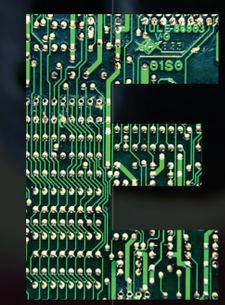
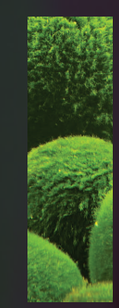
ENGINEERING DESIGN DAY 2019





THE UNIVERSITY OF ARIZONA

COLLEGE OF ENGINEERING

Engineering Design Program

TABLE OF CONTENTS

2 PROJECTS DISPLAYED

6 AWARDS

10 PROJECT DESCRIPTIONS

70 ENGINEERING DEGREE PROGRAMS

71 YEAR AT A GLANCE

72 ACKNOWLEDGMENTS

73 THANK YOU TO OUR SPONSORS

SCHEDULE

8:30-11 a.m.
PROJECT DEMONSTRATION FOR JUDGES

11 a.m.
DESIGN DAY OPENS TO THE PUBLIC

12:30-2:30 p.m.
AWARDS JUDGING

4-5:30 p.m.
AWARDS CEREMONY

Projects are displayed in the Student Union Memorial Center Grand Ballroom and on the UA Mall south of the Student Union. The awards ceremony is held in the Student Union Grand Ballroom.

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

Available on the App Store

ANDROID APP ON Google Play

Welcome to Engineering Design Day 2019



This is – by far – the best day of the academic year!

Today seniors from the College of Engineering showcase their two-semester capstone projects to judges, fellow students, the university and the Tucson community. We are proud of our students' success as engineers and grateful for the partnerships with industry, faculty and student clubs that help bring the senior design projects to life.

This year, 616 students from almost every degree program in the college are displaying 118 projects inspired and supported by industry and university partners. Sponsors have engaged students to create useful solutions for challenging engineering problems, including 10 that are space-related, 14 in biomedicine and 14 in renewable energy or environmental technology.

The capstone design program provides an unparalleled multidisciplinary experience for seniors, and it's one big reason recruiters look to hire University of Arizona engineering interns and graduates year after year.

Thank you – not only to the 64 corporate and UA project partners, but also to the 120 engineering professionals judging the teams' work and the prize sponsors contributing $36,750 in cash awards this year. A special shoutout goes to the college's Engineering Design Program team as well for its leadership throughout the year. Without all of these groups working together, the program would not be among the best in the country.

We encourage you to ask the students questions about their projects. The teams have worked hard and are looking forward to sharing the details of their efforts with you.

You are witnessing some of the best and brightest UA students display four years of engineering education in design, analysis and creativity. We're glad you are here to be part of Design Day 2019!

Sincerely,

K. Larry Head
Interim Dean, College of Engineering

2019 FAST FACTS

118
DESIGN TEAMS

14
BIOMEDICAL PROJECTS

$36,750
IN PRIZES

616
STUDENTS

64
CORPORATE & UA SPONSORS

120+
TECHNICAL JUDGES

10
SPACE-RELATED PROJECTS

14
RENEWABLE ENERGY & ENVIRONMENTAL PROJECTS



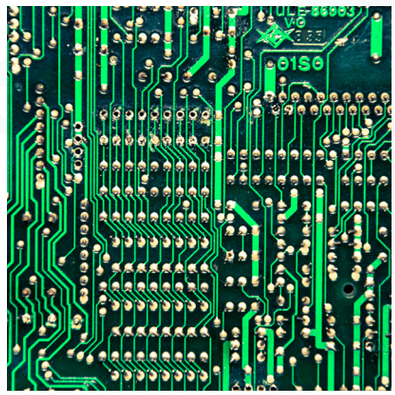
“These kids do such a good job, and it’s great value for the money.”

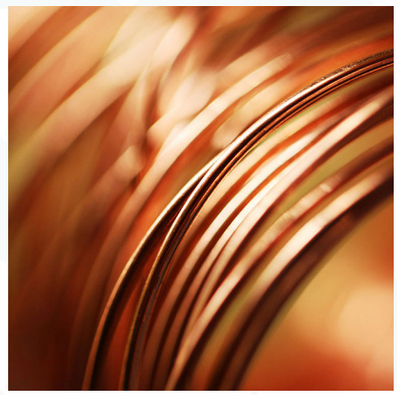
– **Frank Broyles,** *Design Day project and prize sponsor*

