mass manufacturing it. The teams will be judged on completeness of design (meeting as many requirements of the project statement as possible), functionality and build quality of the prototype, extent of testing and results, and ease of implementation and/or manufacturing.

Frank Broyles **ENGINEERING ETHICS** Award

($500)

Increasingly businesses are adopting cultures that emphasize ethical conduct. This is driven in large part by the dollar value financial markets place on business reputation. Questionable shortcuts to save cost or time are a practice that can have catastrophic consequences. Similarly, the marketplace can punish a business that ignores or inappropriately resolves conflicts. The award will be given to a team or individuals that identified and resolved or did not resolve an ethical issue faced during the design and creation of the project. Clarity and organization of the paper will be significant factors that judges will use in the voting process.

Frank Broyles Award for **UNCREWED AIRCRAFT SAFETY**

($500)

Uncrewed aircraft proliferation has raised serious safety concerns in communities across the country. Particularly as they grow larger, fly at higher altitudes and become more autonomous. The FAA has issued regulations (14 C.F.R 107) for unmanned aircraft that weigh 55 lbs. or more including any payload, fly higher than 400 feet above the ground, fly outside the visual line of sight of its operator or observer, or fly during non-daylight hours. The award will be given to the team that best describes why the project uncrewed aircraft could not adequately perform its objectives without an FAA waiver and the proposed safety solution.

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.

L3 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.

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.

Simpson Family Award for **BEST SIMULATION AND MODELING**

($500)

This award recognizes the project that makes the best use of computer-based simulation or modeling. The simulation may be the project itself or a design tool used to model the performance of the project design. Selection criteria for this award include scope of the simulation, the fidelity of the simulation compared to real-world performance, and the engineering judgement exercised in determining the complexity of the model.

Honeywell Award for **TEAM LEADERSHIP**

(two individuals at $250 each)

This award recognizes students who best exemplify teamwork skills. This includes the ability to work cooperatively with others to produce high-quality work, to take the 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.

> “We’re working toward something that will have an actual impact on the market.”
>
> – Danielle Hoare, *2019 biosystems engineering*

PROJECT DESCRIPTIONS

Mobile Utility Connection

Team 19001

Tucson Electric Power

PROJECT GOAL

To design a contained, transportable and renewable energy system that provides power to remote locations where power lines are not available.

Tucson Electric Power and its subsidiaries provide energy to 657,000 people across Arizona. While the majority of these customers are in areas with an existing power infrastructure, transmission lines are unavailable in some locations. Therefore, this project focused on a cost-effective, easy-to-maintain way of providing power to customers is areas without transmission lines.

The team used the same polycrystalline solar panels already deployed in many of TEP's solar fields, combined with a long-lasting, lithium ion battery bank, to provide an average of 150W of power throughout the day. The power generated by the solar panels is handled with a maximum power point tracking charge controller. This acts as a DC to DC converter to ensure that the rapidly fluctuating power from the panels maintains voltage consistency across the batteries. This process, in conjunction with a high-quality DC to AC converter, minimizes the system's power loss. The team housed the system in an insulated enclosure mounted in a transportable shipping container, so customers can use the renewable energy in a wide range of devices and locations.

TEAM MEMBERS

Kevin Minh Chau *Electrical & Computer Engineering*
Spencer Lyon-Gross *Electrical & Computer Engineering*
Ilse Yukie Morales Duarte *Systems Engineering*
Colter Ogden *Electrical & Computer Engineering*
Abhishek Sharma *Systems Engineering*
Jesus Alejandro Suarez *Mechanical Engineering*

COLLEGE MENTOR

Steve Larimore

SPONSOR MENTOR

Ana Bustamante, Christopher Lynn

Off-Grid Community Wi-Fi Terminal

Team 19002

ViaSat

PROJECT GOAL

To provide off-grid internet access by powering a community Wi-Fi terminal with renewable energy.

Four billion people worldwide lack internet access. This project, the Off-Grid Community Wi-Fi Terminal (OGCWFT), provides reliable wireless internet to remote communities. The system
– with solar panels to harvest energy and power the terminal and a battery to store the excess
– is a portable, low-cost alternative to using cable or mobile data.

OGCWFT is split into four weather-resistant containers for ease of transportation. Two boxes house solar panels, one holds the Community Wi-Fi Terminal, which communicates with a geostationary satellite, and the last box contains the Renewable Energy Power System (REPS). A solar charge controller inside the REPS safely sends the modulated power from the solar panels to the battery and terminal. When sunlight is unavailable, the battery provides energy to an inverter and the terminal. The device can also run on external power. The system has fans to prevent overheating in extreme temperatures. Additionally, battery and temperature data are collected for trend monitoring.

TEAM MEMBERS

Blake Denny *Mechanical Engineering*
Rachel Ellen Greenland *Mechanical Engineering*
Petit Izere *Electrical & Computer Engineering*
Khibar Hayatkhan Malekzai *Mechanical Engineering*
Mansur Bolaji Olaitan *Systems Engineering*
Dario Salinas *Electrical & Computer Engineering*

COLLEGE MENTOR

Bob Messenger

SPONSOR MENTOR

Sarah Shepis

TEAM MEMBERS
Allison Gilbreath *Electrical & Computer Engineering*
John Gorosave *Computer Engineering, Mechanical Engineering*
Ian Tortor Singco *Electrical & Computer Engineering*
Raad Sharrar Syed *Industrial Engineering*
Ariel Roman Villasenor *Electrical & Computer Engineering*

COLLEGE MENTOR
Gregory E. Ogden

SPONSOR MENTOR
Mike Garcia

Object Detection Using WiFi

Team 19003

RINCON RESEARCH
AN EMPLOYEE-OWNED COMPANY

PROJECT GOAL

To create a low-cost prototype engineering tool for drone detection and security applications that detects movement using Wi-Fi channel state information.

Object and motion detection are extremely useful in various fields, but these capabilities typically require the production and installation of costly infrastructure. Wi-Fi signals are near-ubiquitous and can be used to detect objects and motion with minimal additional materials and cost. This team designed a system that primarily consists of an Intel NUC minicomputer, a Wi-Fi adaptor card, a dedicated battery and a monitor display housed in a portable case.

Two adjustable directional antennas and one omnidirectional antenna are externally attached to the case to allow the user to focus on a target area. The device uses channel state information from traveling Wi-Fi signals to determine changes the signal underwent during propagation. This information represents the RF propagation channels as amplitude and phase values captured by three receiving antennas over time. These values are analyzed using Python libraries to help the user visualize the data and allow the system to identify movement.

TEAM MEMBERS
Camden Alexander Frisby *Mechanical Engineering*
Kali Gagne *Optical Sciences & Engineering*
Weishi Guo *Electrical & Computer Engineering*
Ryan Knox *Optical Sciences & Engineering*
James Edgar Sharp *Electrical & Computer Engineering, Systems Engineering, Engineering Management*

COLLEGE MENTOR
Mike Nofziger

SPONSOR MENTOR
Brian Bellah

Simultaneous Discrete Beam Steering for Multi-Wavelength Coherent Sources

Team 19004

NIGHTFORCE

PROJECT GOAL

To design a system that simultaneously steers two different wavelength laser beams to a target.

A well-aligned rifle scope can improve aim. The purpose of this project was to create specialized equipment to aid in aligning different optics on rifle scopes. The team created a device that simultaneously steers two laser beams of different wavelengths and delivers them to a specified angle on a target that is a fixed distance from the system.

The steering system consists of beam-combining optics whereby the lasers enter the system at a desired position. The system is designed to work using four wedge prisms that control the steering of each beam when rotated. Electronically controlled rotation mounts hold and move the prisms. A user provides the input angle into team-designed software, which controls the mounts and steers the beams to arrive concurrently at a desired point on the target.

Personalized Lab Notifications

Team 19023

PROJECT GOAL

To design, build, and verify a cloud-based, real-time notification parsing and delivery system enabling users to subscribe to relevant messages from medical devices.

In high-volume medical laboratories, keeping track of the status of individual tissue staining devices is a difficult task, potentially leading to lost productivity or decreased awareness of device errors. This team developed a cloud-based notification system, built with Python, React Native, Node.JS and MySQL, that delivers customizable notifications in real time from tissue staining devices to subscribed users' smartphones.

The system includes two main software components: a centralized, server-based collection of cloud services hosted on AWS; and an efficient log-parsing application on the device's host computer. In a responsive, secure web front-end, users can select relevant machines and customize which types of notifications to receive, such as experiment completion, errors or suggested maintenance. Users receive notifications through text messages or by using a cross-platform smartphone application, which provides native push notifications, device notification history, and analytics capabilities. The service delivers over 100 notification types reliably within 15 seconds of event occurrence. This system, built on scalable modern technologies, will enhance laboratory workflows by increasing awareness of device events.

TEAM MEMBERS

Rigel Sterling Carlson *Systems Engineering*
Jake Hageman *Biomedical Engineering*
Miranda Nicole Hampton *Computer Engineering, Electrical & Computer Engineering*
Connor Musick *Computer Engineering, Electrical & Computer Engineering*
Kris Rockowitz *Electrical & Computer Engineering*
Jessica Noelle Sofka *Electrical & Computer Engineering*

COLLEGE MENTOR

Cathy Merrill

SPONSOR MENTOR

Benjamin Blehm

Capacitive Volume Sensing

Team 19024

PROJECT GOAL

To create a liquid volume sensor that can measure with high resolution, accuracy, and precision eight different reagents.

The HE 600 is used for hematoxylin and eosin diagnostic tissue stains and contains eight reagent reservoirs. The current method for measuring the liquid level uses floats that are in direct contact with the reagents. These expensive floats are mechanical and analog assemblies that break down easily, as corrosion from the reagents creates small defects that can render them nonfunctional. They also lack high resolution, measuring only to discrete levels.

This design uses capacitive volume sensing to monitor the fluid levels without making contact with the reagents. The easy-to-assemble and cost-effective system consists of electrodes and a flexible printed circuit board that adheres to the outside of the reservoir. The system analyzes the difference in capacitance to measure the change in volume and can achieve a resolution of 0.1 mL. The data is recorded via USB.

TEAM MEMBERS

Chandler W Gillette *Mechanical Engineering*
Alana Gabrielle Gonzales *Biomedical Engineering*
Lindsay Nicole Pruitt *Biomedical Engineering*
James Rowley *Electrical & Computer Engineering*
Paul Michael Udorvich *Electrical & Computer Engineering*
Christine Elisabeth Wiltbank *Biomedical Engineering, Electrical & Computer Engineering*

COLLEGE MENTOR

Mark Brazier

SPONSOR MENTOR

Benjamin Blehm

TEAM MEMBERS
Brian Beutler *Systems Engineering*
Julia Chen *Electrical & Computer Engineering*
Sabrina Huaraque *Electrical & Computer Engineering*
Pengyu Liu *Optical Sciences & Engineering*
Mustafa Mamerji *Industrial Engineering*
Rishab Verma *Electrical & Computer Engineering*

COLLEGE MENTOR
Cathy Merrill

SPONSOR MENTOR
Benjamin Blehm

Authentication With Facial Recognition

Team 19025

Roche

PROJECT GOAL

To design a facial recognition system capable of authenticating users who are accessing tissue diagnostic devices.

With increasing FDA regulations, simple password user authentication is no longer secure. Facial recognition is considered secure for user authentication, however it can be difficult to implement successfully in a lab environment. This design uses Microsoft Azure, Microsoft Face API and an Azure Kinect camera to produce a system that captures images from live frames, parses those images into facial data, and saves facial data into user profiles.

Users are categorized into user groups, each with their own permissions. From the user interface, administrators can add, delete or modify users. These actions update the user in the Azure data structure for future authentications. The system is designed for a lab environment where it may interact with multiple users at once, workers in protective gear, such as face masks. Upon authentication, the system matches live data to store user profiles with a confidence level of 99%. If the confidence level is not met, the interface presents options for the user to continue.

TEAM MEMBERS
Sahachel Jesus Flores *Electrical & Computer Engineering*
Jorge Manuel Gracia *Industrial Engineering*
Ce Jiang *Mechanical Engineering*
Alexander Lim *Mechanical Engineering*
Marek Fernando Perez *Electrical & Computer Engineering*
Jacob Jeffrey Sindorf *Biomedical Engineering*

COLLEGE MENTOR
Pat Caldwell

SPONSOR MENTOR
Benjamin Blehm

Automated iButton Placement Device

Team 19026

Roche

PROJECT GOAL

To automate the process of placing an iButton onto a sticky pad, which will significantly reduce labor costs.

Penny-sized RFID chips, called iButtons, are used for temperature monitoring and e-commerce, for example. However, placement of the chips onto double-sided adhesive pads for diagnostic kits takes thousands of labor hours a year. This project uses a Raspberry Pi and an interactive touch-screen graphical user interface to automatically control a custom system that places iButtons onto sticky pads.

The design uses a vibratory feeder bowl with mechanical stack and orientation correction to feed the iButtons onto a rail. The sticky pad roll is loaded onto the system, and two motorized axles remove the protective cover. A guided servo arm allows for accurate placement between the sticky pad and the feeder bowl rail. Optical sensors ensure the pieces are properly lined up and the rail is full. After joining, the iButton and adhesive are rerolled for easy distribution. The touch-screen GUI guides the user through the startup, refill and completion of the process.

Physical User Interface for Digital Pathology

Team 19027

PROJECT GOAL

To bridge the gap between traditional and digital pathology by providing pathologists a device for reading digital slides that mimics a compound microscope's structure and function.

Because digital pathology is making its way into the diagnostic workflow, this team designed a device for reading digital slides that is comparable to using a compound microscope. The physical user interface design integrates an Arduino Leonardo – a microcontroller board based on the ATmega32u4 – with existing lab software.

All internal components are housed in 6061 aluminum casing to reduce weight and provide sufficient durability. The ergonomic trackpad sits at a 5-degree offset to decrease user fatigue. The XY panning knobs are placed vertically to mimic compound microscopes used by pathologists. Magnification knobs are set horizontally on the opposite side, so the user can pan images and change magnification simultaneously. The software package, OSD Viewer, imports a BIF file into a C# .NET application that implements OpenSeadragon, a JavaScript viewer for high-resolution zoomable images. OSD Viewer interfaces via serial communication with an Arduino program, written in C++, to translate physical inputs into viewer controls.

TEAM MEMBERS

Madeleine Armstrong *Electrical & Computer Engineering*
Dana Nicole Bernhardt *Biomedical Engineering*
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Slide Randomizer

Team 19028

PROJECT GOAL

To design a device that randomizes glass microscope slides and records answers to test questions, improving the pathologist training process.

Pathologists use stained-tissue microscope slides to determine the presence of disease in a patient. As part of their training, pathologists are tested on their ability to evaluate a diagnostic assay for cancer. Randomizing the slides and scoring answers is tedious and time-consuming for the person giving the test. This team designed a slide randomizer to speed up the testing process.

The low-cost, benchtop prototype scans, stores and delivers 40-60 cases, each containing three glass slides. During testing, the device presents each case in a random order and asks a series of questions. The pathologist's answers are entered manually and saved into a passcode-protected data file. The small, lightweight design meets all Transportation and Security Administration regulations, making it easy to transport.

TEAM MEMBERS

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Small Aperture Daylight Star Tracker

Team 19029

Ball Aerospace & Technologies Corp.

PROJECT GOAL

To apply alternative methods to increase the signal an optical system receives from stars under daylight conditions, making it easier to determine the system's orientation with respect to a celestial frame of reference.

The emergence of GPS jamming has created an increased demand for celestial navigation on airborne platforms. Such platforms operate within the atmosphere, where star signal is weakened, and vehicle size and weight are constrained. Finding alternative methods to increase the signal received from faint sources is an important area of study, as it allows for more information to be collected without increasing telescope size or the length of time spent observing.

This team produced a design that uses image stacking, as well as optimized wavelength, telescope size and exposure time selections, to increase the signal as the telescope scans the sky. Taking multiple images for a single exposure time and stacking them over the total integration time creates a much stronger signal than just one exposure. This is done to prevent the signal from traveling across multiple pixels. With the images properly stacked, the system determines the celestial coordinates using an astrometry algorithm, which compares the distances between the detected stars, as well as their brightness relative to each other, to an established star catalog.