PROJECTS DISPLAYED



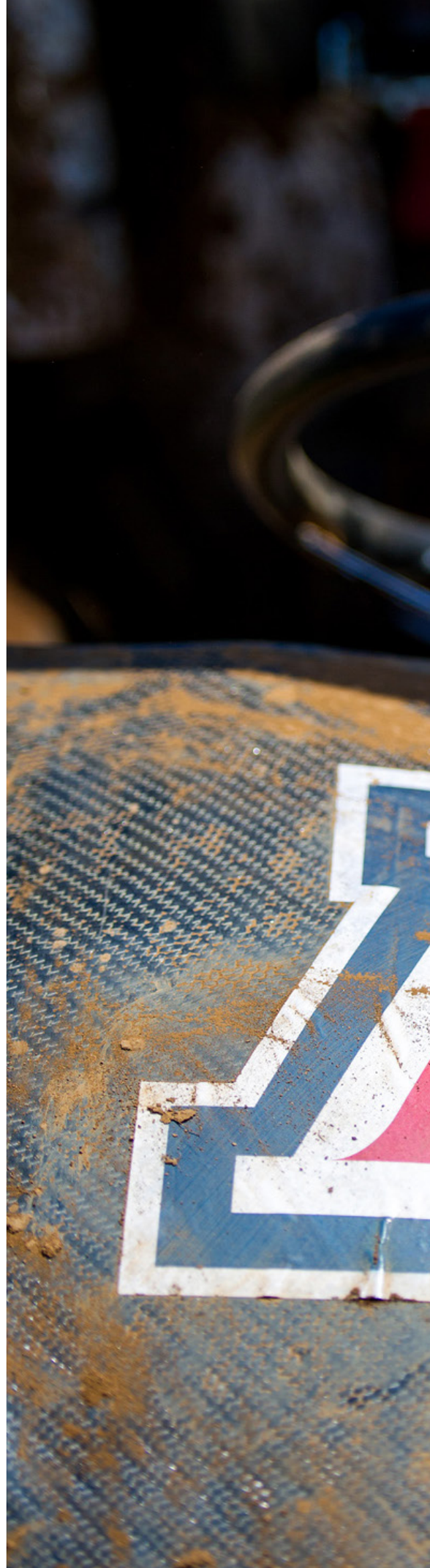


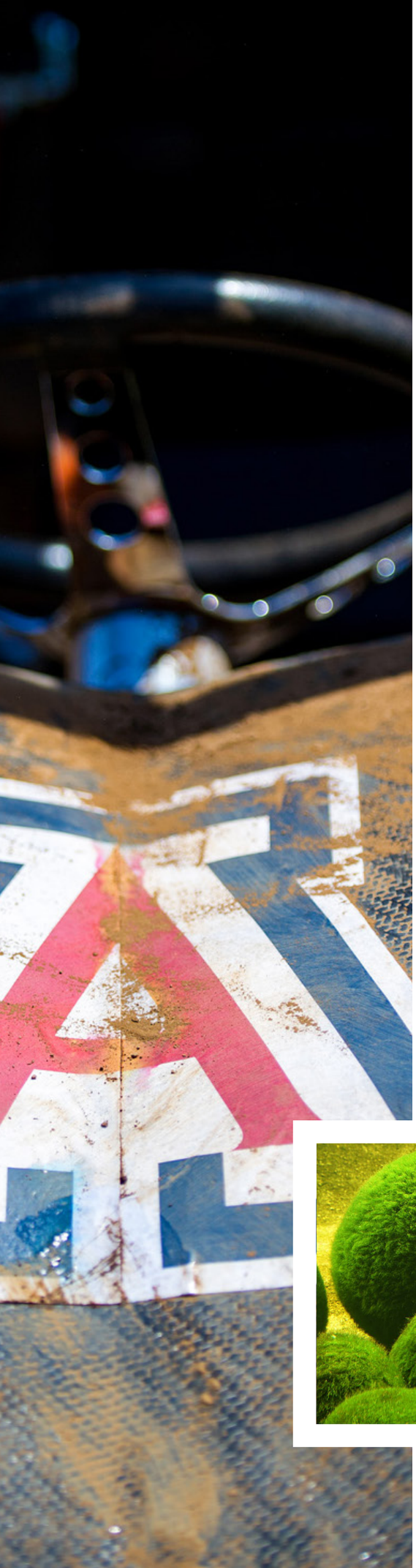




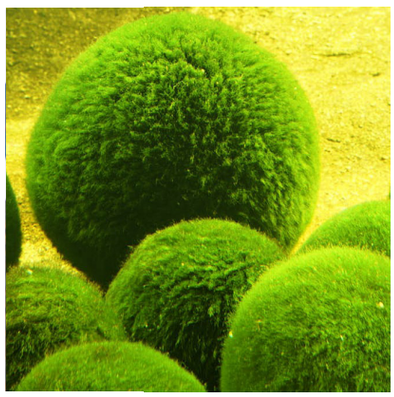
PAGE	TEAM #	PROJECT TITLE
11	18002	Mounted Gemstone Weight Calculation Device
11	18003	Mattress Rolling Device
12	18004	Greenhouse Smart Watering System
12	18005	Optical System for Super Resolution Images
13	18006	One-Click Food Bank
13	18007	Customer-Optimized Power Use and Cost
14	18008	Large Aperture Alignment Telescope
14	18009	Flexible Event Data Recorder
15	18010	Gas Turbine Engine-Cooled Turbine Vane Feather Seal Leakage Reduction
15	18011	Frangible Bearing Support High-Cycle Fatigue Test Rig
16	18012	Pressure Vessel Testing of Sealing and Leakage at Bolted Joint Interfaces
16	18013	Foil Bearing Dust Filtration System
17	18014	Additive Manufacturing Process and Dimensional Control
17	18015	Oil Spray Cooling on Rotating Machines
18	18016	Heat Transfer Rig
18	18017	Ultrafine Particle Sensor Suite
19	18018	Honeywell Engine Communications Card
19	18019	Three-Way Heat Exchanger
20	18020	Automated Deburr of Hydraulic Sleeve Internal Elements
20	18021	Automated Wire Winder and Cutter
21	18022	Repurposing Exhaled Carbon Dioxide for Spacecraft
21	18023	Automated Scale Placement System
22	18024	Reconnaissance Unmanned Aircraft Automation Improvements
22	18025	Grasshopper Harvester
23	18026	Formula SAE Torsion-Testing Rig
23	18027	Hyperspectral Imaging Smartphone
24	18028	Golf Course Pin Placement System
24	18029	Robotic Weeding Machine for Leaf Lettuce Crops
25	18030	Aviator Night Vision Augmented Display
25	18031	Vehicle Biocular Digital Display Viewer
26	18032	CubeSat Camera Space Ruggedization
26	18033	Integrated Image Enhancement System for Autonomous Vehicles
27	18034	Imaging Polarimeter Software Model
27	18035	Reuse of Fuel Cell Byproducts

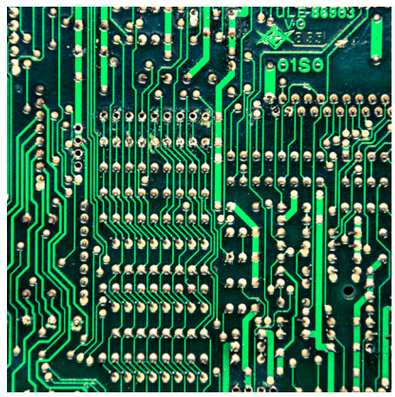
PAGE	TEAM #	PROJECT TITLE
28	18036	Large Mining Truck Optimized Mirror Design
28	18037	Vehicle Detection for Cyclist Safety
29	18038	Ankle Fusion Joint Preparation System
29	18039	Automated iButton Placement Device
30	18040	Scooter Electric Propulsion System
30	18042	Size, Weight and Power Optimization for Aircraft Cabin Avionics Unit
31	18043	Tissue Thickness Analyzer
31	18044	Glue Dispensing Automated Glass Coverslipper
32	18045	Dairy Animal Detection and Environmental Control System
32	18046	Rotor Temperature Measurement
33	18047	Wireless Body Temperature Sensor for Implantable Ports
33	18048	Covert Short-Wave Infrared Illuminator Core
34	18049	Cellular Secure Video Transmission from an Unmanned Aircraft
34	18050	System-on-Chip Video Encoding System
35	18051	Graphics Processing Unit-Based High-Speed Demodulation
35	18052	OKL4 Hypervisor Software Development Kit
36	18054	Unmanned Aircraft Dispenser for Automated Date Pollinator
36	18055	Unmanned Aircraft Control System for Automated Date Pollinator
37	18056	Unmanned Aircraft Fleet Management for Automated Date Pollinator System
37	18057	Naval Drone Recovery System
38	18058	Ground-Based Optical Target Tracking
38	18059	Smart Distributed Environmental Beacon
39	18060	Automated Inspection Point Measurement and Documentation
39	18061	Wide Area Drone Situational Awareness
40	18062	Southwest Gas Natural Gas Aerator
40	18063	Reclamation and Reuse of 3D ABS Printing Waste
41	18064	‘Last Mile’ Underground Construction Communication
41	18065	Multifunctional Mining Machine Boom and Conveyor System
42	18066	Dynamic Bioreactor for Engineered Cartilage Tissue
42	18067	Portable Medical Diagnostics in Deep Space
43	18068	Autonomous Self-Driving Solar Race Car
43	18069	Electric Vehicle Motor and Inverter Design and Integration
44	18070	Power Supply Effect on Image Quality
44	18071	Microfluidic System for Determination of Platelet Stiffness
45	18072	Virtual Reality System for Realistic Cardiopulmonary Resuscitation Training
45	18073	Virtual Reality Treatment System for Eating Disorders
46	18074	Component Sound Analysis for Extracting and Analyzing Medical Information from Patient Encounters
46	18075	Visual Natural Language Processing of Medical Images for Enhanced Value
47	18076	Smart EMILY Transmitter
47	18077	Robotic Gait Simulator
48	18078	Bruise Age Measurement Sensor
48	18079	Air-Liquid Heat Exchanger Improvement Through Additive Manufacturing
49	18080	Payment Transaction System Using QR Codes
49	18081	Standard Operating Sheets Management System
50	18082	Manufacturing Execution System Self Service
50	18083	Autonomous Multiagent Guided Vehicles Implementation
51	18084	Virtual Mapping of Data Centers with Robots
51	18085	Waste Air Recapture Study





PAGE	TEAM #	PROJECT TITLE
52	18086	Lighting Installation Using Full-Spectrum White Light Emitting Diodes
52	18087	Submersible Breather Valve
53	18088	Autonomous Orbiting Earth Camera
53	18089	UAS-Sensor Integration and Improvement
54	18090	Yuma International Airport Baggage System Improvement
54	18091	Open Pit Mine Life Design
55	18092	Copper Mine Leach Pad Design
55	18093	San Xavier Mine Training Tunnel Design
56	18094	Impact of Haul Road Width to Open Pit Mining Costs
56	18095	Glacial Research CubeSat
57	18096	CubeSat Radar for Ice Observation
57	18097	Design/Build/Fly Aircraft Design Competition
58	18098	Firefighting Unmanned Aircraft
58	18099	Magnetic Field Readings with Lunar CubeSat Lander
59	18100	Autonomous Lunar CubeSat Lander
59	18101	Sonar EMILY Autopilot System
60	18102	Steampunk Cold Brew Coffee Machine
60	18103	Microbial Fuel Cell
61	18104	Water Independence: Near Zero Liquid Discharge
61	18105	NASA Challenge: Conversion of Carbon Dioxide to Glucose
62	18106	Sludge-Handling Process Promoting Energy Recovery
62	18107	Solid Rocket Propellant and Liquid Oxygen Manufacturing
63	18108	Vodka Distillery and Infusion
63	18109	Remote Restrooms
64	18110	Liquid Natural Gas Terminal Design
64	18111	Distillation Modeling and Simulation
65	18112	Net Zero Water Use at Data Centers
65	18113	Production of Dimethyl Ether as an Alternative Automotive Fuel
66	18114	Vodka Distillery Design Upgrade
66	18115	Ten-Kilowatt Polymer Electrolyte Membrane Fuel Cell
67	18116	Biosphere Ocean Life Support
67	18117	Heat Exchanger Network
68	18118	Cave Creek Water Rehabilitation Project
68	18119	Arizona Water Competition
69	18120	Mixer-Settler Design
69	18121	West Speedway Boulevard Reconstruction









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

– **Jay Crossman,** *Aviation Communication & Surveillance Systems*

AWARDS

RAYTHEON AND TELEDYNE BROWN ENGINEERING AWARD FOR BEST OVERALL DESIGN

(1st prize, $5,000; 2nd prize, $2,500)

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

MICROSOFT AWARD FOR BEST SYSTEM SOFTWARE DESIGN

($2,500)

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

FRANK BROYLES ENGINEERING ETHICS AWARD

(1st prize, $1,500; 2nd prize, $750)

Businesses are increasingly adopting cultures that emphasize ethical conduct, driven in part by the dollar value that financial markets place on reputation. Questionable shortcuts to save cost or time can have catastrophic consequences. Similarly, the marketplace can punish a business that ignores or inappropriately resolves conflicts. A team might experience a significant conflict between team members, or between the team and its sponsor or mentor. This award is designed to reward the team that best recognizes and resolves a significant ethical issue, whether that issue concerns a tempting shortcut, a conflict or another factor.

BLY FAMILY AWARD FOR INNOVATION IN ENERGY PRODUCTION. SUPPLY OR USE

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

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

THORLABS PHOTONICS IS THE FUTURE AWARD

($250 per person, up to $1,750)

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

> "I've already put experience I've gained from this on my resume."
>
> – **Alexandra Janowski,** *2019 biomedical engineering*

ANDRESSEN AWARD FOR DESIGN ABOVE AND BEYOND

($1,500)

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

RINCON RESEARCH AWARD FOR BEST PRESENTATION

($1,500)

This award reflects the quality of the overall verbal and poster presentations. Verbal presentations should be well-structured to describe efficiently the overall problem being solved and the specifics of how the team accomplished its design. Answers to questions should be direct and demonstrate mastery of the project. Presenters should speak in a clear and easily audible voice, making good eye contact with the judges. The project poster should be visually interesting, and graphically well-organized to tell a standalone story of the project.

ROCHE TISSUE DIAGNOSTICS AWARD FOR INNOVATION IN ENGINEERING

($1,500)

Innovation may include the novel use of existing components or the creation of entirely new components to meet customer requirements. The most innovative design is not only a creative solution to a problem but also an effective solution that is implemented well. 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 MOST CREATIVE SOLUTION

($1,250)

This award honors a student team that has implemented a unique and creative solution within its project. It recognizes outside-the-box thinking that pushes boundaries and hands-on approaches to creative solutions. Projects are judged on the elegance and creativity of the technical solutions and their implementation. Teams should be able to communicate effectively their design and the processes they use for creativity.

MICROSOFT AND II-VI OPTICAL SYSTEMS FISH OUT OF WATER AWARD

(1st prize, $750; 2nd prize, $500)

The Fish Out of Water award congratulates students for successfully accomplishing a task that was not in their realm of expertise. The projects in the design program require skills from many disciplines, and students must sometimes learn a new subject or skill in an area outside of their major to help the team succeed. A student who not only learns this new subject or skill, but also uses it to effectively help the team thrive, shows dedication and initiative, traits that will continue to help in an engineering career.

ACSS/L-3 COMMUNICATIONS AWARD FOR MOST ROBUST SYSTEMS ENGINEERING

($1,000)

This award goes to the team that most robustly addresses all aspects of the project from the systems perspective. Criteria include requirements capture and flow down, technical risk identification and mitigation, manufacturability, integration and test plan. Judges look holistically at the program to determine overall effectiveness of the systems process.

BALL AEROSPACE GO BEYOND AWARD FOR PIONEERING DESIGN

($1,000)

Whether designing Geiger-Mode cameras or finding new uses for artificial intelligence, Ball Engineering believes in creative originality when it comes to solving its customers' hardest engineering problems. In the spirit of going beyond conventional engineering approaches, this award recognizes a team that uses creative and nontraditional methods in its design. Consideration will also be given to how well the team works collaboratively and strives for excellence, integrity, humility, transparency and agility.

CYBER WARRIOR AWARD FOR BEST CYBERSECURITY DESIGN

($1,000)

Cybersecurity is becoming one of the most challenging and threatening issues of the 21st century. Evaluating and designing security into the products that engineers and computer scientists build is essential to providing a cyber-resilient solution, along with the other capabilities and attributes of any given product or system. As a result, cybersecurity has become an integral part of the design of complex systems. This award will be given to the team that either develops tools or products, or both, that can be used to ensure that cybersecurity is factored into the development of any given system or subsystem; or designs cyber-resiliency into the product it is developing.

MENSCH FOUNDATION AWARD FOR BEST USE OF EMBEDDED INTELLIGENCE

($1,000)

The Mensch award recognizes the 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 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 these capabilities that can demonstrably surpass human abilities to perform the same function.

HONEYWELL AWARD FOR EXCELLENCE IN AEROSPACE ELECTRONIC SYSTEM DESIGN

($1,000)

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

RBC SARGENT AEROSPACE & DEFENSE VOLTAIRE DESIGN AWARD

($1,000)

The French philosopher Voltaire is credited with the saying "Le mieux est l'ennemi du bien," which means "the best is the enemy of the good." Similarly, Leonardo da Vinci is credited with the saying "Simplicity is the ultimate sophistication." This award recognizes the design team that best emulates these ideals and resists the temptation to overly complicate the design to yield a clean, simple, elegant, lowest-cost design that simply works well.