TEAM MEMBERS
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Predictive Maintenance Trend Monitoring for Avionics Equipment

Team 19030

L3HARRIS | LATITUDE ENGINEERING

PROJECT GOAL

To predict potential failure in NXT transponders through analysis of historical fault information by artificial intelligence.

Unplanned maintenance negatively affects airline operations and travelers. This project developed a software program to analyze and evaluate historical fault information recorded for NXT series transponders, which transmit data from an aircraft. Using agile methodology, several design solutions were applied to different machine-learning and deep-learning techniques to maximize the accuracy of the analysis. The software includes an AI prediction algorithm with gradient boosting to generate maintenance schedules for transponders.

The design implements deep learning with Keras, gradient boosted decision trees using XGBoost, and manual concentration interval identification. These single-vector identification approaches are then aggregated throughout a unit's lifetime with statistical methodologies. The schedule provided by the software allows aviation maintenance teams to more accurately predict when to service the transponders.

SWIR Transmitting Optical Beacon

Team 19031

Elbit Systems™

PROJECT GOAL

To develop and deploy a short-wavelength infrared transmitting optical beacon to identify a target or position in the field.

Search and rescue systems and military operations depend greatly on beacons. This team designed a small, portable signaling beacon that creates a cone of infrared light in the 1500-1600 nm range visible only to individuals equipped with specialized optical devices. It is small enough to be operated and deployed by a single user and rugged enough to work in adverse conditions and environments. The housing is strong but flexible, so the beacon can survive a drop onto concrete from 6 feet. The beacon controller can remotely operate the optical settings of three devices at a time.

The beacon is assembled with a thin rectangular prism that contains two emitters – one on each side. Equipped with an accelerometer, the beacon triggers the output of the upward-facing emitter, which ranges from continuous wave to 100 Hz repetition at 50% duty cycle. A microcontroller was employed for computing and remote-control interfacing. The pulsed operation was output to an external circuit responsible for powering the laser diode. The unit has enough energy capacity to be powered continuously for 30 minutes and is powered with AA batteries for versatile field applications.

TEAM MEMBERS

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COLLEGE MENTOR

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Jeremie Jackson, Matthias Whitney

Uncrewed Ground Vehicle Sensor Integration

Team 19032

Equipment Share

PROJECT GOAL

To integrate a lidar sensor onto an autonomous vehicle platform for detection of obstacles.

Track loaders are heavy machinery used for digging and loading, often in high dust and shock environments. This team designed a system to enable a track loader to operate autonomously using a lidar sensor for surveying the vehicle's surroundings. Optical instruments obtain an all-inclusive view of the vehicle, while an embedded computer processes the data and controls basic loader functions.

The team created a 3D simulation of the track loader to demonstrate the scope of view capable through the system. The data captured by the lidar and auxiliary cameras is processed by an integrated computer powered through the vehicle's battery. The system analyzes the resulting imaging and engages the appropriate stopping or starting functions of the loader. Custom-engineered mounting and enclosures protect the equipment to meet the standards required for operation in construction environments.

TEAM MEMBERS

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Custom Python API Generator for Controlling Existing User Interfaces

Team 19033

Facade Technologies Inc.

PROJECT GOAL

To create a simple and flexible way to automate user interactions with Graphical User Interfaces.

Many software programs are designed to only interact with users through a graphical user interface (GUI). Although this is usually convenient, some users may prefer to automate frequently performed tasks. Existing automation solutions either require users to have extensive programming knowledge, or they do not scale well to larger applications. This team designed a simple GUI that allows the user to create an Application Programming Interface (API) to control another application's target GUI.

By automatically deconstructing the target GUI into its constituent components, an accurate model of the target GUI is generated. Users can interact with visual diagrams of the models to identify the components of the target GUIs on which they want to perform specific actions. With the push of a button, the user can run a custom-built compiler that produces the API in the form of a Python library. This library can interact with the target GUI in ways specified by the user and is complete with formal documentation describing the interface. The generated library can perform a desired action in as few as three lines of code in a user-written script.

TEAM MEMBERS
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Next-Generation Turbogenerator Lightweight Gearbox Design

Team 19034

Honeywell

PROJECT GOAL

To design and build a prototype of a compact, lightweight gearbox for Honeywell's next-generation turbogenerator engine.

Honeywell Aerospace is developing a new hybrid-electric turbogenerator engine for urban air vehicles that employ vertical take-off and landing. It requires a small gearbox that still provides the power to efficiently operate the engine and auxiliary power unit. This team designed a lightweight, compact, durable and easily maintained gearbox.

Models were created and analyzed using ANSYS and Solidworks mass estimation, and ultimately, bevel gears were selected for their light weight. The gearbox has properties to reduce input RPM of 32,000 to an output of 21,000 RPM. It performs all functions within a temperature limit of 300 F and can withstand at least 30,000 hours of usage. The gearbox weighs less than 50 pounds and accommodates either a horizontal or vertical mounting of the turbine engine in the aircraft.

Heated Build Plate for Additive Manufacturing System

Team 19035

Honeywell

PROJECT GOAL

Design, fabricate and integrate a custom heated build plate system for a laser powder bed fusion additive manufacturing system.

Materials science research and theory has shown that dynamic recrystallization of parts will occur if the parts are manufactured on a heated build plate that approaches half the melting point of the material being printed. This project uses 316 stainless steel, which melts between 1375 and 1400 C, for a custom heated build plate, so additive manufactured parts can be created at temperatures exceeding 200 C.

The team used ANSYS heat transfer modeling to determine heater sizing and Solidworks™ to design a build plate and heat plate with minimal thermal expansion and warping under high temperature conditions. Then, the team machined a prototype from 316 stainless steel and designed and fabricated a temperature regulating system. They put together the plates, heaters and temperature regulating system. Testing showed that the heated build plate system resulted in fewer flaws and created finer grain boundaries, which will improve the mechanical properties of manufactured parts.

TEAM MEMBERS

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Additive Manufacturing Optimized Particle Size

Team 19036

Honeywell

PROJECT GOAL

To improve additive manufacturing processes by optimizing particle size composition through distribution control.

Additive manufacturing offers unique advantages over traditional methods of casting and machining. Powder is layered and heated by a laser to create complex shapes and formations. However, during the printing process, large temperature gradients affect the eventual residual stress of the part. This can lead to deformities and render the piece unusable for its designed application.

This team designed an experiment to accurately understand how particle size of the powder can affect that residual stress. The results showed that multiple variables related to particle size distribution can directly impact the printing process – relative particle size distribution, packing density, and deflection and residual stress. Variable analysis showed the individual relationship between dependent variables and the outcome variables. A statistically relevant correlation was determined between packing density, relative particle size distribution, and the eventual residual stress of the part. This led to a recommendation of relative particle size distribution to greatly optimize the effectiveness of the additive manufacturing process.

TEAM MEMBERS

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Test Fixture for LCD Light Guide Plates

Team 19037

Honeywell

PROJECT GOAL

To design and fabricate a fixture that can create optical patterns on a light guide plate material to produce high luminance and uniform performance in a display.

Light guide plates are thin sheets of acrylic used in most LCD displays, such as cell phones or laptops. The light guide plate is the first step in providing uniform illumination to the LCD screen.

This team designed and modeled the light guide plates and scattering patterns in TracePro, using the software's texture utility to optimize the position of each scattering feature and provide uniform illumination. Then, the team built a CO_2 laser etcher to etch the scattering pattern onto the light guide plate. To test the light guide plates, the team designed and modeled a fixture in SolidWorks before building it. The designed light guide plate will provide a uniform illumination profile to an LCD screen while maintaining a specified optical efficiency.

TEAM MEMBERS
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Additively Manufactured Cooled Turbine Airfoil Flow and Heat Transfer Rig

Team 19038

Honeywell

PROJECT GOAL

To accurately measure the pressure drop across an additively manufactured coupon to determine the surface effects.

Aerospace companies are experimenting with additively manufactured components. But this process can introduce surface roughness, presenting problems for turbine blades, which require an extremely smooth finish to function properly and ensure longevity. This team designed a system to aid in understanding how the roughness affects fluid flow. The project involved creating an additively manufactured coupon to emulate the cooling structures within the turbine blades.

High-pressure air is channeled through a test rig to the coupon, using a series of piping, a converging nozzle, and a device to control for different flow conditions. Additional instrumentation measures temperatures and pressures throughout the rig as well as differential pressure across the coupon. Predictive mathematical models and simulations determine the theoretical flow properties needed for an accurate design. The test rig output readings fall within the desired accuracy and indicate the expected pressure drop across the coupon. This, in turn, shows the effect surface roughness has on the flow properties of additively manufactured turbine blades.

Optimized Urban Air Mobility Vehicle Design

Team 19039

Honeywell

PROJECT GOAL

To develop and validate, through analytical modeling and a physical scale model, an urban air mobility concept that maximizes efficiency, minimizes emissions and provides vertical takeoff and landing for congested population centers.

As world population increases and cities become more dense, urban travel is projected to become increasingly congested, to the point where time- and energy-efficient travel on surface streets is impossible. One solution to this expected dilemma is short distance air travel.

This team conducted a trade study based on performance, safety and emissions requirements to determine an aircraft configuration with the best chance of success. Team members also developed and analyzed a conceptual aerodynamic design to validate stability requirements and created a control model to ensure critical flight characteristics, including vertical takeoff and landing.

TEAM MEMBERS

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Rotor Temperature Measurement System

Team 19040

Honeywell

PROJECT GOAL

To accurately monitor the temperature of an auxiliary power unit wirelessly.

Honeywell Aerospace needs to know the temperature of an auxiliary power unit to verify thermal models with test results. Effectively measuring and tracking the temperature of the rotor on a wound field salient pole generator presents challenges. A rotary union is not an option due to space constraints.

The self-sustainable rotor temperature measurement system determines the temperature of a field coil on a spinning rotor and wirelessly transfers the data to an outside source. The team developed a mockup of the system to gather the needed data from inside an auxiliary power unit.

TEAM MEMBERS

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Connected Battery Management System

Team 19041

Honeywell

PROJECT GOAL

To add a transmitter system to existing battery management electronics, which will send data to a website and mobile application, allowing for real-time assessments of battery status and maintenance/repair conditions.

Battery management systems do not have transmitters for real-time access to system data. Presently, analysis of battery health requires direct connection to the system. This is largely inefficient for monitoring an array of batteries. This project adds the required transmitter technology to a battery management system for faster and more remote access to battery health data.

The recorded information is converted to transmittable data and packaged to be sent to a cloud server, as well as to a local SD card. The data stored on the server is interpreted and available via a website and mobile application. Interested parties can be granted access to the website and app to ensure the battery is performing to the desired specifications. Should the battery begin failing or degrading, mechanics can prepare and react accordingly.

TEAM MEMBERS
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Automated Taquito Rolling Machine

Team 19042

Rollies MEXICAN PATIO

PROJECT GOAL

To design, build, and test an automatic machine that expedites the taquito rolling process.

It takes up to four hours to complete 100 taquitos by hand. This team designed an automatic taquito rolling machine to produce more than 300 taquitos per hour, with minimal human intervention.

Six stations each perform different steps in the process to assemble a fully rolled taquito. After a tortilla stack is placed into an interior load cell, the machine begins by moving a single tortilla onto a mesh conveyor with a suction mechanism. The tortilla is dipped in oil before moving to the dispensing assembly, where stuffing and paste are added. The loaded tortilla then transitions to the rolling assembly, which uses a custom-designed surface to give it an initial tuck. This prepares the tortilla for complete rolling by a double conveyor system. Finally, the finished taquito is delivered to a storage container.

Automated Hydraulic Test Apparatus

Team 19043

RBC | SARGENT AEROSPACE & DEFENSE

PROJECT GOAL

To design and fabricate an acceptance test plan test fixture and data acquisition system that meets proprietary specifications.

Test fixtures are vital in the aerospace industry for ensuring quality and performance. RBC Sargent's acceptance test plan test fixture is inefficient and cumbersome. The size of the apparatus makes it a challenge to transport to external hydraulic pressure sources for validating actuators, and the technician must use a stool to reach the mounts that secure the test hardware to the fixture. This project designed a more efficient, ergonomic automated hydraulic test apparatus for full rate production.

The fabrication design can withstand its own weight and resist fatigue of loading and unloading from external hydraulic power. The structure has a yield strength of 3 and an ultimate tensile strength of 5. The apparatus can cycle the shrink actuator according to a user's input and switch between left- and right-hand variations of the shrink actuator in less than five minutes. Initial setup takes 15 minutes or less, enabling Sargent to streamline the verification process and free up personnel for other projects.

TEAM MEMBERS

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Tom Howard, Jeremy Ulliman

Lattice Winding Machine

Team 19045

NORTHROP GRUMMAN

PROJECT GOAL

To design and test an automated device that produces small-scale cylindrical lattice structures of carbon fiber material at specified geometries.

Small-scale cylindrical lattice structures, cured at high temperatures, are used for structural testing. The current method of manually laying carbon fiber strands in specific geometries is time intensive and prone to error.

This automated system is designed with two precisely controlled motors: one that spins the cylinder and another that travels along the length of the cylinder and applies the carbon fiber material. Initially, the material is manually attached to the cylinder at a single point, and a user inputs specific geometry parameters on the graphical user interface. The machine then runs the motors synchronously according to the desired pattern to place the fiber on the cylinder. The tensioner on the system ensures that the carbon fiber is pulled tightly to the cylinder throughout the winding. When the winding is complete, the carbon fiber is cut manually, and the cylinder is separated from the machine and placed in a high-temperature environment to cure the carbon fiber. The cured carbon fiber lattice then goes through post-processing, and the cylinder is returned to the machine to be reused.

TEAM MEMBERS

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Double-Ended Interferometer

Team 19046

Sandia National Laboratories

PROJECT GOAL

To measure the absolute length of a gauge block using a double-ended interferometer with uncertainty on the order of 100nm.

Industry uses gauge blocks as a standard for precision lengths. Current techniques for these length measurements involve a process called wringing, where one end of the gauge block is wrung onto a platen using grease. This layer of grease introduces uncertainty to the measurement.

This project provides a solution for that issue by using a double-ended interferometer with uncertainty on the order of 100 nm. By measuring from both ends, the process uses the speed of light constant and temporal phase shifting to eliminate the uncertainty of the grease layer and determine the length of a gauge block down to the nanometer scale.

TEAM MEMBERS
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797F Haul Truck Catwalk Weight Reduction

Team 19047

CATERPILLAR

PROJECT GOAL

To develop a lightweight catwalk platform for the 797F haul truck, providing a 2% to 5% weight reduction while maintaining compliance with all regulations.

Lightweight structures are important in the aerospace and racing industries. Every pound costs significant time and money. With challenges around constraining cost and easing maintenance, this trade-per-pound concept also applies to heavy machinery. This project focused on designing a safe, durable, low-maintenance, lightweight catwalk for the 797F haul truck. Operators use the catwalk platform to enter and exit the haul truck cab.

The proposed design mimics biological structures by incorporating a floating compression model similar to the human skeletal system. The team evaluated structural stability through ANSYS workbench. Custom pieces were subjected to stress/strain and liquid penetrant testing to verify results. The resulting catwalk is light, durable, cost-effective, and modular to fit with other structures on the truck. The redesigned catwalk will reduce stress on the front-end running gear and improve the haul truck's payload.

Automated Wire Winder and Cutter

Team 19048

CATERPILLAR

PROJECT GOAL

To automate the process of unwinding, measuring and cutting different diameter wire samples to various lengths.

The manual process for measuring the length of and winding wires for testing large mining equipment is time-consuming. Thus, this project involves building a machine to automate the process. The automated wire cutting machine consists of four primary subsystems: the supply spool holder, the drive system, the cutting system and the collection system.

The sub-systems were tested individually and integrated through an Arduino MEGA as the controller. The housing unit itself was designed using SolidWorks. The machine works with copper wire up to one-quarter inch in diameter. The only labor involves replacing the supply spool and removing cut samples from the collection bin. To use the machine, an employee loads a spool of wire, enters on a laptop the desired length and quantity, then collects the samples once the cutting process is complete.

TEAM MEMBERS

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Grasshopper Harvester

Team 19049

THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE & LIFE SCIENCES
Entomology

PROJECT GOAL

To design and build a device that mechanically harvests grasshoppers from agricultural fields.

Home to crops like citrus, cotton, soy, peanuts and leafy greens, Arizona is one of the most important agricultural regions in the United States. However, the state's climate is also ideal for more than 300 species of grasshoppers, many of which are herbivores. Traditionally, pesticides have been used to keep down the grasshopper population. However, health risks associated with pesticides and an increase in demand for organic produce, have farmers seeking alternatives for managing these pests.

Grasshoppers' natural response to perceived predators is to jump high in the air, and their physiology prevents them from controlling their descent. This team's Grasshopper Harvester+ is a remote-controlled vehicle that captures jumping grasshoppers by deflecting them into a directed air stream that pushes them into a storage compartment. The removable storage compartment is outfitted with infrared sensors to notify an operator when it is 20%, 40%, 60% and 80% full. The operator empties the compartment as needed so the harvester can continue capturing grasshoppers. The four remote-controlled motors on the harvester enable it to maneuver through rows of crops and efficiently remove 70% of the grasshoppers it encounters.

TEAM MEMBERS

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Daniel Shannon *Mechanical Engineering*
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Medical Device Fluid Management Connecting System

Team 19050

xeridiem MEDICAL DEVICES

PROJECT GOAL

To design, develop, and verify a low-profile gastrostomy tube connecting system capable of 360-degree rotation between an enteral medical device and a detachable tubing accessory.

When a patient cannot ingest food or medicine by normal means, a gastrostomy tube is often inserted into the abdomen for fluid delivery directly into the digestive system. The enteral medical device can be left in the body for extended periods with limited clinical oversight. By coupling it with a detachable tubing extension set, patients can use the feeding tube from home without a caretaker, thereby lowering the cost of health care.

Most gastronomy tubes function with a quarter-turn internal locking mechanism that limits the rotational freedom of the tubing accessory in the locked position. This team developed a system capable of a 360-degree rotation between the enteral device and the extension set. A novel external locking component prevents inadvertent disconnection. The system maintains functional geometry for leakage prevention as well as a low insertion and removal force, ensuring the device is easy to use. Prototypes were injection molded using CALIBRE 2061-15 polycarbonate resin for verification of durability, leakage, flow rate, shelf life and life cycle testing.

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Ceramic Edge Finishing Device

Team 19051

HF COORS MADE IN USA DINNERWARE 1925 A.D.

PROJECT GOAL

To design a device that automatically smooths the edges of unfired ceramic plates of varying geometric shapes and sizes.

HF Coors employees smooth the edges of unfired, non-circular, ceramic dinner plates by hand. An adaptive mechanism that can finish the rough edges will save time. This team designed an edge-tracking-and-finishing mechanism for ceramic plates of varying sizes and shapes.

The device includes a probe and a mechanical arm, which contains a rotating sponge. The sponge wipes away excess clay from the edge of a rotating plate placed between the probe and arm. The probe is in constant contact with the edge of the non-circular plate, adjusting its pressure as the plate rotates. This pressure adjustment changes the output voltage of a linear potentiometer, which relays the output voltage to an Arduino microcontroller. Based on the voltage received, the Arduino supplies specific pulse width modulations to the motor driver. This engages the stepper motor and actuator, moving the mechanical arm with the sponge either forward or backward to ensure contact is constantly within the nominal range.

Precision Brachytherapy Device for Esophageal Cancer

Team 19052

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To design a precise brachytherapy device that delivers twice the radiation dose to cancerous tissue than to healthy tissue for patients with esophageal cancer.

Brachytherapy is a form of internal radiation therapy in which small radioactive seeds are placed close to cancerous tissue. Compared with external beam radiation, brachytherapy can deliver higher doses of radiation to the primary cancer, while sparing healthy tissue. This project focused on creating a precision brachytherapy device with multiple applicator channels.

The team used materials compatible with the gamma radiation applied during the procedure, the ethylene oxide that sterilizes the device, and diluted acid to simulate the conditions of the esophageal tract. Balloons were filled with water and contrast mixture – used for visualization during a CT scan – to stabilize the device. The multiple seed channels were compatible with existing brachytherapy equipment, and the device does not require additional training of radiation oncologists or medical physicists. Analysis showed that the device delivers twice the dose of radiation to cancerous tissue than to healthy tissue.

TEAM MEMBERS

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Jennifer Barton

Laser Communication Boresight System

Team 19053

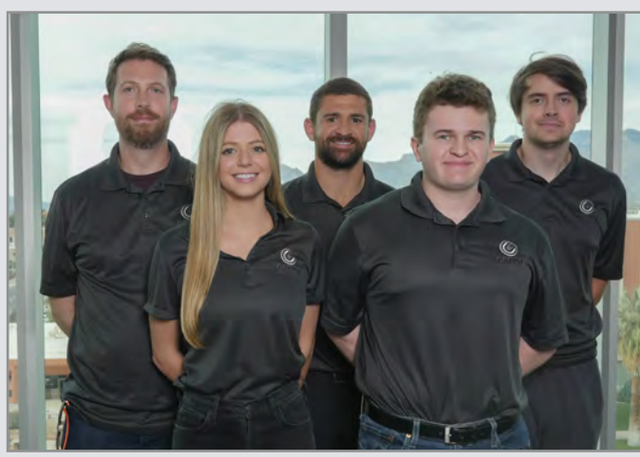
GEOST

PROJECT GOAL

To co-align a transmitting laser beam to a receiving telescope within 10 arc seconds for long-range communication.

Defense and commercial industries need long-range laser communication. As distance increases, so does the need for more precise and stable alignment systems to prevent interruption of data transfer. This design for a modular, quick-to-assemble system focuses on obtaining precise alignment between the transmitting beam and receiving telescope.

The assembly consists of a lateral transfer hollow retroreflector that aligns with the receiving telescope via a mount and magnetic base connected to a dovetail mount. The system verifies alignment using an image captured by the camera, which interfaces with the receiving telescope. The system's software finds the centroid of each signal and determines the distance between the two signals, confirming alignment within 10 arc seconds.



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Drone-Swarm Synthetic 3D Imagery

Team 19054

NORTHROP GRUMMAN

PROJECT GOAL

To survey an area with a swarm of drones and create a 3D model from the data.

The SERAPH (Swarm of Electro-optical Recording Aircraft for Photogrammetry) is a semi-autonomous drone swarm system for surveying compromised regions. The system incorporates drone-mounted optical cameras and 3D modeling software. SERAPH could help first responders assess and approach disaster-stricken regions, reducing cost, time and risk. This project focuses on how to adapt the commercial drones and software to the specific needs of the first responders.

A swarm of drones and their onboard cameras gather the necessary data. Open source C++-based software controls multiple drones simultaneously from a central computer, and proprietary software constructs the 3D model. Testing verified the ability to plan and execute flight patterns for multiple drones. The team's proof-of-concept 3D model provides insight into scalability to advance the use of SERAPH.

TEAM MEMBERS
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Dennis Arnold

Optimized Brewery Chilling System

Team 19055

BARRIO BREWING CO.

PROJECT GOAL

To optimize the brewery chilling system at Barrio Brewing Co. through analysis of the current system and implementation of a centralized monitoring system.

The chilling system at Barrio Brewing Co. did not have a centralized monitoring system, and company representatives were uncertain about whether it was operating efficiently. This project involved collecting data from the chillers and glycol transportation pumps to guide modification of the system.

The team installed a centralized monitoring system to give brewers a single location to monitor all tank temperatures, rather than the four inconveniently located clusters of temperature controllers they were using. The monitoring system includes tank profiles, which can store data for each tank, as well as a calendar to input and display notifications for each day. The system alerts operators when a chilling system fails, so the brewers can identify and fix problems to avoid delays to the production schedule.

High-Definition Aircraft Camera Video Stitching

Team 19056

MEGGITT

PROJECT GOAL

To create software that stitches two airplane-mounted video streams into one wide, accurate field of view.

Cameras positioned on a plane's fin can capture video that provides pilots with a better understanding of their surroundings and gives passengers a more engaging flight experience. Two wide-angle video streams, each with 91-degree fields of view, are needed to capture the entirety of the plane from the fin forward, including both wings.

This team developed software to implement algorithms that combine video from two independent cameras to generate a single video stream encompassing a 180-degree field of view from atop a plane's fin. A distortion correction algorithm within the software corrects for any radial magnification errors that occur from using wide-angle cameras lenses. A homographic matrix then identifies corresponding points between the two distortion-corrected video streams where their field of views overlap. These similar points are directly used to stitch the two videos together and achieve a single wide-angle view.

TEAM MEMBERS

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Jason Shroyer

Digital Alarm Indicator Circuit Board Redesign and 3D Work Instructions

Team 19057

MEGGITT

PROJECT GOAL

To redesign a digital alarm indicator with modern components and upgrade work instructions.

The digital alarm indicator is part of the Meggitt Securaplane PreFlite system for private aircraft. It detects and logs intrusion into a parked aircraft to help protect intellectual property, luggage, equipment and aircraft components. The digital alarm indicator arms and disarms the security system and usually is placed on the outside of an aircraft.

The redesign of the digital alarm indicator focused on removing obsolete parts from the circuit board – which included its microcontroller, display and transistor – and replacing them with modern parts. In addition to redesigning the circuit board, the team used SolidWorks Composer, a 3D product documentation software, to update work instructions. The redesigned system will serve as a prototype for creating 3D work instructions for assembling all aircraft components at Meggitt.

TEAM MEMBERS

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Olatunde Oyeside *Mechanical Engineering*
Yoselyn Maide Vargas *Systems Engineering*
Mansour alkaabi *Industrial Engineering*

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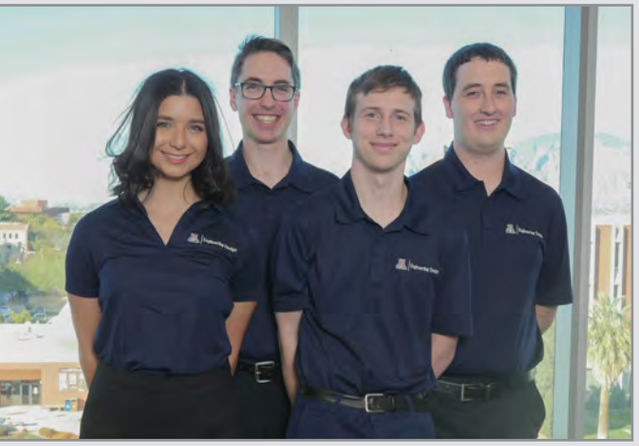
SPONSOR MENTOR

Jason Shroyer



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Kaden Jacob Skow *Electrical & Computer Engineering, Mechanical Engineering*

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Perfusion Control System for Bioreactors

Team 19058

Center for Applied NanoBioscience & Medicine

PROJECT GOAL

To design a perfusion control system for human microbial crosstalk experiments without the use of large incubators.

The design of this perfusion control system enables multiple human-microbial crosstalk experiments in a bioreactor. The system monitors and maintains an environment conducive to cell growth via subsystems for thermal control, gas flow, media flow and usability.

The thermal control system consists of a fan, Phidget, heating plate and proportional-integral-derivative controller. The gas flow system depends on communication between a microcontroller, CO_2 sensor and gas valve. A viewing port lets users perform visual inspections on their experiments without disturbing the cell environment. The module's removable tray makes it easy to transfer equipment from the module to a biosafety cabinet.

TEAM MEMBERS
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Autonomous Mining Truck Remote Stop Transmitter

Team 19059

CATERPILLAR

PROJECT GOAL

To design an upgraded autonomous stop transmitter capable of sending a signal that can stop all autonomous mining trucks in the vicinity of an emergency.

The current autonomous stop system design sends signals at a 918-926 MHz ±1MHz fixed frequency to autonomous stop receivers within the operation range. User-input commands to the remote vehicles include stopping the trucks in case of an emergency, resetting the system after clearing the danger and setting the trucks back to automatic mode.

This new design focused on reducing the size of the transmitter and developing a way to locate misplaced transmitters. To reduce the size of the current transmitter, the team replaced the existing battery, an NiMH 1.2V, with a 3.7V Pentax D-LI78 rechargeable lithium-ion battery. To address locating the stop transmitter, the team created a phone application connected to a cloud server that sends longitude and latitude values from the GPS tracker in the stop transmitter. The location tracking setup facilitates recovery of a missing stop transmitter from anywhere in the world.

Microbiome Analysis Tools

Team 19060

THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE & LIFE SCIENCES
COLLEGE OF ENGINEERING
Biosystems Engineering

PROJECT GOAL

To develop novel methods and visualizations that improve the interpretability of microbiome data sets.

The gut microbiome has been identified as an important factor associated with numerous conditions and diseases. Microbiome data has been linked to immune system function, gastrointestinal tract function, sleep quality and athletic performance. It also provides indicators for digestive disorders that are difficult to diagnose.

Translating these complex data sets into actionable reports can help physicians and patients make better-informed decisions. The application designed provides a way to better visualize, interpret and understand microbiome sample data.

TEAM MEMBERS

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Powder Mill

Team 19061

PROJECT GOAL

To redesign a powder-mixing assembly to increase efficiency and decrease hands-on labor.

The powder mill is used to mix two different substances for moisture-absorbing products. Each of the powder mill's three major components performs a different job. The ribbon mixer blends the two powders, dispatching the mixture into the volumetric screw feeder, which transports the mixture at a steady pace to the ball mill to grind the compound one last time.

The redesigned assembly achieves a more consistent, higher volume output, while decreasing labor spent on the process. A more reliable process ensures the mixed substance is within the desired ratio for creating the best possible moisture-absorbing product. The hands-off process allows for more work to be completed in less time and reduces the possibility of human error.

TEAM MEMBERS

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Preventing Theft at Retail Self-Checkouts

Team 19062

PROJECT GOAL

To design a system for prevention of theft at retail self-checkouts and explore the potential of using a multispectral sensor in conjunction with a computer vision algorithm.

Self-checkouts are a low-cost, convenient way to improve the retail shopping experience. However, self-checkouts have higher rates of intentional and unintentional theft. To prevent theft, self-checkouts often include visual components. This project focused on development of an AI-powered computer vision algorithm to increase accuracy of item identification and decrease the time required to make an inference.

The resulting system is designed to recognize grocery items accurately by making an inference on images captured in real time. The team tested the speed and accuracy of different algorithm options and analyzed advantages of multispectral sensor integration. The neural net was trained on a set of augmented prelabeled images to handle many classifiers. Algorithms assessed included Faster RCNN and SSD. The prototype provides a preliminary solution for theft prevention at self-checkouts and a foundation for development of computer vision algorithms with more broad applications.

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Epileptic Sleep Seizure Detection and Notification System

Team 19063

PROJECT GOAL

To design a non-intrusive system for detecting epileptic seizures that occur during sleep.

Early notification of seizures can help prevent Sudden Unexpected Death in Epilepsy. Several devices on the market attempt to detect epileptic seizures. However, the devices are either uncomfortable, which reduces patient compliance, or imprecise. This team designed an open-source, real-time, noninvasive system to better detect epileptic seizures that occur during sleep.

The system incorporates a stereoscopic infrared camera to collect a depth map – an image in which pixel values correspond to the distance from the camera – and performs a discrete Fourier transform on the image as a function of time. The resulting spectrum is analyzed by machine learning methods, trained with clinical data from epileptic patients. The machine learning methods identify seizures based on frequency of rhythmic motion, which does not occur during normal sleep. A smartphone alarm notifies the patient's caregiver when a seizure is detected.

Smart Odor Monitoring Network

Team 19064

PIMA COUNTY
WASTEWATER RECLAMATION

PROJECT GOAL

To design and develop a remote sensor network that monitors sewer odors within the collection system and certain locations in treatment facilities.

Nuisance odors from sewers are the result of high concentrations of hydrogen sulfide and ammonia. Remote sensing of these gases assists in detecting the sources of sewer odors, decreases complaints by residents, and improves chemical dosing and vapor recovery units within the collection system. This project uses recent advancements of sensor technology, microcontrollers and mobile applications to create a real-time remote sensing network of assessment and control.

Sensors measure the ambient air conditions and communicate with a microcontroller to wirelessly transmit the concentration values from the network to a database. The modular devices are deployed near high-risk areas within the collection system. A real-time mobile application displays a map of the system with the odor concentration levels depicted for each deployed device and provides alerts if concentrations rise above standard levels.