TECHNICAL DOCUMENTATION CONSULTANTS OF ARIZONA AWARD FOR BEST DESIGN DOCUMENTATION

($1,000)

Successful implementation of any innovative design requires that all members of the design and production team communicate effectively. Design intent must be communicated from the design activity to the rest of the team using design documentation with a clear map for others to reproduce the design based on documentation only. The mechanical portion of the design is evaluated on the use of drawings with geometric dimensioning and tolerancing, solids models, illustrations and presentations that can be used to manufacture and inspect design hardware. Software and other systems are evaluated on the use of documentation that clearly and fully describe the system.

TRAX INTERNATIONAL AWARD FOR BEST IMPLEMENTATION OF AGILE METHODOLOGY

($1,000)

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

ARIZONA TECHNOLOGY COUNCIL FOUNDATION 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.

EDMUND OPTICS 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 caused by issues or roadblocks and the features in the final design that contribute to recovery from them.

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.

II-VI OPTICAL SYSTEMS AWARD FOR BEST USE OF OPTICAL DESIGN AND TECHNOLOGY

($500)

This award is given to the team that demonstrates the most thorough approach to the design and engineering of its optical system. The award recognizes complete understanding of the optical design, system requirements, tolerance analysis, and optical component usage. Important criteria are integration of optics into the overall system, novel use of optical components, creative use of commercial off-the-shelf items, verification of optical components, meeting system requirements, use of standard optical design software, and manufacturability of optical design and components.

DATAFORTH CORPORATION AWARD FOR BEST DESIGN USING A DATA ACQUISITION AND CONTROL SYSTEM

($500)

This award recognizes the design team that best implements a modern data acquisition and control system. Recognition is given for the use of the system to collect data that characterizes project performance and assists in project optimization and, ideally, uses the same data acquisition system to perform feedback and control operations.

HONEYWELL AWARD FOR TEAM LEADERSHIP

(two individuals at $250 each)

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

L3 LATITUDE ENGINEERING AWARD FOR BEST PHYSICAL IMPLEMENTATION OF ANALYTICALLY DRIVEN DESIGN

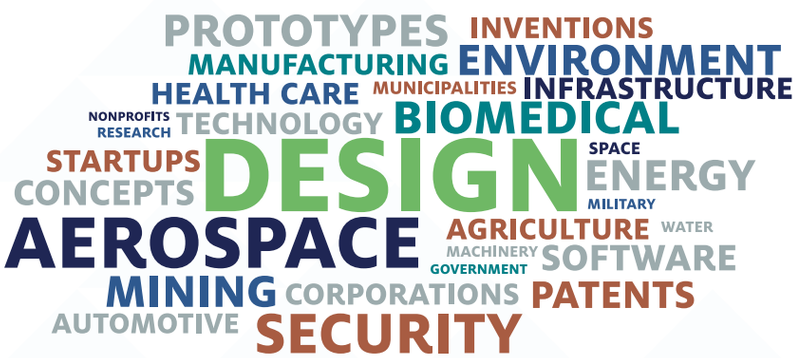
($500)

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.





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

PROJECT DESCRIPTIONS

MOUNTED GEMSTONE WEIGHT CALCULATION DEVICE

Team 18002

The RealReal



PROJECT GOAL

To design a device that uses angular spectrum evaluation technology to calculate the weight of mounted gemstones.

Mounted gemstones are not measured accurately because the depth of the stones is obscured by the metal mount of the jewelry. This leads to major disputes about the size and worth of gemstones. The team developed a mounted gemstone weight calculation device, based on the technology found in the Angular Spectrum Evaluation Tool created by the American Gem Society, to measure mounted gemstones quickly and accurately.

Angular spectrum evaluation technology uses multicolored light to illuminate the stone, which produces a unique pattern specific to its internal angles. This pattern is compared to a software-generated matrix of stones using image-processing software in Matlab. Image analysis makes it possible to find the internal angles of the gemstone using only a photo of the color-illuminated top surface. The gemstone's weight is then calculated from its density and surface measurements. Efficient structural design and advanced software make the mounted gemstone weight calculation device significantly faster, easier to use, and more accurate than the current method for mounted gemstone measurement.

TEAM MEMBERS

Ludovico Borghi *Electrical & Computer Engineering, Optical Sciences & Engineering*
Emily Elizabeth Calara English *Biosystems Engineering*
Matthew Heger *Electrical & Computer Engineering*
Chengyu Zhu *Materials Science & Engineering*
Meghan Elizabeth Ryterski *Mechanical Engineering*

COLLEGE MENTOR

Bob Messenger

SPONSOR MENTOR

Loretta Castoro

MATTRESS ROLLING DEVICE

Team 18003

J David Art



PROJECT GOAL

To design and build a tool to increase production of "logs" made from rolled mattress spring units for use in art projects.

J David Art creates sculptures by repurposing spring units from common household mattresses and transforming them into custom pieces of art. Sculptures are made using "logs" formed by rolling the steel mattress spring units into a cylindrical shape. Hand-rolling the logs is time-consuming and physically strenuous and limits the number of pieces of art that can be produced.

In a design based upon industrial rolling machines, the device incorporates rollers that compress the mattress springs before wrapping the flattened spring unit around a spindle to form a cylinder. The device operator anneals the spring unit with a torch, which causes it to retain its cylindrical shape when it is removed from the device. The mattress rolling device reduces the time required to produce a log and protects the operator from injury and fatigue.

TEAM MEMBERS

Bader N.B.A.H. Alshatti *Industrial Engineering*
Christian Baker *Mechanical Engineering*
Bamidele Joseph Omotinugbon *Industrial Engineering*
Christian Scott Pappas *Mechanical Engineering*
Tyler Lee Regan *Electrical & Computer Engineering*
Jake Williams *Mechanical Engineering*

COLLEGE MENTOR

Frank Principe

SPONSOR MENTOR

John David Yanke



TEAM MEMBERS
Syntia Bebongchu *Electrical & Computer Engineering*
Joaquim Hernani Duarte Fernandes *Systems Engineering*
Veronica Paz *Biosystems Engineering*
Troy Kyle Petty *Biosystems Engineering*
Eric Romero *Mechanical Engineering*
Joshua P. Vanderwall *Mechanical Engineering*

COLLEGE MENTOR
Gregory E. Ogden

SPONSOR MENTOR
Lisa Jones

GREENHOUSE SMART WATERING SYSTEM

Team 18004

Bayer CropScience

PROJECT GOAL

To design an automated watering system with adjustable electromechanical parameters that uses software to determine the volume of water dispensed to plants, and which saves and communicates data to a cloud-based application.

When watering plants, greenhouse owners must consider a range of environmental and biological variables. Greenhouse plant watering is challenging, inconsistent and labor intensive, and growers need to evaluate which systems best suit their greenhouse operation, such as hose with spray attachments versus overhead sprinklers versus single-volume automated systems.

The team's automated system uses sensors to measure parameters such as soil moisture and plant maturation to analyze crop health and determine how much water to dispense. Three Pixy2 cameras analyze crop appearance and detect barcodes that uniquely identify plants. An actuated sensor probe inserted into the plant substrate records soil moisture data as percent saturation, and a coin load cell measures the weight of each plant.

The team designed graphical user interfaces that reflect the data acquired from the various sensors, and which allow manual control of all motors and valves if necessary. Combining these subsystems creates an accurate automated system capable of watering three plants at a time without generating any solid or liquid waste outside of normal maintenance.



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OPTICAL SYSTEM FOR SUPER RESOLUTION IMAGES

Team 18005

Ball Aerospace & Technologies Corp.