TEAM MEMBERS

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SPONSOR MENTOR

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Dairy Animal Detection and Environmental Control

Team 19065

THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE & LIFE SCIENCES
COLLEGE OF ENGINEERING
Biosystems Engineering

PROJECT GOAL

To create a cost-efficient camera system capable of detecting and reporting the bird population in a dairy feedlot throughout the day.

Birds are more than just a nuisance at Arizona dairies. They selectively feed on proteins and other nutrients meant for the cows and carry diseases and bacteria, both of which can be detrimental to the health of cows. Unhealthy cows means reduced milk production and financial loss for dairy companies. This design focused on bird detection and data logging/reporting for eventual use in a deterrent system.

The team developed an array of affordable, easily reproducible smart cameras to differentiate birds from other objects in a static video frame then deployed the cameras across a large dairy feedlot. The camera system counts and tracks the bird population throughout the day, week, month and year and reports the information to a password protected website for data analysis. The camera system will be applied initially to the Rovey Dairy Farm in Glendale, Arizona.

TEAM MEMBERS

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Narda Valeria Martinez *Systems Engineering*
Davis Sparks *Optical Sciences & Engineering*
Lu Yu *Electrical & Computer Engineering*

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SPONSOR MENTOR
Will Blair, Rob Heisterman

Machine Vision System for Car Wash Applications

Team 19066

Mister™

PROJECT GOAL

To design an optical system that provides quality assurance and process control for the car wash industry.

The ability to achieve a clean, dry and shiny car depends greatly on the chemical composition and distribution of the washing agents and the dryers being used. The effects of any changes to the chemical composition can be seen through analysis of water droplets present after the washing process. This team designed two separate quality-control systems for the carwash industry.

The first is an in-lab system that provides numerical outputs for water droplet size and count, as well as RGB values of the sample coupon. The design uses a scientific camera to capture an image of a sample coupon that has been treated with the washing agents. The image is processed through Python algorithms that output the desired numerical data to the user. With this information, the chemical formulas can be adjusted to ensure that the water droplet size and count on a vehicle are minimal after a wash. The second system uses 2D LIDAR in the car wash tunnel to determine where the side-view mirrors are located on the vehicle. These mirrors are often left with a high number of water droplets, and the data aids in more effective drying.

TEAM MEMBERS
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Caining Jin *Industrial Engineering*
Derui Ma *Mechanical Engineering*
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Water Reclaim System for Car Wash Applications

Team 19067

Mister™

PROJECT GOAL

To design a small-scale, on-site water reclamation system that cleans water and reduces overall water use in a car wash.

Water reclamation systems are used in several fields, but there has not been a consistent technique for car washes. The system designed treats contaminated water using advanced oxidation processes, which involve a combination of hydrogen peroxide and ultraviolet light.

Contaminated water is passed through a green sand filter to reduce turbidity, pumped into a nurse tank and circulated through an ultraviolet light chamber. After ultraviolet treatment, the water returns to the nurse tank. The water is recirculated multiple times until it achieves the desired sanitation level. The prototype is a scaled-down version that outputs 15 to 20 gallons a minute. It achieves the requested flow rate, treats the water for reuse and can adapt to the full needs of the car wash.

Real-Time Super Sensor

Team 19068

Bayer CropScience

PROJECT GOAL

To develop a low-cost multiparameter water monitoring device that collects data continuously and provides updates in real time through a mobile phone application.

Close monitoring of water chemistry is vital for a successful fertigation system. However, lab analysis of water samples takes time, and many small businesses cannot afford commercial multiparameter probes. This project combines commercial off-the-shelf probes and supporting electronics into a single device to measure the pH, dissolved oxygen, oxidation reduction potential, and conductivity of greenhouse fertigation water.

A microcontroller records the sensor data, indexes it by timestamp, and uploads it via Wi-Fi to a database. Once the data is uploaded, each probe's value is compared to a user-set threshold value stored in the database. If any values fall outside of their thresholds, the user is notified through an app. The app is based on Facebook's React Native framework and functions across iOS and Android devices. In addition to water quality warnings, the app can access and visualize current and historic water quality data for each metric, set or change threshold values, and receive warnings if the database loses connection with the device.

TEAM MEMBERS

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Autonomous Uncrewed Aircraft for Greenhouse Applications

Team 19069

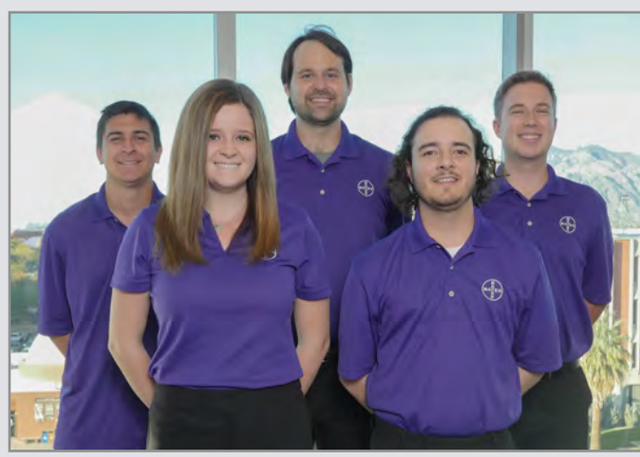
Bayer CropScience

PROJECT GOAL

To develop an autonomous uncrewed aircraft for use in an advanced automated greenhouse with various plants.

In an automated greenhouse, it is difficult to accurately survey and determine crop health because engineers are unable to physically access individual plants. The uncrewed aircraft system designed for the greenhouse stops at each bench of crops, measures the ambient temperature and humidity, and takes a photograph of the crops.

Because of conditions in the greenhouse, GPS is not a viable navigation method for the uncrewed aircraft. Instead, a series of stationary beacons are placed throughout the greenhouse to communicate with a mobile beacon on the uncrewed aircraft. This internal positioning system uses ultrasonic frequencies to determine distances between the beacons and triangulate the position of the uncrewed aircraft. A coordinate map of the greenhouse also aids in navigation and control for autonomous flight. The aircraft can take off, fly throughout the greenhouse, avoid obstacles and land without human assistance.



TEAM MEMBERS

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Doug May

SPONSOR MENTOR
Rohan Morajkar

Automatic Hypodermic Tube Bending Machine

Team 19070

ALICAT SCIENTIFIC

PROJECT GOAL

To design, build and verify a low-cost electromechanical solution that bends hypodermic-size tubing and improves fluid loop design for Coriolis mass flow controllers.

The design of Coriolis mass flow controllers, which are used to measure gases and liquids, relies on tube bending. Tube bending is an inherently difficult manufacturing process, and with increased precision comes increased cost. This project analyzed open-source wire bending performance then developed a low-cost alternative that converts wire bending technology to a tube bending machine.

The resulting prototype is the Hypodermic Tube Bending Machine that bends 25-gauge tubing made from 316L full hard stainless steel into a triangular shape of varying bend radii. The machine can be reprogramed and modified to bend a variety of shapes and tube sizes.

TEAM MEMBERS
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George Robert Hughes *Information Science & Technology*
Jakob Aakvik Langseth *Information Science & Technology*
Jiyu Liu *Electrical & Computer Engineering*
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Ryan John Skarnulis *Information Science & Technology*
Tian Yang *Electrical & Computer Engineering*

COLLEGE MENTOR
Cathy Merrill

SPONSOR MENTOR
Oscar Ramirez

Information Interchange Between Collaborative Robots and Smart Devices

Team 19071

Continental
The Future in Motion

PROJECT GOAL

To develop a software application for Android and iOS devices to remotely control and monitor a UR-10 collaborative robot.

The sponsor works with an assembly line of 500 collaborative robots that build small parts for automotive projects. The robots sometimes stop working without anyone noticing. The breakdowns cause production decreases and profit losses.

This team developed an application that can start operation, stop operation, count the units produced by the collaborative robot and provide employees with status updates. The application receives information by interacting with the sponsor's database and the collaborative robot's software. This user-friendly application also works with the company's telecommunication application to give employees up-to-date information.

Benchmarking Signal Processing Complex Math in an ARM General Purpose Processor

Team 19072

GENERAL DYNAMICS
Mission Systems

PROJECT GOAL

To evaluate and compare performance of the Texas Instruments TMS320C6000 DSP and the ARM Cortex-A53 in processing complex math functions common to digital signal processing applications.

This project tests the performance of the ARM Cortex-A53 processor and the Texas Instruments TMS320C6000 DSP by comparing the processing time of 20 complex math functions necessary for many digital signal processing tasks. The project demonstration runs an example program using these complex math functions across both hardware solutions. The resulting speeds are displayed on a monitor with single variable statistics for comparing the two processors.

The complex math functions were converted from their Texas Instruments TMS320C6000 DSP-specific implementation to an ARM Cortex-A53-compatible version. These converted functions made special use of single-instruction multiple-data machine instructions specific to the ARM platform to achieve better performance. The team provided single variable statistics for each function across both platforms so the company can make informed decisions about which platform to use in the future.

TEAM MEMBERS

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Cordell Justin Freeman *Electrical & Computer Engineering*
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Michael Inouye *Electrical & Computer Engineering*

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Glen Abousleman

Opportunistic Radio Signal Positioning and Navigation

Team 19073

GENERAL DYNAMICS
Mission Systems

PROJECT GOAL

To develop a machine learning algorithm capable of distinguishing between at least three different locations based on radio frequency signals.

Interference and other environmental factors can interrupt GPS signal acquisition. A possible solution is to exploit the diverse nature of radio frequency signals, which vary in strength and bandwidth. The variations result in unique RF fingerprints that enable identification of different locations. This design uses machine learning based on RF fingerprints to distinguish – with at least 75% accuracy – between locations.

The project explored multiple algorithms, including a k-nearest neighbor, a support vector machine, a long short-term memory and a multilayer perceptron to determine the best method for identifying location. The team used a software-defined radio in combination with GNU Radio to obtain multiple sets of RF signals from each of three separate locations then extracted the features of the signals and entered them into each algorithm for training and testing.

TEAM MEMBERS

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Secure Video Transmission Over Cellular Network for Uncrewed Aircraft

Team 19074

GENERAL DYNAMICS
Mission Systems

PROJECT GOAL

To develop a system for securely controlling uncrewed aircraft and receiving surveillance data over a cellular network.

Drones are important for gathering surveillance information in remote locations. When connected to cellular networks, drones can be controlled from anywhere with internet access. This project uses a novel approach to operate drones via a secure server with which the uncrewed aircraft and ground control station communicate. An operator anywhere in the world can control the drone and view a live video stream.

The connection integrates military-grade encryption for a secure line. An onboard microcontroller cluster is the main computing source. Using Long-Term Evolution technology, the drone transmits data through a secure channel in the cloud to the central server and the user. The user employs a graphical web interface to control the drone and view the data.

TEAM MEMBERS
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Non-Destructive Field Robotic Biomass 3D Scanner

Team 19075

THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE & LIFE SCIENCES
COLLEGE OF ENGINEERING
Biosystems Engineering

PROJECT GOAL

To estimate the weight of plant material in a given area using non-destructive optical sensing methods.

Biomass is an important parameter for analyzing plant productivity. By analyzing just a few biomass samples, a grower can estimate yield of the entire crop and predict profits for the growing season. Direct harvesting is often used to calculate plant biomass. This project presents 3D scanning as a nondestructive alternative for estimating biomass.

The design uses a combination of hoverboard components and class 1M lasers (lidar) to scan vegetation along a crop row. The team developed an autonomous frame that supports the on-board sensors and data processing components and can gently navigate through densely packed crop rows. A Raspberry Pi single-board computer controls the lidar units, and hoverboard motors drive the system. Sensor data stored on the Raspberry Pi can be compiled to generate a 3D visualization of the scanned area using open-source 3D point cloud processing software. The volume of the scanned area is multiplied by the canopy density to produce a final estimation of the sample biomass. Multiple biomass samples can be taken, averaged and extrapolated to approximate the crop biomass in an entire field.

Rebreather Monitoring and Control System

Team 19076

PARAGON SPACE DEVELOPMENT CORPORATION

PROJECT GOAL

To build a rebreather system that monitors and controls oxygen levels in various environments.

Rebreather systems, also known as self-contained breathing apparatuses, are essential for humans' ability to survive in dangerous and inhospitable environments. As an integral part of space suits, diving suits, hazmat suits and life-support systems, they enable crewed space exploration, deep-sea diving, firefighting, and work in hazardous industrial environments. They are also used for oxygen therapy in emergency medicine.

The rebreather system needs to be accurate, reliable, and responsive in delivery of a desired oxygen concentration for varying breathing demands under a wide range of environmental conditions. This team built a functional rebreather system that monitors and controls oxygen levels in various environments. It also validates the flow loop and control system design using Simulink to achieve responsive and accurate control of oxygen levels.

TEAM MEMBERS

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COLLEGE MENTOR

Doug May

SPONSOR MENTOR

Robert Jacobi

Autonomous Torque Robot

Team 19078

Raytheon

PROJECT GOAL

To develop an autonomous device that torques fasteners to a specified value in the desired order and records all results for quality assurance.

Methods to reliably torque fasteners require multiple tools and employees. The process is time consuming, labor intensive, and prone to human error. Automating the process can reduce the possibility of error. Thus, this project uses a rail system for positioning a torque driver over fasteners. The system is similar to an XYZ gantry used in many computer numerical control machines and 3D printers.

The team developed a graphical user interface to enter positions of fasteners and a desired torque value for each fastener. To improve accuracy, the design includes a camera system to detect the positioning error of the torque driver over each fastener. An output file – created while the device is in operation – includes each fastener's true position, achieved torque value, and the date and time.

TEAM MEMBERS

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Print-on-Demand Uncrewed Vehicles

Team 19079

Raytheon

PROJECT GOAL

To create a system that produces low-cost, 3D-printable and easily assembled uncrewed vehicles that can be configured for reconnaissance and utility missions.

Sometimes when a mission calls for a certain configuration of uncrewed vehicle that is not on hand, the mission must wait for remote systems support and crew-served infrastructure. With this design, an operator can select a configuration for an upcoming mission, print the vehicle's structural components on a local 3D printer, and quickly assemble and program the vehicle.

At the core of the system is a graphical user interface that details the parts required for construction and files to be used for 3D printing. The user can assemble the uncrewed vehicle from the 3D-printed chassis components and a kit of commercial, off-the-shelf parts. Operators avoid an extensive supply chain and gain access to a wide variety of remotely operated vehicles.

TEAM MEMBERS
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Basketball Shooting Machine

Team 19080

Raytheon

PROJECT GOAL

To design and build an autonomous basketball shooting machine that scores higher than a player from the Arizona Wildcats basketball team.

This project involved creating an autonomous Basketball Shooting Machine that can defeat a human player from different locations on the court. The device detects the hoop, measures its own relative location to the target, calculates optimal trajectory, feeds the ball to the shooting subsystem, and shoots the ball into the basket.

It uses computer vision algorithms to characterize and understand its environment. An artificial intelligence algorithm coupled with cameras detects and measures the location of the hoop. All software is embedded in a microcontroller that commands different functions. The user interacts with the device through an external controller with a graphical user interface. The machine stores balls in a hopper, and an elevator arm transfers them to the shooter. A spinning flywheel mechanism shoots the basketballs using a dual motor set, which provides control over the shooting force. A set of static and dynamic rails control the movement of the ball. The dynamic rails can move around the axis of the flywheel, allowing the shooting angle of the system to change.

Virtual Reality System for Treating Eating Disorders

Team 19085

Center for Accelerated Biomedical Innovation

PROJECT GOAL

To develop a virtual reality system aimed at treating eating disorders through physiological monitoring and self-assessment capabilities.

Approximately 30 million people in the United States suffer from eating disorders, which have the highest mortality rate of any mental illness. This team created a virtual reality therapy experience that exposes people with eating disorders to increasingly complex food and social scenarios. The progressive, self-directed software desensitizes and acclimates individuals diagnosed with anorexia or bulimia.

The team developed the multilevel, multi-branching virtual reality program in Unity for display on the head-mounted Oculus Go. The therapy includes physiological monitoring and self-assessment. A wearable device equipped with biosensors monitors patients' heart rate and galvanic skin response to characterize stress response. These metrics, which help determine the speed of progression through the treatment, are displayed in real time. The information is stored for future analysis of best practices in treating these disorders.

TEAM MEMBERS

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Visual Natural Language Processing of Medical Images

Team 19086

Center for Accelerated Biomedical Innovation

PROJECT GOAL

To create software for research in deep learning and medical image classification, through natural language processing theory.

Proper analysis of histological images is critical for medical professionals to determine the presence of diseased tissues. This project uses concepts of natural language processing to deconstruct an image to detect abnormal cells. The team designed FractalEyes, software that segments an image into smaller, uniform sections, termed image voxels – similar to how a sentence is segmented by words. The software generates relevant data from each image voxel to be used for future deep learning applications.

Using histological data that contain uniquely identifiable cells, FractalEyes allows a user to segment the image into a grid of predefined shapes and extract the color data. The software uses two operations to extract color data from image files: a preprocessing algorithm, which normalizes an image using a mask function and a unique color library, and a feature extraction algorithm, which determines the color frequencies of each image voxel. FractalEyes achieves an analysis of unique cells types, while retaining well over 50% of the original image data.

TEAM MEMBERS

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Component Sound Analysis for Medical Information From Patient Encounters

Team 19087

Center for Accelerated Biomedical Innovation

PROJECT GOAL

To design and build a system to capture, evaluate and analyze the breathing sounds of patients in clinical settings.

Respiratory diseases are the fourth leading cause of death in the United States. In doctor-patient interactions, more than 30% of the information about the patient comes from non-verbal cues. Unfortunately, the majority of nonverbal acoustic information is not captured. Further, breathing sounds are critical for diagnosing patients who have chronic or acute respiratory illnesses.

This team designed a component sound analysis that incorporates a high-fidelity microphone placed 1 to 3 feet from the patient, natural language processing technology, several Raspberry Pi microcontrollers and a touch-screen tablet. The system is programmed mostly with open-source codes that use MatLab and Python to assess the breathing sounds. It analyzes harmonic-to-noise ratio, noise-to-harmonic ratio, zero-crossing rate, entropy of energy, spectral roll-off, spectral centroid, spectral flux, short-time energy, jitter and shimmer. A tablet displays the results.

TEAM MEMBERS
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Mixed Reality With Artificial Intelligence for Cardiopulmonary Resuscitation Training Team

Team 19088

Center for Accelerated Biomedical Innovation

PROJECT GOAL

To improve cardiopulmonary resuscitation through an assist device with a mixed reality system and an integrated sensor network.

The American Heart Association estimates that there are more than 356,000 out-of-hospital cardiac arrests each year in the United States. About 90% of these cases are fatal. Fear of performing cardiopulmonary resuscitation likely contributes significantly to the high fatality rate. This team developed a system in accordance with AHA guidelines to improve performance of CPR, thereby mitigating the fear of doing the emergency procedure.

The mixed reality system uses integrated physiological sensors to create a CPR feedback device that provides comprehensive, real-time, user performance information. It collects sensor data and processes it with a game engine and spacial computer headset. The integrated sensor network adheres to an elastic glove that contains an Inertial Measurement Unit and multiple pressure sensors. The glove detects compression depth, frequency and position while relaying feedback.

Microfluidic Determination of Platelet Stiffness

Team 19089

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To design and build a more robust and compact point-of-care microchannel-based/microfluidic system to measure the stiffness of circulating platelet cells.

The ability to analyze the stiffness of platelets and other circulating cells is crucial for researching implantable devices. Understanding the effects of external forces acting on cells can help determine possible solutions for making the cell more resistant to forces that may cause unwanted thrombotic behavior.

The system designed inserts platelets into a microfluidic chip containing a microelectrode connected to a custom-made electrical system. The electrical system delivers a sinusoidal voltage with peak-to-peak amplitude ranging from 15 to 150 volts at a 1 MHz frequency to create an oscillating electric field across the microelectrode. This sinusoidal signal is gradually stepped up in voltage, starting from zero, to deform the platelet. The system uses a dichroic-based epifluorescence illumination system in conjunction with custom optics to capture images of platelet deformation at the various voltages. An existing image processing software, ImageJ, measures the physical deformation of the platelet. The stiffness of the platelet can then be determined by plotting this deformation against the stress applied to the cell.

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Wearable Cooling Device

Team 19090

PROJECT GOAL

To design a low-cost, compact wearable device that can effectively cool a user for one continuous hour in low-impact athletics.

Heat-related illness has long been a pervasive health issue in Arizona. This team designed and built a wearable cooling device that takes advantage of the Peltier effect. The thermoelectric phenomenon transfers heat to one side of a Peltier module, generating a significant cooling effect on the opposite side.

The team placed a Peltier module in the center of the cooling device harness plate to optimize the effect on the user. While the module delivers a strong cooling effect, it also produces a sizable amount of heat. To prevent overheating, the design features a custom-built heatsink and forced airflow from a brushless fan blower. With its small profile and efficient output, the wearable cooling device presents new possibilities for outdoor activities in hot environments.

TEAM MEMBERS

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Bruise Age Sensor

Team 19092

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To measure and analyze the optical spectrum of a bruise by determining the concentrations of the physiological components.

Children's Advocacy Centers in the United States provided victim support for 311,000 children and their families in 2015. Almost 20% of these children disclosed that they had been subject to physical abuse, according to data from the National Statistics on Child Abuse. If there are single or multiple bruises on a child suspected of having been abused, then an accurate time window in which the bruise or bruises occurred is important to establish the abuser.

The low-cost Bruise Age Sensor measures the concentrations of multiple physiological components of a bruise by determining the optical spectrum of the skin using mathematical models over time. These measurements are transferred automatically via Wi-Fi to a database, where the data is analyzed to obtain the different concentrations of the bruise's components. The analysis is used to determine the age of the bruise, which can be crucial for identification of the abuser and helpful in court proceedings that require an accurate time window in which the bruise occurred.

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Multichannel Head Cap for Transcranial Acoustoelectric Brain Imaging

Team 19093

COLLEGE OF MEDICINE TUCSON
Medical Imaging

PROJECT GOAL

To build a noninvasive, transcranial head cap that detects and displays acoustoelectric signals from neuronal current densities in the brain.

This project addresses limitations with functional human brain imaging methods, especially surface electroencephalography, which has poor spatial resolution due to the blurring of electrical fields as they spread across the brain and skull. The design consists of two parts: a headcap subsystem, which acts as the sensing platform to detect the signal from the brain, and a signal processing subsystem, which processes, stores and displays the data.

The headcap contains 32 channels to detect radio frequency signals using an active electrode circuit. A novel clip design maximizes the electrodes' contact with the head. The software processes the digitized signal, stores the filtered data and enables graphical display of the data from the headcap in nearly real time. The brain imaging system senses acoustoelectric signals with improved signal-to-noise ratios compared with current tools and displays. The acoustoelectric effect enables the system to sense current densities with 4D resolution (temporal and spatial), providing researchers with more sensitive data to advance development of acoustoelectric imaging.

Biosphere 2 Controlled Systems Monitors Project Description

Team 19094

Biosphere 2

PROJECT GOAL

To design and build real-time, low-cost, high-precision, high-accuracy environmental monitoring systems for two controlled environments at Biosphere 2.

This project developed two low-cost environmental monitoring systems for different controlled environments at the University of Arizona Biosphere 2. Each embedded sensor system consists of the necessary circuitry, software and mechanical housing required for their respective environments – one aquatic, and the other terrestrial.

The Coral Reef Raceway Monitoring System measures water temperature, pH and salinity, housed in a compact, waterproof case with a built-in touchscreen and number pad for user input and control. It uses inexpensive components that improve upon the bulky, inconvenient and expensive commercial alternatives. The Lunar Greenhouse Monitoring System features temperature, relative humidity, and carbon dioxide air quality monitoring in a protective case that interfaces with existing equipment in use at the exhibit. Each system is equipped with an LED and email alert system to signal when values are out of desired bounds.

TEAM MEMBERS

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Mitigating Moth Infestation at Large Binocular Telescope Facility

Team 19095

Large Binocular Telescope Observatory

PROJECT GOAL

To gain insight into how moths respond to nonhazardous repellents.

A seasonal moth infestation at the Large Binocular Telescope Observatory on Mount Graham worsens each summer. The moths infest equipment cabinets, create fire hazards, and leave behind scales that bring on allergies. Because the facility houses many employees, dangerous chemicals are not an option. That leaves three methods for non-hazardous insect repellent: sound, scent and light. This project aims to understand how moths behave in response to these repellents.

This team created simple corridors in which the moths are forced to interact with various repellents. In the scent category, the team tested a variety of oils, at different concentrations, extracted from plants that moths typically avoid. For sound, the team ran an ultrasonic frequency sweep from 30kHz to 60kHz with multiple modulations. The students used a three-corridor chamber with a central release to test moths' behavior when faced with various wavelengths of light. The team compared the results using the repellency index, which generated a series of curves to identify the most effective repellant.

TEAM MEMBERS

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Submersible Optical Sensor Platform

Team 19096

Areté
DISCOVER. DEVELOP. DELIVER.

PROJECT GOAL

To design and build an underwater remotely operated vehicle to test a variety of optical devices and equipment.

The Submersible Optical Test Station is a remotely operated vehicle that can test optical equipment and devices in an underwater environment. The system consists of six thrusters for positioning and stability and a depth sensor to monitor and maintain depth. A camera and subsea lighting provide a clear visual display to the user.

The design runs a Raspberry Pi 4 embedded microprocessor, with two lithium ion batteries that provide operational power for up to four hours. Two watertight enclosures house the electronics, and an ethernet umbilical transfers data to and from the surface. The system is controlled through an engineering laptop and an Xbox game station controller. The user receives a visual display of the environment, along with depth and orientation data.

TEAM MEMBERS
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Hydraulic Mining Shovels Slew Ring Flatness Measurement System

Team 19097

CATERPILLAR

PROJECT GOAL

To design and build a handheld device that measures local and global flatness of hydraulic mining shovel slew ring gear mounting surfaces.

Precision metrology equipment typically costs hundreds of thousands of dollars and requires a highly controlled environment and highly educated operator. Taking such controlled measurements is also time consuming, often immobile and costly. The ring gear surface being measured must be flat to prevent premature failure and excessive wear on the top and bottom gear halves.

The system designed creates a fast, simple and highly accurate measurement technique capable of determining deviations well below .02 mm in a 150 x 150 mm area. Highly sensitive digital contact probes automatically record and display a flatness measurement at every contact point across the gear mounting surface. The simple measurement device is also ambidextrous and requires little understanding of the metrology process. The frame of the measurement device is lightweight yet rigid, lending to simple construction and ease of maintenance. The measurement system is centered around a rubber expansion plug assembly operated by levers at the top. This expansion plug also allows for the device to be operated in an inverted position, which holds it in existing bolt holes within the measurement surface.

Bicycle Handlebar Mounted Automobile Proximity Sensing, Warning and Reporting Device

Team 19098

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To design and build a device that improves the safety of cyclists on the road.

In 2018, 857 bicyclists were killed in traffic crashes in the United States, representing more than a 6% increase from the year before, according to the National Highway Traffic Administration. To address the growing number of cyclist fatalities, this team designed a handlebar-mounted device that detects nearby motorized vehicles.

When a vehicle is within 3 feet of a cyclist, the device flashes a bright LED to warn the motorist. It also records the license plate number of the offending driver so it can be reported to law enforcement. The compact and lightweight mechanical design uses the handlebar to house a portion of the device to avoid compromising the mobility of the bicycle. It also uses a small microprocessor, camera and ultrasonic sensor to quickly detect a motor vehicle intrusion within the 3-foot required passing radius.

TEAM MEMBERS

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COLLEGE MENTOR

Bob Messenger

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Dan Latt

Improved Washing and Coating Facility for the Large Binocular Telescope

Team 19099

Large Binocular
Telescope Observatory

PROJECT GOAL

To detail the design plans for an improved washing and coating facility for the mirror systems at the Large Binocular Telescope's primary facility on Mt. Graham.

The current procedure for cleaning the adaptive secondary mirror of the Large Binocular Telescope at Mount Graham involves removing the mirror from the optical system and transferring it to a facility in Tucson. Because the secondary mirror is only microns thick, it must be transported slowly and carefully. The process results in several days of the arm of the telescope being out of commission and the secondary mirrors being at risk of severe damage.

The proposed modification creates a coating and washing facility on the mountain itself. The team also suggested improvements to scheduling and developed a new mirror fixture. The students laid out the facility to fit in an existing storage room, avoiding the construction of an enclosure around the aluminizing chamber. Additionally, the team designed the electrical and gas lines for the coating process. A cost-benefit analysis showed that the facility would be profitable.

TEAM MEMBERS

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ASML – Level Sensor Lens Window Birefringence Investigation

Team 19100

ASML

PROJECT GOAL

To propose and evaluate potential solutions for reducing the stress in the window optic assembly of ASML's level sensor system.

ASML is a photolithography system supplier for the semiconductor industry. This team investigated and evaluated different options for ASML to reduce the stress on the window optic assembly during its manufacture.

The project consisted of exploring the various manufacturing methods that cause stress birefringence. The team evaluated three solution configurations with a high likelihood of decreasing birefringence. The first method was to change from a full-surface optical contact to a three-point adhesive contact. The second method changed the starting blank size from 10 mm thickness to 5 mm. The final method switched to finer abrasive stages in the grinding process.

TEAM MEMBERS
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Automated Micro-Scale 3D Printer

Team 19101

FDM

PROJECT GOAL

To automate the use of a 3D printer by reducing the amount of interaction people have with the printer.

Over the last 20 years, the development of 3D-printing technology has enabled engineers and fabricators to produce parts more quickly and efficiently. A wide variety of affordable printers on the market can produce functional parts from advanced materials. While 3D printers have shown their value in prototyping, they cannot quickly and easily make parts in high volume.

This team developed a feed system to automatically store and replace up to 10 build surface plates, so the printer to which the plates are fixed can sequentially print many models with limited human involvement. Using a pair of parallel tread assemblies and a linear actuator fitted with electromagnetic solenoids, the system can quickly and reliably move replaceable plates in and out of a printer. Because it incorporates a readily available microcontroller and many 3D-printed parts, the system is easily configured for different-sized surface plates and affordable to build.

Biosphere 2: Ocean Wave Generator

Team 19102

Biosphere 2

PROJECT GOAL

To improve the reliability of the ocean wave generator at the University of Arizona Biosphere 2 so it more accurately simulates the ocean environment.

The wave generator is a key piece of equipment at Biosphere 2. It ensures water is well-mixed with no stratification. This team recommended replacement parts for the wave generator. Criteria included that the replacements be readily available, low-maintenance, cost-effective, and equal to or better than the quality to existing parts. In addition, the team created a maintenance manual and troubleshooting guide for quick response to malfunctions.

With the recommended upgrades, the system now has more reliable gates, automated electrical actuators, and code that controls the actuators of the system. It also monitors the water level in the troughs and activates an interlock if the water level passes a critical height.

TEAM MEMBERS

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Cody Petrick *Mechanical Engineering*
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SPONSOR MENTOR

John Adams

Automated Collection of Pre-Clinical Behavioral Data

Team 19103

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To design an automated data collection system that will automatically collect ferret behavioral data for the evaluation of procedural effects on humans.

Some biomedical research aims to translate behavioral knowledge about animals into techniques and tools for treating human disease. Translational studies depend on collection of meaningful behavioral data. However, commercial systems typically only work with select animal species. They are neither open source nor cost-effective, especially for custom applications.

This design for a ferret enrichment chamber apparatus employs radio frequency identification readers and 32-bit chips to automatically obtain each ferret's location upon entering or exiting any of the three enrichment chambers. The data is sent to a board that monitors six universal asynchronous receiver/transmitter lines from the RFID readers. A Raspberry Pi microcontroller reads the data from the receiver board and attaches timestamps. The data collected by the chambers is delivered to the Multiscale Brain Imaging Lab for further study of natural ferret behavior. This ferret enrichment chamber apparatus is a low-cost, easily movable product.

TEAM MEMBERS

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Smart Ultrasound Marker with Signature Recognition for Improved Cancer Tissue Targeting and Subsequent Excision

Team 19104

BD

PROJECT GOAL

To improve existing tissue biopsy needle technology by providing detectable signatures that increase spatial information and indicate needle orientation in tissue.