PROJECT GOAL

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

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

This project uses the super resolution technique of compressed sensing to improve the resolution of an imaging system limited by too few pixels. Compressed sensing encodes compressed information into low-resolution measurements allowing the reconstruction of high-resolution images from many low-resolution images. The super resolution imager designed uses compressed sensing to decrease the number of samples needed to perfectly reconstruct an image.

With a few low-resolution images modulated by a subpixel code, a linear system is generated and solved for that predicts a high-resolution image using small amounts of measurement data. The prototype imager uses two encoding methods – binary mask-actuator encoding and a digital micromirror device – and two reconstruction methods – an exact L1 minimization reconstruction and an alternative, inexact machine-learning-based reconstruction. The prototype imager built achieves a fourfold increase in spatial resolution in both X and Y directions, providing a total high spatial resolution gain of 16 times.

ONE-CLICK FOOD BANK

Team 18006

PayPal

PROJECT GOAL

To contribute new software functions to Pantry for Good, the open source web-based data management system for food banks.

Pantry for Good is an open source application that provides food banks with a way to manage inventory, donor tracking and client intake. The team conducted a gap analysis of Pantry for Good and concluded it was missing some key features. Rather than creating a competing website with similar functionality, the team added new features to those already offered by the application.

The new functionalities included a simple, intuitive volunteer-scheduling platform, an automated donation-weighing interface, and a convenient mass imports feature. The team used open source software development kits, multiple software modules, and embedded systems to enhance Pantry for Good's ability to help food banks around the world manage their operations.



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CUSTOMER-OPTIMIZED POWER USE AND COST

Team 18007

TEP
Tucson Electric Power

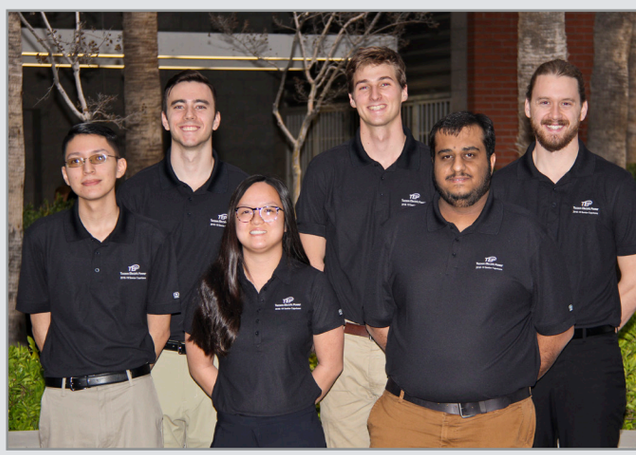
PROJECT GOAL

To design a system of devices to track energy use by home appliances, calculate the corresponding cost, and identify money-saving opportunities.

Tucson Electric Power offers several different rate plans to customers, including a low-cost plan that entices customers to use more power during non-peak times.

The system designed consists of devices that monitor energy consumption by five domestic appliances, and Wi-Fi communication with a server-based open-source web framework built using Django. The result is a database that can be analyzed via user interface, which displays energy consumption and cost, and suggests the best rate plan based on data collected from devices and price points set by Tucson Electric Power.

The system allows consumers to save money and optimize power use while lowering demand for the provider during peak times.



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LARGE APERTURE ALIGNMENT TELESCOPE

Team 18008

RUDA CARDINAL

PROJECT GOAL

To design, build and verify an alignment telescope with a comparably large clear aperture and nonstandard features, such as an internal light source and compatibility with standard test cameras.

The primary application of an alignment telescope is as a reliable optical reference for examining and characterizing external test optics, which it achieves via collimation, autoreflection and retroreflection of projected light and comparison of a reference image, often as reticles or crosshairs.

The large aperture alignment telescope is distinguished by a clear aperture of over 80 millimeters, double that of most alignment telescopes, which allows for a greater field of view. The optical design of a large aperture alignment telescope is optimized for a unique self-contained 528-nanometer monochromatic light source. The large aperture alignment telescope allows for return images to be observed by a standard test camera or traditional eyepiece, depending on user needs and preference. Images can be focused at working distances of 14 inches to infinity while taking up less than two feet of space on an optical workbench.



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FLEXIBLE EVENT DATA RECORDER

Team 18009

NORTHROP GRUMMAN

PROJECT GOAL

To design a device that records transportation event data for subsequent analysis to determine if aerospace components are still flightworthy.

The sponsor transports components ranging from rocket motors to avionics equipment throughout the United States. Harsh transportation events experienced in transit can affect the functionality of components by shortening their lives. The team designed a device to record pertinent data for analysis and determination of component flightworthiness after transportation.

The event data recorder detects whether the cargo shipped has been subjected to events that exceed the design or specified control limits. Information from the event data recorder allows the sponsor to decide if the item meets minimum end-of-life requirements. During transit, data is recorded relating to structural displacement and environmental conditions. The recorder also has room for additional external transducers, such as digital and analog sensors to measure acceleration and vibration. The device houses three internal sensors to monitor six degrees of freedom, temperature and humidity.

The data recorder continuously monitors all operational sensor channels for trigger events that exceed specified threshold conditions, which are set before installation by plugging in a USB 2.0 cord and changing the appropriate threshold parameters. When a trigger event is detected, the recorder saves sensor data for a user-specified duration before and after the trigger. Sensor data is downloaded after the shipment reaches its destination.

GAS TURBINE ENGINE-COOLED TURBINE VANE FEATHER SEAL LEAKAGE REDUCTION

Team 18010

Honeywell

PROJECT GOAL

To design and build a static test rig to evaluate air mass leakage through feather seals in the turbine section of a gas turbine engine.

Feather seals are used to seal the gaps between the stator vanes in the turbine section of the engine. Currently, there is no way to evaluate leakage through these seals on an operating jet engine, nor does the sponsor have a static test rig that can quantify this air mass leakage.

A static test rig was designed that uses sonic nozzles in the choked flow condition. The rig measures ambient pressure and pressure differentials upstream and downstream of these nozzles, and the temperature inside the pressure vessel. The test rig takes in compressed shop air, which flows through sonic nozzles maintained in the choked flow condition by pressure differentials. The pressurized air enters a pressure vessel that houses six feather seals. The small amount of air that flows past the feather seals and into the atmosphere can be quantified using pressure and temperature data. This data can then be used to calculate air mass flow through the feather seals.

The rig can test six seals of the same design at once, allowing average leakage to be calculated for any given design. A variety of seal designs can be installed and tested in the rig to determine which design creates the best seal.



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FRANGIBLE BEARING SUPPORT HIGH-CYCLE FATIGUE TEST RIG

Team 18011

Honeywell

PROJECT GOAL

To design and use a test rig to perform high-cycle fatigue testing on turbofan engine frangible bearing support in icing conditions.

The frangible bearing support is a turbofan engine component designed to break under extreme conditions, such as fan blade-out, to prevent damage to the main structure of the engine. It must, however, be able to withstand icing loads, which are less extreme. Icing loads occur when condensation gathers and freezes inside the engine, creating an imbalance on the main shaft and imparting a rotating load on the frangible bearing support. The frangible bearing support was recently redesigned to meet a stricter icing life requirement of 5,000 pounds radial load for 30 million cycles.

The new test rig design simulates high-cycle fatigue under icing conditions. The cycle count for this test was adjusted to 100,000 cycles with a rotating load of 8,500 pounds, applied radially outward on the inner cylindrical wall of the frangible bearing support. The test rig applies the load through the use of two actuators with connections to a puck in the center of the frangible bearing support. The test rig was designed to last 250,000 cycles so it can test both the original and redesigned frangible bearing support.