Ultrasound tissue biopsies target cancerous tissues for excision and subsequent analysis. While ultrasound imaging provides visualization of tissue in multiple planes, biopsy devices lack distinct features that would allow the user to visualize the tool in multiple dimensions.

This project uses echogenic materials fabricated in specific geometries that provide unique signals when attached to biopsy devices and viewed under ultrasound. Simultaneous image processing uses adaptive thresholding to identify the signatures on the needle attachment. This gives the user relevant information about the biopsy device orientation in space. The increased spatial information reduces the risk of sampling an unintended area and having inappropriate device alignment.

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Distal Tibia Osteotomy Guide

Team 19106

Exclusively foot & ankle Paragon 28

PROJECT GOAL

To design and build a surgical device that provides guidance for uniplanar and biplanar distal tibia osteotomies.

Distal tibia osteotomy corrects deformities at or near the ankle joint that typically result from improper healing of fractures or osteoarthritis. The surgery involves inserting or removing a wedge of bone to realign the anatomical and mechanical axes at the joint. The procedure relies solely on radiographic visualization and freehand cuts. It requires a high degree of surgical skill and is prone to error. This team created a device to improve the accuracy and repeatability of distal tibial osteotomies.

Team members designed a surgical guide that mounts directly to the tibia, allowing the surgeon to measure precise angles in the sagittal plane for opening and closing wedge osteotomies. It uses varied cut guides to allow correction in the frontal plane. The device fits within the surgical site and provides surgeons radiographic visualization of the osteotomy site prior to making cuts in the bone. Following FDA regulations, the team developed parts using computer-aided design and manufactured them with surgical stainless-steel. Team members also created a surgical technique guide that explains how to use the device.

Harnessing the Power of Mathematica, Polaris-M and Unity

Team 19107

AIRY OPTICS
THE POLARIZATION EXPERTS

PROJECT GOAL

To create simulations of optical systems for users to interact with in a 3D virtual reality environment.

Optical benches, elements and mounts can be expensive to purchase and maintain. Creating a virtual simulation to analyze them in an interactive space can drastically decrease costs. This team used the Unity game engine to render three simulations of optical systems in a virtual reality environment. The backbone of all the optical systems and ray data for the simulations, Polaris-M, generated the models.

A software package, created using Polaris-M, generates optical system models and calculates ray traces. The data output from the software is sent to the Unity game engine. The team used Unity's built-in scripting engine to collect the optical element models, render the ray data into visible rays, and assign attributes to each optical element and ray. Users can manipulate the optical systems in a virtual environment and observe how the system and rays change in real time. They were also designed to captivate users with realistic modeling and demonstrate the fundamental principles of optics and polarization.

TEAM MEMBERS

Corbin Edvin Blomquist *Electrical & Computer Engineering*
Kieran Patrick Campbell *Systems Engineering*
Kyler Ray Langworthy *Optical Sciences & Engineering*
Joseph Timlin Scheidemande *Mechanical Engineering*
Momoka Sugimura *Optical Sciences & Engineering*

COLLEGE MENTOR

Claude Merrill

SPONSOR MENTOR

Russell Chipman, Morgan Harlan

Diamond Mine Tailings Facility Closure

Team 19108

COLLEGE OF ENGINEERING
Mining & Geological Engineering

PROJECT GOAL

To develop a closure protocol and design an integrated monitoring system for a diamond mine tailings facility in northern Canada.

Site remediation and monitoring for the closure of a mine is a crucial part of mine planning and design. This project identified several potential closure methods for a diamond mine tailing facility. The team ranked each method on a numerical scale in three categories: environmental effects, social license risk and regulator interest. Additionally, the analysis considered relative costs and other factors.

The team selected the process of hydraulic backfill into the underground mine as the closure method. It received the best ranked score and was of equal cost to the other methods identified. Parameters to monitor the closure and ensure its effectiveness focused on water flow and contaminant levels. Thus, the team developed a plan to ensure adequate response to excess contaminant levels or movement of water into undesired areas.

TEAM MEMBERS

Carl James Holliday *Mining Engineering*
Elizabeth Elaine Jones *Mining Engineering*
Brandon Grantham Sims *Mining Engineering*
Ryan Jeffrey Stewart *Mining Engineering*

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Brad Ross

SPONSOR MENTOR

Gail Heath

TEAM MEMBERS
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Edwin Garsuah Kaykay *Mining Engineering*
Filipe Antonio Narciso *Mining Engineering*
Aditya Singh *Mining Engineering*

COLLEGE MENTOR
Brad Ross

SPONSOR MENTOR
Natska Ericson, Fabio Pinto

Potential Chemical for Mineral Flotation of Copper Sulfides Ore

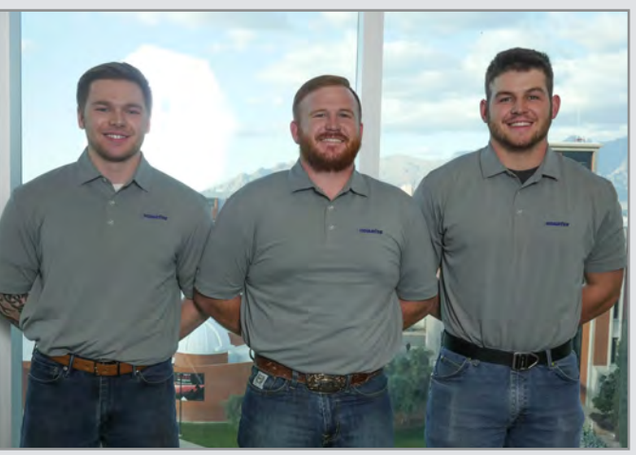
Team 19109

CLARIANT

PROJECT GOAL

To design a flotation system that efficiently recovers copper from sulfide ores with high pyrite content.

Efficiently recovering valuable copper in sulfide ore when non-valuable pyrite is present is difficult for the mineral processing industry. This design investigation focused on the surface tension of copper and pyrite. The team designed four chemical collectors that suppress pyrite and float copper during a flotation test. They designed a flowsheet for the flotation process and conducted eight efficiency tests of the chemical collectors with Clariant's Mining Solution Laboratory.



TEAM MEMBERS
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James Joseph Raica *Mining Engineering*
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COLLEGE MENTOR
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SPONSOR MENTOR
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P&H 4800XPC Electric Mining Shovel Comparison

Team 19110

KOMATSU

PROJECT GOAL

To determine the economical and logistical benefits of the 4800XPC AC electric mining shovel paired with the 980E haul truck in multiple mining scenarios.

Open pit, hard rock mines regularly use electric rope shovels, paired with high tonnage capacity haul trucks, to quickly expose and transport large amounts of valuable material.

This project created three scenarios – an open pit mine with 15-, 18- and 20-meter benches – using MinePlan, an industry design program. Then the team virtually compared combinations of a 4100XPC AC shovel paired with 930E haul trucks and the larger 4800XPC AC shovel paired with 980E haul trucks to determine economical and logistical benefits.

University of Arizona SME/NSSGA Student Mine Design Competition

Team 19111

COLLEGE OF ENGINEERING
Mining & Geological Engineering

PROJECT GOAL

To design and propose a feasible mine plan for a sand and gravel operation based on real-world constraints given by the SME/NSSGA Student Mine Design Competition.

For this project, five mining engineering students participated in an international collegiate competition sponsored by the Society for Mining, Metallurgy & Exploration and the National Stone, Sand & Gravel Association. The teams used real-world data to create a mine plan and evaluate its feasibility.

In phase one of the competition, the team designed an aggregate mine based on provided information, such as assay data from drill holes. The design considered production requirements for final products, environmental regulations, operating and capital expenditure costs, and more. Specific pit designs and locations ensured the material met the processing plant's requirements. Additionally, the submitted proposal outlined a waste handling and storage plan.

This team placed in the top six in the world and went on to phase two of the competition in Phoenix, where they won second place overall.

TEAM MEMBERS

Gabriella Morales Archunde *Mining Engineering*
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Thomas Anthony Holmes *Mining Engineering*
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William Thomas Peterson *Mining Engineering*

COLLEGE MENTOR

Brad Ross

SPONSOR MENTOR

Brad Ross

Twin Decline Realignment Design for Underground Mine

Team 19112

SOUTH32

PROJECT GOAL

To design a realignment of twin exploration declines based on research regarding legacy and historic mine workings near and on property of an underground lead and zinc operation.

Research of historic and legacy workings within the mine district provides data for comprehensive digitization and can aid greatly in mine design. In this case, the team also uncovered information on environmental studies, health and safety, and mining operations, which was categorized into a digital database for future use. Workings that could not be digitized were GPS tagged and mapped for further exploration.

Assuming ideal geologic conditions and the contingencies from the legacy workings, the team used CAD software to design realignment of the declines from the northeast side of the property to the southeast. The purpose of the realignment was to avoid intersection between the new decline route and previous workings.

TEAM MEMBERS

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Melissa Lorraine Talavera Dowdy *Mining Engineering*

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Brad Ross

SPONSOR MENTOR

Robert Tracy

TEAM MEMBERS
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Lee Daniel Headley *Civil Engineering*
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COLLEGE MENTOR
Salvatore Caccavale

SPONSOR MENTOR
Salvatore Caccavale

Multimodal Transportation Facility – CBG Engineering

Team 19113

COLLEGE OF ENGINEERING
Civil & Architectural Engineering & Mechanics

PROJECT GOAL

To create a design concept report for the Houghton Road corridor from Irvington Road to Watson Drive.

Teams 19113-19115 were each separately tasked with the challenge to improve the existing two- and three-lane sections of Houghton Road to a modern, six-lane, urban major roadway with a center median and paved shoulders. The improvements include horizontal and vertical geometry, intersection realignments, traffic control elements, better drainage conveyance and a new bridge over an existing major regional wash.

The new design vastly increases public safety by adding bicycle-accessible paved shoulders, an ADA-accessible pathway, and a continuous center turn lane for enhanced access and reduced traffic congestion. It also eliminates the current substandard curves and line-of-sight conditions. In addition, it improves vehicular ingress/egress, parking and circulation, pedestrian drop-off and access at Secrist Middle School.

Engineering work included roadway design, traffic analysis, hydrology and channel hydraulics, geotechnical analysis, pavement design, bridge design and other structural elements, utility relocations, environmental requirements, construction considerations, cost estimating and scheduling. The team addressed sustainability by applying Envision metrics, and they worked with over 20 industry mentors to develop the design.

TEAM MEMBERS
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Steffen Ryan Cortinas *Civil Engineering*
Kristen Mari Faltz *Civil Engineering*
Jason Javellana Javelosa *Civil Engineering*
Daniel Katib *Civil Engineering*
Jesus Esteban Ruiz *Civil Engineering*
Travis Robert Shollin *Civil Engineering*
Ethan Bruce Stahlhuth *Civil Engineering*
Cory Martin Swieczkowski *Civil Engineering*
Tariq R Tariq *Civil Engineering*

COLLEGE MENTOR
Salvatore Caccavale

SPONSOR MENTOR
Salvatore Caccavale

Multimodal Transportation Facility – Arizona Builders & Associates

Team 19114

COLLEGE OF ENGINEERING
Civil & Architectural Engineering & Mechanics

PROJECT GOAL

To create a design concept report for the Houghton Road corridor from Irvington Road to Watson Drive.

Teams 19113-19115 were each separately tasked with the challenge to improve the existing two- and three-lane sections of Houghton Road to a modern, six-lane, urban major roadway with a center median and paved shoulders. The improvements include horizontal and vertical geometry, intersection realignments, traffic control elements, and a new cost-effective, low-impact bridge over an existing major regional wash.

The new design vastly increases public safety by adding bicycle-accessible paved shoulders, an ADA-accessible pathway, proper storm draining along the corridor, and a continuous center turn lane for enhanced access and reduced traffic congestion. It also eliminates the current substandard curves and line-of-sight conditions. In addition, it improves vehicular ingress/egress, parking and circulation, pedestrian drop-off and access at Secrist Middle School.

Engineering work included roadway design, traffic analysis, hydrology and channel hydraulics, geotechnical analysis, pavement design, bridge design and other structural elements, utility relocations, environmental requirements, construction considerations, cost estimating and scheduling. The team worked to maintain as much of the existing surface as possible, and consulted with over 20 industry mentors on the design.

Multimodal Transportation Facility – T3 Engineering

Team 19115

COLLEGE OF ENGINEERING
Civil & Architectural Engineering & Mechanics

PROJECT GOAL

To create a design concept report for the Houghton Road corridor from Irvington Road to Watson Drive.

Teams 19113-19115 were each separately tasked with the challenge to improve the existing two- and three-lane sections of Houghton Road to a modern, six-lane, urban major roadway with a center median and paved shoulders. The improvements include horizontal and vertical geometry, intersection realignments, traffic control elements, better drainage conveyance and a new bridge over an existing major regional wash.

The new design vastly increases public safety by adding bicycle-accessible paved shoulders, an ADA-accessible pathway, and a continuous center turn lane for enhanced access and reduced traffic congestion. It also eliminates the current substandard curves and line-of-sight conditions. In addition, it improves vehicular ingress/egress, parking and circulation, pedestrian drop-off and access at Secrist Middle School.

Engineering work included roadway design, traffic analysis, hydrology and channel hydraulics, geotechnical analysis, pavement design, bridge design and other structural elements, utility relocations, environmental requirements, construction considerations, cost estimating and scheduling. The team addressed sustainability by applying Envision metrics, and they worked with over 20 industry mentors to develop the design.

TEAM MEMBERS

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Joel Hernandez *Civil Engineering*
Andrew James Jenkins *Civil Engineering*
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COLLEGE MENTOR

Salvatore Caccavale

SPONSOR MENTOR

Salvatore Caccavale

Rover for Exploring the Lunar South Pole

Team 19116

COLLEGE OF ENGINEERING
Aerospace & Mechanical Engineering

PROJECT GOAL

To design a rover capable of exploring and gathering data in the harsh environment of the lunar south pole's Permanently Shadowed Regions.

The lunar south pole contains areas known as Permanently Shadowed Regions that never receive direct sunlight. Within and around these PSRs, the temperatures are predicted to reach as low as -220 C, making it one of the coldest places in our solar system. Scientists have hypothesized from orbital observations that there are signs of water ice, hydrogen, or other volatile compounds on or near the surface of the PSRs.

This team designed a rover to combat the obstacles on the dark side of the moon. Features include a customized wheel assembly for traversing the rocky terrain and insulation to protect instruments so they can complete their operational, navigational and data collection tasks. Instruments on board collect images, gather temperature data, and analyze the chemical composition of the local regolith.

TEAM MEMBERS

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Lindsey Rose Urh *Aerospace Engineering*

COLLEGE MENTOR

Jekan Thangavelauthum

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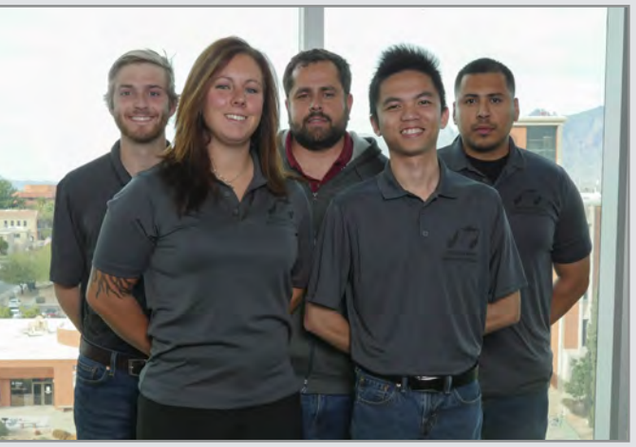
Jekan Thangavelauthum



Active Control Method to Accelerate Vortex Dissipation

Team 19117

COLLEGE OF ENGINEERING
Aerospace & Mechanical Engineering

PROJECT GOAL

To develop an active flow control method that accelerates the dissipation of wingtip vortices on the runway.

Sweeping wingtip vortices off the runway will minimize the time delays between departing and landing aircraft, while also promoting flight safety.

For this project, the team conducted a series of experiments using a high-speed, radio-controlled plane. A smoke generator produced a trail off the wingtip to visualize the development of vortices. To enforce vortex dissipation, the team designed a set of jet ports shooting compressed streams of air aligned with the runway. They took video recordings of the smoke wingtip vortex with and without the use of the compressed streams of air. Then, they investigated findings about the wingtip vortex behavior behind the trailing edge using particle image velocimetry. Finally, they used video analysis to evaluate the jet system's ability to dissipate the vortices.

TEAM MEMBERS

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Riley Sim McClurkin *Aerospace Engineering*
Thinh Phu Nguyen *Aerospace Engineering*
Kylie Lynn Scurto *Aerospace Engineering*

COLLEGE MENTOR

Sergey Shkarayev

SPONSOR MENTOR

Sergey Shkarayev

Lunar South Pole Prospecting Mission

Team 19118

PROJECT GOAL

To design and build a rover for exploring the Permanently Shadowed Regions of Earth's moon and prospect for possible ice deposits.

Researchers have yet to study in depth the Permanently Shadowed Regions (PSRs) of Earth's moon because of their extremely low temperatures and other harsh environmental factors. While NASA scientists are uncertain about the type of terrain in these regions, they have theorized that PSRs could contain some form of ice.

To aid NASA in exploration of the PSRs, the team designed and built a vehicle weighing less than 15 kg to be stored in the Peregrine Lunar Lander. The rover uses a single-nozzle thruster system to hop around. A radio-control system determines movement of the "hopper," and springs inside the legs deploy reflectors onto the moon's surface.

TEAM MEMBERS

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Jose Maria Fernandez Moreno *Aerospace Engineering*
Tony Truong *Aerospace Engineering*
Lucas Miguel Velasco *Aerospace Engineering*
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COLLEGE MENTOR

Jekan Thangavelauthum

SPONSOR MENTOR

Timothy Swindle

Mars Sailplane

Team 19119

COLLEGE OF ENGINEERING
Aerospace & Mechanical Engineering

PROJECT GOAL

To test the viability of dynamic soaring on Mars.

Dynamic soaring is a method of unpropelled flight that uses wind shears to gain energy. To test the feasibility of using dynamic soaring on Mars, the team launched a glider from a weather balloon at high altitudes, where the atmospheric density on Earth is comparable to that on Mars.

During the ascent, the on-board GPS system collected wind shear data to determine the best altitude for testing. Upon release from the balloon, the glider began an experimental flight following a predetermined trajectory. The trajectory was determined by an optimization formula to maximize energy gain based on wind shear data. The data collected from this project will provide design guidance for a glider that can follow these trajectories in low-density conditions.

TEAM MEMBERS

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Trevor Andrew Swafford *Aerospace Engineering*
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COLLEGE MENTOR

Sergey Shkarayev

SPONSOR MENTOR

Sergey Shkarayev

X-56 Scaled Composite Research Test Bed

Team 19120

PROJECT GOAL

To develop a research platform for studying the effect of structural motion on boundary layer transition and separation for the X-56A uncrewed aircraft.

The high aspect ratio wings for Lockheed Martin's X-56A are aerodynamically efficient. However, these flexible wings are more prone to flutter, which can lead to structural failure. A test bed aircraft to study flow interaction in flexible structures is crucial for identifying and mitigating this possible issue.

This project designed and manufactured a 1/4.5 dynamically scaled X-56A model, using a two-piece mold and fiberglass composite construction to accommodate the remotely piloted airplane's complex contours. The model's wing stiffness incorporates an adjustable telescoping carbon spar, allowing for modification of the elastic property. Additionally, the X-56A is a tailless aircraft, so the team integrated an empennage to increase stability for initial test flights.

TEAM MEMBERS

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Joseph Lernor *Aerospace Engineering*
Kyle William McHugh *Aerospace Engineering*
Ezekiel Sisay *Aerospace Engineering*
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Hermann Fasel

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William Cameron Reynolds *Aerospace Engineering*
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Design/Build/Fly Aircraft Design Competition

Team 19121

PROJECT GOAL

To design a banner-towing, cargo-capable uncrewed aircraft to represent the University of Arizona at the 2020 Design/Build/Fly competition.

The team designed and built a remote-controlled aircraft for the international 2020 American Institute of Aeronautics and Astronautics Design/Build/Fly competition in Wichita, Kansas. The design emphasizes speed, cargo-carrying capacity, and the ability to deploy and detach a banner.

They constructed a low-wing aircraft with a 58-inch wingspan, a T-tail and twin engines. It features an integrated passenger bay inside the fuselage with oversized control surfaces for improved maneuverability when carrying many passengers. A specially designed mechanism allows for a banner to deploy mid-flight and detach from the aircraft before landing. The twin-engine configuration provides sufficient stability and properly orients the banner in flight. Large propellers provide ample thrust for multiple mission types and turbulent flow over the wings for prolonged lift generation.

The team verified the design as stable and flightworthy through preliminary prototyping and flight testing. In final tests, they evaluated and optimized propulsion, structures and payload systems to enhance mission scoring potential.

TEAM MEMBERS
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Maleny Marin *Systems Engineering*
Rafael Ortiz *Systems Engineering*
Christian Pascasio *Systems Engineering*
Victor Manuel Ramers *Systems Engineering*
Alan Vega *Systems Engineering*

COLLEGE MENTOR
Samuel Peffers

SPONSOR MENTOR
Tammy Snook

Yuma Crossing Interactive Museum Exhibit

Team 19122

PROJECT GOAL

To design an interactive exhibit that helps visitors understand the importance of historical events that have shaped the Colorado River.

This project developed an interactive topographic display of the lower basin of the Colorado River to help raise awareness about critical changes to the river over time. After conducting trade studies of interactive exhibits, the team chose a 32-inch Android tablet to present historical information and a Raspberry Pi 4 to manage system components. Software was written in the object-oriented, easy-to-use Python programming language.

The output signal generated from the tablet creates a flow of current to light-emitting diodes on the topographic model, which depict ten major dams along the lower basin of the Colorado River. The resulting exhibit enables visitors to interact directly with the display. It also takes into account associated energy and building codes and integrates ergonomic features for compliance with the American Disabilities Act.

Facilities-Related Control of Fire Alarm Systems

Team 19123

PROJECT GOAL

To design a fiber optic secured network capable of interconnecting fire alarm control panels (FACPs) spread across different facilities to an alarm monitoring center within a military installation.

Fiber optics are commonly used in industrial life- and safety-monitoring devices to provide highly reliable signal transmission in network communications, thus improving response time in emergencies.

The team conducted a life- and safety-sustainability study for FACP-protected structures at the Marine Corps Air Station Yuma. The study considered federal regulatory expectations, security, maintainability and centralized monitoring. Based on the study, the team made recommendations to transition from conventional copper wire to a secured fiber optic communications network.

They also performed a cost analysis for the replacement of 22 discontinued FACPs, 123 fiber optic media cards with required fiber optic connectors, 9,616 feet of single-mode fiber optic cable and approximately 7,000 feet of half-inch electrical metallic tubing.

An Arena software simulation showed that the fiber optic network improved the situational awareness for the centralized monitoring section and increased the safety of personnel, facility structures and equipment.

TEAM MEMBERS

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Municipal Recycling Sorting Plant Design

Team 19124

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design an economical and continuous source-separated municipal solid waste sorting plant for the city of Tucson.

In the city's recycling pre-process, not only are various materials sorted by type, but also contaminants, such as plastic bags and trash, are removed. This process preserves the integrity of the materials and decreases down recycling, in which materials are converted into something of less value. Current processes include direct sorting, which is based on characteristics like material density, and indirect sorting that uses optical sensors detect the presence and location of specific materials.

The team designed an economical, continuous source-separated municipal solid waste sorting plant, which can process paper, cardboard, metals, glass, aluminum and two plastics: polyethylene terephthalate and high-density polyethylene. The design can be accomplished with equipment such as rotary screen and eddy current separators, a cross-belt magnet and air classifier. To further ensure the quality of sorted materials, a second separation stage in the plan uses processes such as an ultrasonic bath and dry washing. The proposed design greatly improves the materials separation process and minimizes contamination levels, while also considering physical, environmental, economic and time constraints.

TEAM MEMBERS

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Zizhao Yu *Chemical Engineering*

COLLEGE MENTOR

Adrianna Brush

SPONSOR MENTOR

Adrianna Brush

Water Testing Device

Team 19125

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

TEAM MEMBERS

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Brett Isadore Levine *Chemical Engineering*
Ciara Avelina Lugo *Chemical Engineering*
Adam Douglas Spaulding *Chemical Engineering*

COLLEGE MENTOR

Adrianna Brush

SPONSOR MENTOR

Adrianna Brush

PROJECT GOAL

To design a process that removes arsenic and total trihalomethanes (TTHM) from drinking water sources in Arizona.

Consumption of TTHM and arsenic is linked to health repercussions such as cancer. The team designed a system for the removal of those compounds to exceed water quality standards mandated by Arizona Department of Environmental Quality and the Environmental Protection Agency.

The team explored various methods for removing arsenic and TTHM to determine a suitable design and the appropriate process conditions. Tested methods include adsorption and diffusion in a packed bed via strong base anion resin exchange, granulated activated carbon, powdered activated carbon, and iron sorbents. They mathematically modeled the compound removal using equations for packed bed weight, porosity of the packed resins/media, and kinetics of the adsorption process. Using research simulations with these unit operations, the team determined the quantity of arsenic and TTHM removed from drinking water after processing.

Recycled Waste Plastics as Building Material for Low-Cost Shelters

Team 19126

Infinite Options

TEAM MEMBERS

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Madison Kate Matson *Chemical Engineering*
Kara Alexandra Walton *Chemical Engineering*
Stanley Wong *Chemical Engineering*

COLLEGE MENTOR

Adrianna Brush

SPONSOR MENTOR

Prashant Marathay

PROJECT GOAL

To create a process that recycles waste plastic into consumer-friendly building materials.

The quantity of waste plastics has increased greatly over the last few years. Presently, 91% of waste plastics are not recycled. This project aims to recycle that waste into building materials.

Various kinds of waste plastics were tested for their chemical and physical properties to determine which would be the best fit for building materials. The waste was heated to the lower limit of its melting range while pressure was applied to fuse the plastics into solid panels or interlocking bricks for easy assembly. This process was optimized to operate at the lowest temperature and pressure, to minimize the energy required. The ensuing building materials are lightweight with high thermal resistance for low-cost construction in challenging situations, such as natural disasters.

Safety Relief Valves

Team 19127

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design and construct a safety relief valve laboratory for the Department of Chemical and Environmental Engineering.

It is important for undergraduate chemical and environmental engineering students to learn how to properly size valves and vent lines. Thus, this project involved designing a student lab system that can withstand over-pressurization while maintaining laboratory safety. Over-pressurization occurs when the transient air pressure exceeds the atmospheric pressure. Excessive rise in temperature, uncontrolled flow, loss of contaminants and incorrect mixing can lead to over-pressurization.

The system consists of an air compressor, large pressure storage tank and smaller test vessel. The test vessel consists of two inlets and two outlets. The inlets include a regulated feed from the air compressor and an instant or continuous release of air from the large pressure storage tank. The outlets include a regular drain line with a back-pressure regulator and a safety release port. Team members tested the size of the valves and vent lines and pressurized the testing vessel steadily until a release occurred. Then they measured the time it takes to release all the air.

TEAM MEMBERS

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Corey Allen Colbert *Chemical Engineering*
Mark Alan Solomon Fabros *Chemical Engineering*

COLLEGE MENTOR

Gregory E. Ogden

SPONSOR MENTOR

Gregory E. Ogden

Biosphere 2 Landscape Evolution Observatory Upgrade

Team 19128

Biosphere 2

PROJECT GOAL

To upgrade the existing irrigation system and design a lithium chloride tracer injection system for the Mini Landscape Evolution Observatory at Biosphere 2.

The Landscape Evolution Observatory at Biosphere 2 studies how the landscape is affected by physical and biological processes, how water flow is affected by time and climate change, and how biological communities evolve in response to changes in landscape and environment. The LEO is a single, ongoing operation that cannot be paused or restarted. Therefore, Biosphere 2 researchers perform pilot-scale tests on a mini LEO before making changes to the Landscape Evolution Observatory.

The team developed a comprehensive design and cost estimation for making the mini LEO's injection system compatible with existing equipment. Design constraints included the uniform distribution of rainfall, existing sensor network, and placement of irrigation heads in relation to the gas chamber and grow lights.

TEAM MEMBERS

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Brooke Lillian Rizzetto *Chemical Engineering*

COLLEGE MENTOR

Wei-Ren Ng

SPONSOR MENTOR

Wei-Ren Ng

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Carlos Weiler *Chemical Engineering, Environmental Engineering*
Kira Zeider *Chemical Engineering, Environmental Engineering*

COLLEGE MENTOR
Gregory E. Ogden

SPONSOR MENTOR
Gregory E. Ogden

Chemical Engineering Unit Operations Laboratory Upgrades

Team 19129

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design and install a hydraulic friction loss experiment and chilled-water system for the Department of Chemical and Environmental Engineering's unit operations laboratory.

The UA Department of Chemical and Environmental Engineering is growing, and part of that expansion was the construction of a new unit operations laboratory for environmental engineering seniors.

The team designed and installed the hydraulics lab to encourage students to investigate common fluid flow principles. The experiment allows students to compare real-time pressure data to theoretical calculations. It also implements two flow visualization modules, a cavitation demonstration and a laminar-turbulent transition regime, which prepare students for industrial applications of fundamental engineering principles.

Additionally, the team designed an updated chilled-water system to provide tankless cooling water to several undergraduate experiments. These include two distillation columns and three heat exchanger networks.

This project applied fluid mechanics, focusing on frictional losses and process controls using underlying engineering principles of mass and energy balances.

TEAM MEMBERS
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Ibrahim Rreshka *Chemical Engineering*
Garlin Zappia *Chemical Engineering*

COLLEGE MENTOR
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Fred Brinker

Alkylation Unit

Team 19130

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design a process for producing enough alkylate to supply a gasoline blending unit that produces 130,000 barrels of liquid per day.

Methyl Tertiary Butyl Ether (MTBE) is commonly used worldwide as a fuel additive to improve octane number in gasoline. Because it is highly soluble in water and moves with groundwater, it can contaminate large areas quickly.

This project features an alkylation unit that produces alkylate as a replacement for MTBE. The process begins with a feed preparation unit to purify the isobutane and light olefin feed. This removes normal butane from the isobutane and eliminates propane and propylene from the olefin feed. The increased concentration of isobutane and double bonded butanes ensure a high conversion to alkylate in the unit. The alkylate is then sent to a gasoline blending unit and mixed with other fuel additives to produce high quality gasoline, with winter and summer blends of regular (87) and premium (93) octanes.

2020 AZ Water Student Design Competition

Team 19131

AZ Water Association

PROJECT GOAL

To analyze the prior wastewater flow rate data and treatment methods used in the Kyrene Water Reclamation Facility and propose methods to improve the treatment processes.

The city of Tempe is planning to reopen the Kyrene Water Reclamation Facility, which was shut down in 2010. This project identified cost-effective technologies to improve the primary, secondary and tertiary treatment stages of wastewater effluent.

The main stage of redesign was in the aeration chamber, where much of the plant's energy powered several large blowers. The team redesigned this stage to significantly increase the blowers' capability. The redesign also provides the correct amount of oxygen to ensure the proper reduction of biological content in the wastewater.

TEAM MEMBERS

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Marcos David Lee *Chemical Engineering*
Xavier Alexis Plascencia *Chemical Engineering*
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Wastewater Reuse

Team 19132

College of Engineering
Chemical & Environmental Engineering

PROJECT GOAL

To lower the concentrations of trace organic compounds in wastewater through advanced oxidation process, ultrafiltration and a combination of both.

Wastewater discharge can contain high levels of trace organic compounds – natural and anthropogenic substances, including industrial chemicals. Achieving lower levels of trace organics can enable industrial reuse of treated wastewater. This project assessed three processes for reducing these contaminants – ultrafiltration, ultraviolet advanced oxidation and a combination of the two.

Test procedures included measuring trace organics before and after ultrafiltration and varying configurations of hydrogen peroxide in oxidation. Equipment included a reactor, provided by NeoTech Aqua Solutions, which was made of a 50-centimeter stainless steel cylinder with a low-pressure amalgam ultraviolet lamp located concentrically in the barrel. An elementary reaction was triggered within the device, destroying a wide range of target compounds, and data was collected. The data indicates that ultrafiltration reduces the initial trace organic compounds by 10%, while ultraviolet advanced oxidation reduces the amount by 90%. Processing the wastewater first through ultrafiltration then oxidation reduces trace organics by 98%.