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PRESSURE VESSEL TESTING OF SEALING AND LEAKAGE AT BOLTED JOINT INTERFACES

Team 18012

Honeywell

PROJECT GOAL

To design a gasketless modular flange and leakage capturing device to measure the leakage rate at metal-to-metal bolted joint interfaces.

The sponsor's sealing criteria are based on experience domain and rule of thumb, rather than being quantifiable criteria supported by testing.

Previous capstone projects designed and built a pressure test rig along with multiple sets of flanges. A flange pair from a previous project has been resurfaced to get the surface roughness down to 30 root mean square, which is similar to the sponsor's specifications. A new flange pair was designed and created with a few modifications to reduce leakage. The bolt holes were moved closer to the hub to reduce the moment arm, and stronger hardware was used to withstand higher torque values. Finite element analysis was performed on the flange and bolts to understand the structural integrity of the material and ensure there was no plastic deformation on the flanges.

A leakage collection and measuring apparatus was designed and built to capture and quantify any leakage from the bolted joint interface. Testing from previous years showed heavy leakage from the bolted joint interface and through the bolt holes. The new capture device fully encloses the bolted joint interface and directs any leaking water to graduated cylinders for measurement. Multiple rounds of testing were conducted with a constant pressure, varying bolt torque values, and leakage was measured multiple times at steady state conditions.



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FOIL BEARING DUST FILTRATION SYSTEM

Team 18013

Honeywell

PROJECT GOAL

To design, prototype and test a dust filtration system that reduces particulates entering the foil bearing of an auxiliary power unit, thus increasing bearing life.

Auxiliary power units, or APUs, ingest more dust in high-growth regions such as Asia and the Middle East. Dust ingestion causes premature wear to foil bearing surfaces and reduces bearing life. Three different filters were designed that use inertial separation to isolate clean air from dust: a reverse pitot tube, a reverse pitot tube with vanes, and a straight tube. Tradeoffs in weight, size, cost and performance were made to determine optimal configurations. The filters draw in air by a pressure differential, require no additional parts, and are virtually maintenance free.

A flow chamber was designed to simulate the Mach 0.1 flow experienced in APUs. The flow chamber can accommodate the three filter geometries and features the same integration piece used in APUs. The design features a dust release system that disperses dust at a constant rate into the flow chamber. Airflow, efficiency and particle size were tested using this system. Overall, the prototypes either met or exceeded the project requirements.

ADDITIVE MANUFACTURING PROCESS AND DIMENSIONAL CONTROL

Team 18014

Honeywell

PROJECT GOAL

To improve additive manufacturing dimensional control of direct metal laser sintering printed parts by varying geometric positioning and alloy selection.

Direct metal laser sintering offers many advantages over traditional casting and forming processes because it can produce complex geometries using materials that cool rapidly due to their specific microstructure and properties. During printing, however, large temperature gradients can develop and cause distortions that render parts unusable for aerospace applications.

After an extensive literature search and multilevel, multivariable design of experiments, Inconel 718, a high-temperature alloy powder, was chosen for the print prototype. Alloy selection, build orientation, support structures, layer thickness, and precompensation for distortion were considered in the design of experiments. The turbine blade produced was scanned using blue light interferometry in order to compare the simulation's predicted results with a physical print. Metallurgical analysis was performed to evaluate the material properties and microstructure achieved during the printing process.

A strong correlation was found between the simulated distortion and the actual distortion of the printed part, indicating that dimensional control in additive manufacturing can be achieved using computer simulation and careful alloy selection.



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OIL SPRAY COOLING ON ROTATING MACHINES

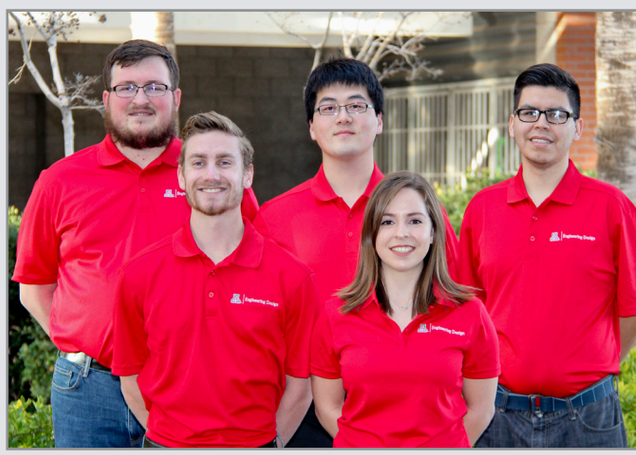
Team 18015

Honeywell

PROJECT GOAL

To improve a test model for the copper windings in the end-turn region of an oil-cooled aerospace generator and develop a heat transfer model to identify a heat transfer coefficient for the cooling process.

Generators operating at lower temperatures enable a higher energy density output. The test model was designed to investigate the cooling variables of oil pressure, oil flow rate, number of nozzles, and radial distance of nozzles from the end-turn region. The improved test rig mimics the internal generator geometry and possible cooling configurations. With empirical data, these primary cooling variables were analyzed to develop a heat transfer model to determine the overall heat transfer coefficient. This model considered two separate modes of heat transfer, conduction and convection, occurring in the system. Empirical data used in conjunction with primary assumptions and boundary conditions completed the model and returned the system's heat transfer coefficient. This improved test model can be applied to almost any generator's cooling system configuration to optimize performance.



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HEAT TRANSFER RIG

Team 18016

Honeywell

PROJECT GOAL

To design and fabricate an experimental system to measure heat flow and temperature gradients through a perforated metal coupon for jet turbine engines.

Jet turbine engines operate at temperatures in excess of 2,000 degrees Celsius, or approximately 3,600 degrees Fahrenheit, which can limit engine performance and efficiency. To counteract this, coolant air is injected onto the engine surface to discharge the hot gases. Research by the sponsor has shown that engine surfaces can be cooled using perforated metal sheets, or coupons, to provide a film cooling layer.

The system designed to test the new method involves blowing hot air over the surface of the coupon while blowing coolant air perpendicular to the hot air flow. The hot air blown over the coupon surface is supplied via a mesh heating element powered by an external variable voltage source and an air blower. A mass flow controller blows coolant air perpendicularly through the coupon's perforations to the rear coupon surface, which creates a film cooling layer on the opposite side of the coupon. A forward-looking infrared thermal camera is positioned to view the surface of the coupon through an infrared-transmitting acrylic sheet. This allows thermal imaging of the heat flow and temperature gradients between the perforations on the coupon surface.

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ULTRAFINE PARTICLE SENSOR SUITE

Team 18017

Honeywell

PROJECT GOAL

To design and construct a system that monitors and displays air quality information in an aircraft, office or home.

Monitoring recycled air in aircraft, businesses and homes is important for short- and long-term health and safety reasons. The team's ultrafine particle sensor suite monitors the concentration of harmful gases and airborne particulates and displays this information to users, who are notified when levels exceed safety thresholds, indicating that the air is unsafe to breathe.

The system draws in air to six commercial sensors that detect volatile organic compounds, carbon dioxide, carbon monoxide, formaldehyde, fine particulate matter, and ultrafine particles. Through integration of software and electrical design, the sensor data is transmitted wirelessly from the sensors to a graphical user interface, where users can view air quality information and input their own concentration thresholds for each compound or particulate.