TEAM MEMBERS

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Manuel Lontoh *Chemical Engineering*
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Andrea Achilli, Eduardo Saez

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Rodney Keith

Municipal Recycling of High-Density Polyethylene

Team 19133

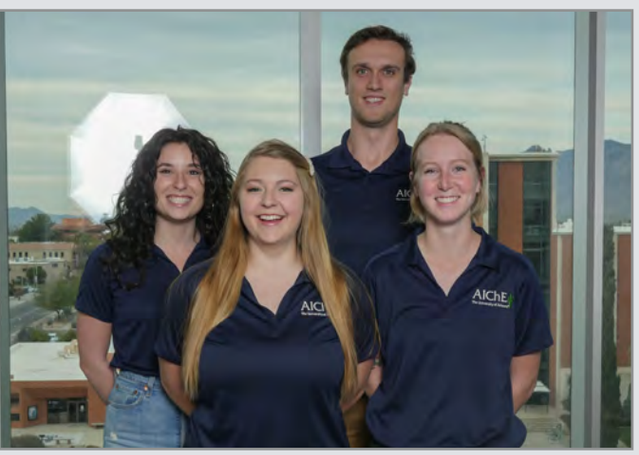
COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design a facility that processes high-density polyethylene jugs derived from municipal recycling programs into high-grade pellets for plastic jug manufacturing and low-grade pellets for brick manufacturing.

High-density polyethylene (HDPE) is a common plastic found in packaging from household waste. This team designed a plant for processing the recyclable plastic into pellets that companies can use to make HDPE products.

The sustainability-oriented project focused on reducing emissions, energy use and water consumption to establish HDPE recycling as a safe, cost-effective alternative to landfills. In the recycling process, HDPE jugs are washed in a tank with cold water to remove residual contents and odor. The bottles are then ground to 5-10mm flakes and sent to a flotation tank, where HDPE is separated from contaminants by density. After being rinsed with an antifoaming agent, the flakes are sorted by color, and the clear HDPE flakes are extruded into pellets.



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Tucker Glenn Hookstra *Chemical Engineering*
Jessica Lynn Peebles *Chemical Engineering*
Victoria Marie Perreault *Chemical Engineering*

COLLEGE MENTOR
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AZ Water Competition: Rehabilitation of the Kyrene Water Reclamation Facility

Team 19134

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To rehabilitate and renovate the Kyrene Water Resource Center in compliance with Environmental Protection Agency regulations.

The Kyrene Water Reclamation Facility in Tempe, Arizona, has been shut down because of noncompliance with Environmental Protection Agency regulations. This project investigates ways to bring the plant back to working order while also improving energy efficiency and reducing operational costs.

Criteria evaluated included an A+ effluent, implying less than two Nephelometric Turbidity Unit, containing no detectable fecal coliform organism, and ensuring water denitrification under 10 mg/L total nitrogen. Additionally, the team determined that shifting to renewable energy – hydropower or solar power – could lower power consumption by approximately 5%. The team also recommended that excess water, which historically has been dumped in a lakebed, be used for commercial, recreational and landscaping purposes as well as scientific advancement, such as an algae raceway for research or biofuel production.

Large-Scale Steam Decontamination System

Team 19135

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To improve capacity of a steam decontamination system for organic medicinal herbs.

In decontaminating medicinal herbs, local manufacturing labs use gamma irradiation to control microbial load. However, this decontamination process cannot be used for herbal and natural products that are certified as organic. Herbanext Labs in the Philippines uses a small-scale steam decontamination system instead of gamma irradiation for organic products.

This project focuses on scaling up the steam decontamination system. The team developed a prototype that can handle 10 times the current capacity, and the herbs spend less time in the steam chamber. The design also includes changes that allow for decontaminating multiple types of herbs in the same system.

TEAM MEMBERS

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Devon Julius Schmitt *Chemical Engineering*
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Adrianna Brush

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Rinly Gecosala

Microplastics Remediation

Team 19136

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To apply chemical engineering and design process fundamentals to the removal of microplastic particles from contaminated water sources.

Plastic debris less than 5 mm in diameter that come from industrial waste and consumer products, such as sunscreen, have been detected in marine water, wastewater, fresh water, food, air and drinking water. These microplastics enter the environment through wastewater effluent and surface run-off, combined sewer overflows, industrial effluent, degraded plastic waste and atmospheric deposition. Evidence suggests that microplastics harm aquatic life and disrupt the food chain.

Fionn Ferreira, an 18-year-old Google Science Fair winner, developed a technique that uses the chemical attraction of vegetable oil to remove microplastics from water. This project builds on that technique by implementing distillation alongside filtration, such as with granulated activated carbon, to achieve a success rate greater than 90%.

TEAM MEMBERS

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Lionel Duran *Chemical Engineering*
Stephanie Sanna Mikaela Gustavsson *Chemical Engineering*
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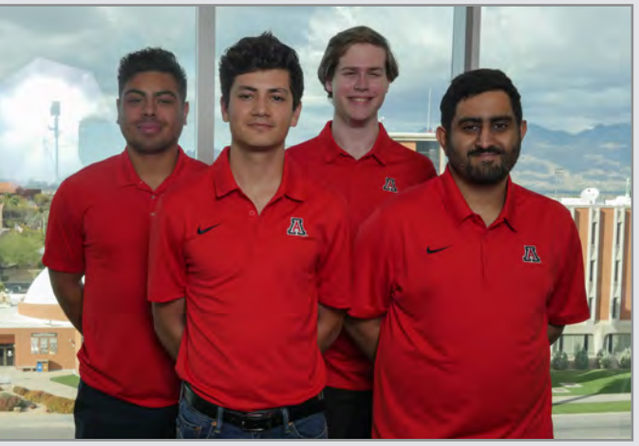

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Isaac Stephen Mendoza *Chemical Engineering*
Henry Hobart Nordbrock *Chemical Engineering*
Hernan Oviedo *Chemical Engineering*

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Caitlin Schnitzer

Municipal Paper Recycling Plant

Team 19137

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design a municipal recycling plant that can effectively process paper and cardboard materials and is scaled to successfully manage an intake capacity generated in Tucson, Arizona.

Recycling one ton of paper material, as opposed to letting it decompose in a landfill, can reduce greenhouse gas emissions by the equivalent of one ton of carbon. Using statistical data archived from the city, this project scaled a process to successfully manage the intake capacity generated in Tucson, Arizona. The team created two separate processes to maximize operation continuity and prevent cross-contamination between materials.

The design employs several mechanical processes to optimize the percent recovery from each input material. These processes focus on retaining fibers with larger lengths to ensure quality retention and combat downcycling effects. Floatation deinking in the cleansing process helps to optimize operation costs. Integrating these various procedures resulted in a cost-effective, sustainable and efficient recycling plant that can benefit the community and world.

TEAM MEMBERS
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Machine Learning Demand Prediction and Process Optimization for UA Cooling Facilities

Team 19138

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To use machine learning techniques for predicting cooling demand and optimizing the chilled water distribution system for University of Arizona facilities.

UA Facilities Management estimates expenditures of $54.4 million in Fiscal Year 2019. A large percentage is spent on cooling for instructional, research, housing, hospital and athletic facilities. Traditionally, facilities operators have configured cooling systems by trial and error in response to the prevailing heat duty. Whereas, a machine learning architecture – incorporating data on prior heat duty, local weather, occupancy estimates and other variables – can better predict campus cooling demand and help operators more effectively configure cooling systems.

This team used Python programming language to implement a neural network and analytical techniques, including higher-order linear systems, to determine energy-efficient operating conditions for a diverse system of chillers, cooling towers and pumps. The final product is a trained neural network that predicts energy demand and produces an analytical optimization algorithm, resulting in significantly reduced energy consumption and lower cooling costs.

Cellphone Powered by a Microbial Fuel Cell

Team 19139

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To provide power to charge a cellphone using energy harnessed from anaerobic bacteria in a small-scale microbial fuel cell (MFC).

While microbial fuel cells with low-toxicity by-products generate less power than some sources, they can be an excellent source of alternative energy for smaller electronics, such as cellphones. Using microbe-containing sludge from local wastewater treatment facilities, this project identified parameters for the best MFC cellphone charging configuration.

Evaluation centered around varying the residence time of the sludge-filled anode and the amount of fuel cells in series. Increasing cells in series increases the total output voltage to charge the cellphone. Varying the residence time allows for a better characterization of the microbial fuel cells and optimal lifetime of the anaerobic bacteria in the sludge. A cable connected to the wires from the MFC via a USB port was used to charge the cell phone. Data collected to optimize MFC cellphone charging capacity included the rate of charge, current and voltage.

TEAM MEMBERS

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Chelsie Shalei Pribonic *Chemical Engineering*
Lyra Star Troy *Chemical Engineering*

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Suchol Savagatrup

Sustainable Vertical Farming Using Abandoned Malls

Team 19140

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design a vertical farm, using an aquaponic system and other renewable energy sources, in an abandoned mall.

With restrictions on what land is available for crop growing, it is becoming increasingly difficult to supply enough food for the global population. Vertical farming, in conjunction with new agricultural techniques and renewable energy, presents a viable solution.

This project focused on design of a vertical farm and aquaponic system for an abandoned shopping mall in Tucson, Arizona. The project uses fluid flow, mass balances, process control and heat transfer. They team also performed energy balances and calculations associated with the use of renewable energy sources and conducted a 25-year cost-benefit analysis of the operation. The resulting design can be expanded to other locations around the world to meet 8% of the population's demand for each of three types of vegetables or fruits.

TEAM MEMBERS

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Benjamin Grant Martinez *Chemical Engineering*
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Daniel Marshall

Optimization of Crema Produced in Coffee

Team 19141

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design and test a novel coffee filtration method that optimizes crema volume while minimizing the mass of grounds passing through the filters.

Espresso, which originated in 19th-century Italy, is produced by forcing near-boiling water under high pressure through compacted, finely ground coffee beans. A key characteristic of quality espresso is the crema, or frothy aromatic oils, resting on top of a freshly brewed cup. Using a hand-pressed coffee brewing system, this project focused on generating and preserving the greatest amount of crema while limiting the quantity of grounds passing through the filters.

The process depends on inverted filtration, which forces brewed coffee grounds and crema upwards vertically through a set of reusable filters varying in pore size and shape. Directly after filtration, a set of baffles – known as a static mixer – agitates the fluid, developing and mixing the foam emulsion. The main parameters were filter pore shape and size and the baffle structure in the coffee press. The team designed, built, and tested filters and static mixers, ultimately creating a prototype with the most effective filtration assembly.


ARIZONA

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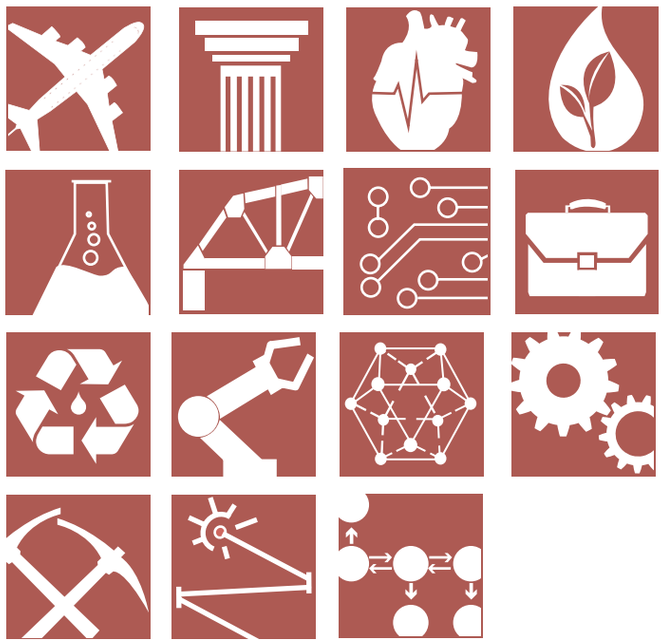

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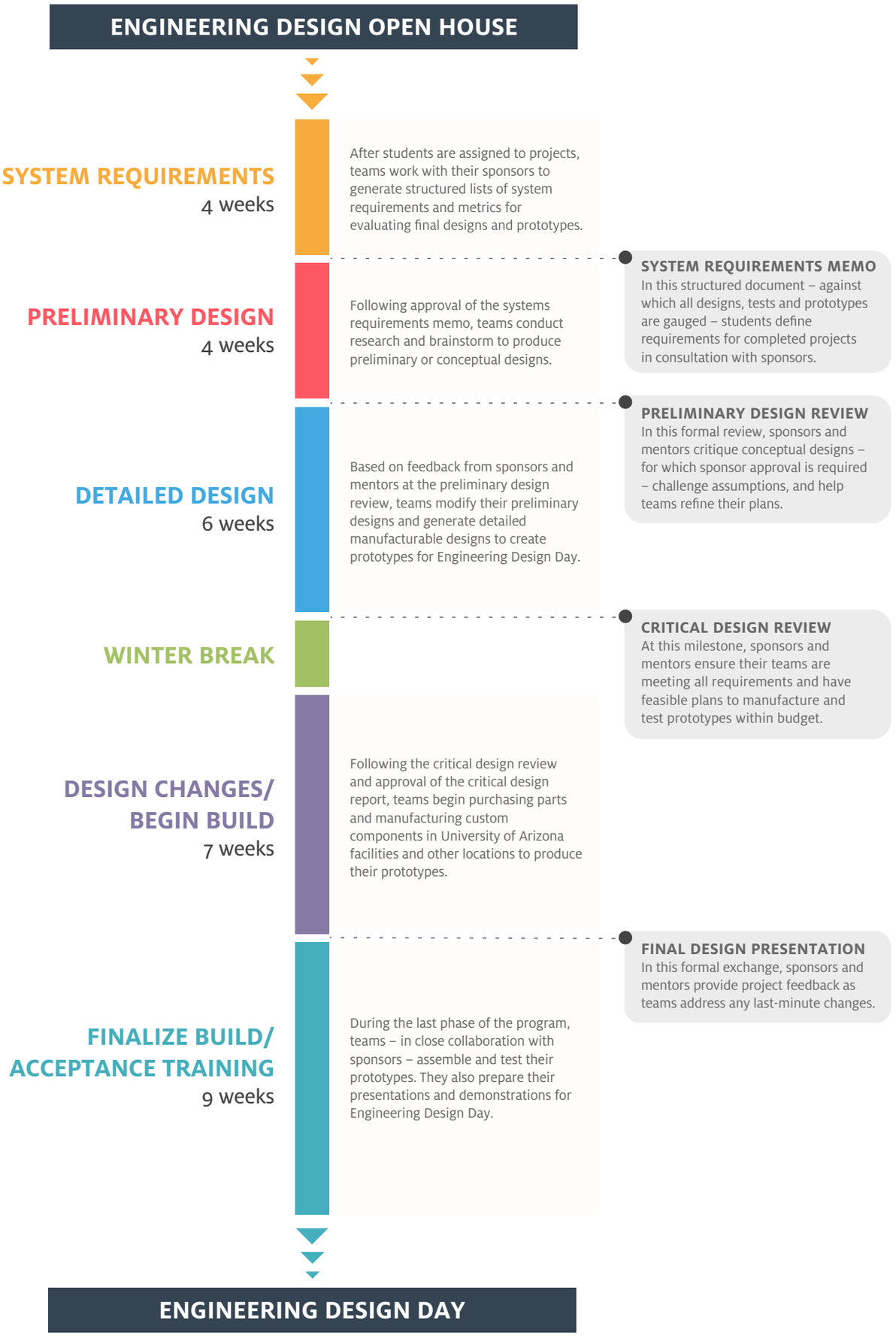
"Who doesn't want to make a robotic foot?"

– Michael Polenick, *2019 electrical and computer engineering*

CRAIG M. BERGE ENGINEERING DESIGN PROGRAM
YEAR AT A GLANCE



CRAIG M. BERGE DESIGN DAY
ACKNOWLEDGMENTS

STUDENTS

Projects exhibited 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.

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Lauren Stock - *Office Specialist*

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