Tests and analyses were completed at different pressures and temperatures to ensure that the system accounted for the varying conditions found aboard an aircraft. The sensors require regular maintenance, so pullout drawers have been incorporated in the design so that individual sensors can be accessed without disrupting the performance of the entire system.

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HONEYWELL ENGINE COMMUNICATIONS CARD

Team 18018

Honeywell

PROJECT GOAL

To design a modular circuit card that handles various communication protocols used by aircraft engines.

Universal communications cards for aircraft do not currently exist. The engine communications card designed provides a common interface between a memory bus and several signals, and features include parallel transmission of communication signals. Protocols transmitted by the card include CAN, ARINC 429, RS-485/422, MIL-STD-1533 and Ethernet. It is contained in a chassis that is resilient to vibrations and fluctuating temperatures such as those found in an aircraft engine bay.

Card design is modular, allowing one or more of the input signals to be missing without affecting the operation of the card, as well as providing a basis for the design of more application-specific cards in the future. The engine communications card is suitable for most engine configurations, allowing easier serviceability.



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THREE-WAY HEAT EXCHANGER

Team 18019

Honeywell

PROJECT GOAL

To design a heat exchanger that can be produced by additive manufacturing and which uses engine fuel as the primary cooling method.

Honeywell wants to create a heat exchanger that is more efficient than the standard tube and fin design by using more than one fluid for heat evacuation.

The team's three-way heat exchanger, which has flow paths for oil and fuel and a cross-flow path for air, is designed for aircraft auxiliary power units operating under normal conditions. The design uses the additive manufacturing process of direct metal laser sintering to lower production times and cost.

Features such as turbulators were added after the preliminary design to reduce heat concentrations and overall size. The heat exchanger is smaller than the current tube and fin design. Heat transfer optimization was analyzed by finite element techniques and by conducting experimental tests to verify results.



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AUTOMATED DEBURR OF HYDRAULIC SLEEVE INTERNAL ELEMENTS

Team 18020

RBC | SARGENT AEROSPACE & DEFENSE

PROJECT GOAL

To automate the project sponsor's manual hydraulic sleeve deburring processes.

The sponsor manufactures the hydraulic sleeves used to move fluid from one control port to another in hydraulic valves. Precision grinding and honing the inner surfaces of the sleeves raises small burrs on interior edges that prevent smooth operation. Burrs are removed manually, which is labor-intensive and time-consuming.

The machine designed moves hydraulic sleeves up and down while a motor-powered steel brush deburrs the inner surface of the sleeve from above, requiring no human interaction after setup. To ensure that the device is compatible with all hydraulic sleeve sizes, it has been designed to accommodate interchangeable brush sizes, and the user interface allows input of various sleeve parameters.

The automated deburring machine allows users to load and secure a hydraulic sleeve, and then to select a preset deburring option or manually input sleeve parameters. The machine is oil and water resistant, reduces hydraulic sleeve touch time, and meets sponsor requirements for safety and efficiency.



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AUTOMATED WIRE WINDER AND CUTTER

Team 18021

CATERPILLAR®

PROJECT GOAL

To design and test an automated device that produces spools of wire of specified lengths and quantities.

The sponsor's instrumentation team spends a lot of time manually spooling the lengths of wire it needs to run tests on large mining machines. Tests require multiple quantities of wire, from 15 to 150 feet in length, which must be measured, cut, wound, bound and dropped into a bin for collection.

The automated system designed is housed in a vertical metal frame with a protective screen to shield the user from the operating mechanism. The system uses a standard spool of wire, which is loaded into the top of the device. The wire is threaded through a measuring device and cutting mechanism and attached to a winding drum. A touch screen allows the operator to input the desired length and quantity of the wire sections needed. The device automatically measures and spools the wire to within one inch accuracy. It cuts the wire, binds it with tape, and drops the fully prepared wire into a bin for collection at the bottom of the frame. This process repeats autonomously until the desired quantity of each wire length is achieved. If the wire supply runs out, the system stops and provides a message on the touch screen telling the operator to load additional wire. Once the wire is loaded, the system completes the interrupted job.

REPURPOSING EXHALED CARBON DIOXIDE FOR SPACECRAFT

Team 18022

Honeywell

PROJECT GOAL

To find applications for the carbon, as carbon composite, produced by the sponsor's methane pyrolysis reactor used aboard spacecraft.

Life support on the International Space Station and other manned spacecraft yields a methane byproduct that is vented to space. The sponsor's methane pyrolysis reactor allows this waste methane to be reclaimed by transforming it into useful hydrogen and a solid carbon composite material.

A storage box was designed and built from the carbon material with few additional resources. It is constructed out of six square carbon pieces adhered to a fabric base, which can be oriented to form a cubic container. The design employs the carbon material in an application that is appropriate to the spacecraft environment and could be used by astronauts on a trip home from Mars. It can also make use of other waste products that have reached the end of their lifetime usability, such as astronaut clothing.

The box designed is simple, collapsible for easy storage, and easily scalable depending on intended use. Astronauts will be able to store experimental samples, food and other items in carbon boxes produced while breathing into a life-support system that produces almost no waste.



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AUTOMATED SCALE PLACEMENT SYSTEM

Team 18023

CATERPILLAR®

PROJECT GOAL

To automate the process of adjusting the spread between load cells used to weigh off-highway mining vehicles of varying wheelbases.

An important part of machine performance analysis is knowing the weight of loaded vehicles and determining their center of gravity. The off-highway vehicle weigh station consists of two independent load cells that sit in a recessed concrete channel. Load cells are spread manually with heavy equipment to distances that accommodate vehicles of varying wheelbases. The automated scale placement system designed has electronically controlled retractable lifting rollers, winches and a distance sensor. The system installs without requiring modification to the existing load cells or scale channel and does not interfere with the weighing process. The retractable feature on the scale lifting mechanisms eliminates the need to support vehicle weights that can reach 800 tons. The system is controlled through an Arduino Mega microprocessor that interfaces with software run on a tablet.

Implementation of this automated scale placement system allows a single user to prepare the weigh station for any vehicle in a matter of minutes and removes constraints the sponsor faces when needing to consecutively weigh vehicles of differing wheelbases.



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RECONNAISSANCE UNMANNED AIRCRAFT AUTOMATION IMPROVEMENTS

Team 18024

BAE SYSTEMS
INSPIRED WORK

PROJECT GOAL

To create a software program that autonomously conducts missions using two unmanned aircraft that record data and images.

The software designed guides the unmanned aircraft on a 3D flight path to a predetermined location while avoiding threat zones defined by the user. The flight path is optimally generated using the A* algorithm and executed using the Ardupilot open source flight-control software. During flights, the unmanned aircraft capture and record live photos and videos of the mission. The system also gathers statistical data, such as coordinates, altitude, and size of and distance from the area of interest.

The software generates a mission report that provides images of the area of interest along with statistical data about the location. These mission reports are generated using SOCET GXP, developed by BAE Systems. This data is cataloged in an online database using Amazon Web Service S3, from which a user can search and filter for more specific results. The graphical user interface for the program is completed using Node.js and Electron, an open source framework for creating desktop applications.



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GRASSHOPPER HARVESTER

Team 18025

THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE & LIFE SCIENCES
Entomology

PROJECT GOAL

To design and build an autonomous method of collecting and lowering the density of grasshoppers in agricultural fields.

Grasshoppers are a major pest in agricultural fields, and pesticides are commonly used to prevent them from damaging crops. A self-driving electric vehicle was developed that collects grasshoppers by exploiting the way they hop. The harvester uses GPS to move throughout a designated area and relies on ultrasonic sensors to map the terrain and avoid obstacles.

Grasshoppers cannot control the direction in which they jump, and launch themselves into the air based upon the direction they are facing. Relying on that fact, the harvester seeks to scare the grasshoppers into the air and move fast enough to catch them in a bucket like that found on a front-end loader. Vibrations from the harvester operation keep the grasshoppers from jumping and holding onto the sides of the bucket, and a conveyor belt moves the grasshoppers into an internal storage container. The storage container is modular and can be easily removed and replaced on location. Container capacity is calculated using a scale and when it is full, the harvester returns to a designated home location.

FORMULA SAE TORSION-TESTING RIG

Team 18026

WILDCAT FORMULA RACING

PROJECT GOAL

To design and build a torsion-testing rig that can measure the torsional rigidity of any rules-compliant Formula SAE chassis.

Currently, the only way to estimate torsional rigidity of a chassis is using SolidWorks finite element analysis. A torsion-testing rig will allow verification of the analysis and lead directly to a higher score in the design presentation at the yearly competition.

The torsion-testing rig designed secures the two rear corners of the chassis while allowing the front of the chassis to pivot on a stand. A torsion load is applied to the front two corners of the chassis and the resulting displacement is measured at various points along its length. With the torsion load and resulting displacement known, the torsional rigidity of the chassis can be calculated.

The torsion-testing rig designed has adjustable hub interfaces, a rigid rear constraint system built using a welding table, and weights to apply moment on any Formula SAE rules-compliant chassis. Dial indicators, accurate to 0.001 inches, were used to gather the chassis displacement data.



TEAM MEMBERS

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Kyle Brown *Mechanical Engineering*
Zachary Jordan Faulk *Mechanical Engineering*
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COLLEGE MENTOR

Bob Messenger

SPONSOR MENTOR

Cesar Martell

HYPERSPECTRAL IMAGING SMARTPHONE

Team 18027

HELLMAN OPTICS

PROJECT GOAL

To build an optical attachment and smartphone app that enable a smartphone to capture hyperspectral images and make an informed decision for a real-world application.

Hyperspectral imaging is used in fake currency detection, quantification of carbon dioxide concentrations in air, food safety, cancer screening, and many other applications. Hyperspectral imaging techniques require complex optical systems, making devices expensive and nonportable and restricting the impact hyperspectral imaging can have on society.

The system designed trades optical system complexity for postprocessing requirements, enabling a compact assembly that, at quantity, can be produced for less than $10. The phone attachment minimizes the number of optical elements necessary for hyperspectral imaging while maintaining very wide tolerances, fully compensating for poor user alignment. The phone app provides a user interface and controls calibration, data capture, and processing. Once calibrated, the system captures raw data from a real-world situation, processes the raw data into hyperspectral image data, and uses the hyperspectral image data to make an informed decision about the real-world situation through machine learning.



TEAM MEMBERS

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COLLEGE MENTOR

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GOLF COURSE PIN PLACEMENT SYSTEM

Team 18028

FL Broyles, LLC

PROJECT GOAL

To design and build a system that uses an unmanned aircraft to accurately and efficiently mark locations for pin and tee box placement on a golf course.

Golf is a game of inches, so it is important to know exactly what conditions each hole brings. Every morning, golf course operations teams get to work early to mark the location of the pin and tee boxes for that day. The current process involves the team walking the course and approximating the location of the pin based on a pin sheet.

This project uses an unmanned aircraft to autonomously mark the location on a green for a new hole to be cut. The system includes an unmanned aircraft equipped with a paint-dispensing attachment, a golf operations app to control the unmanned aircraft, and a player's app to see daily course information. The paint-dispensing subsystem includes a light sensor, a pump that pushes the paint through a nozzle, a microcontroller, and an external battery as the power source. All of these components are integrated in the 3D-printed attachment mounted on the legs of the unmanned aircraft. The system is controlled through the golf operations app that inputs the desired GPS locations and monitors the status of the system.

The golfers' app contains hole information, including pin placement on the green and distances from the tee boxes. The apps were created and programmed using Java and, after extensive testing, the system accurately and efficiently marks the pin and tee box locations on a golf course.

TEAM MEMBERS

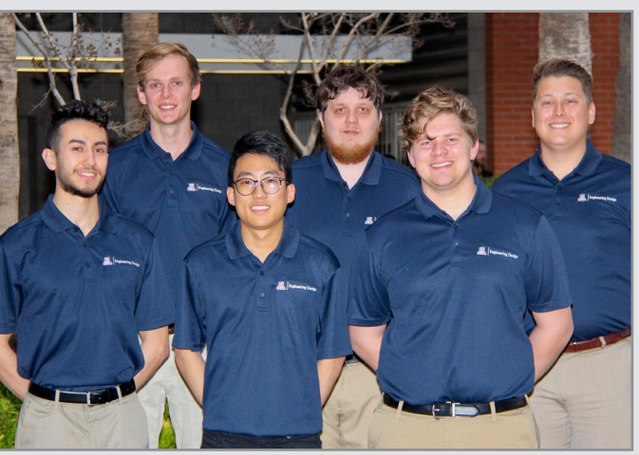
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ROBOTIC WEEDING MACHINE FOR LEAF LETTUCE CROPS

Team 18029

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

PROJECT GOAL

To design a prototype robotic weeding machine for leaf lettuce fields.

In large-scale lettuce farming, farmers do not have an economical and sustainable method to control weeds and prevent them from emerging and competing with their crops. They rely on costly and tedious manual weed removal.

The robotic weeding machine prototype consists of a pneumatic piston, stepper motors, an Arduino for control of actuators, and a laptop for the graphical user interface and software. The system uses parts created using computer numerical control for precise and accurate positioning of the weed removal apparatus, which is controlled with software for physical positioning corresponding to the user input. The user is provided with an easy-to-use graphical user interface on a touch-screen laptop for weed selection. The prototype and software have been constructed to be compatible with sponsor-owned weed-lettuce discrimination software to maintain continuity with the eventual mission, an autonomous weed identification and removal robot for lettuce fields.

TEAM MEMBERS

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SPONSOR MENTOR

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AVIATOR NIGHT VISION AUGMENTED DISPLAY

Team 18030

MTEQ CIRCUITS TO SYSTEMS

PROJECT GOAL

To design a head-up primary flight display for integration with the pilot's night vision goggles.

Safety in military aviation depends heavily on the pilot's ability to see and avoid traffic, obstacles and terrain. Night vision goggles are used by pilots to perform operations in low light conditions and are essential to the safety and performance of the aircraft. However, pilots are unable to view key aircraft performance parameters often shown on instrument displays, which are too bright for the goggles.

The design subtly introduces critical flight information within the pilot's field of view with an augmented display system, an avionics software package, a nonintrusive mounting unit, and a power system. A lightweight optical housing was developed and is mounted to the pilot's helmet, allowing easy connection to vehicle power systems without introducing discomfort for the user. The software package was developed for easy implementation on a readily available lightweight computer, while human factors considerations were at the heart of each graphical design choice. System requirements were validated based on testing and modeling, to military specifications, for vibration, heat, acceleration, data transfer and electromagnetic interference.



TEAM MEMBERS

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Andrew Dotson

VEHICLE BIOCULAR DIGITAL DISPLAY VIEWER

Team 18031

MTEQ CIRCUITS TO SYSTEMS

PROJECT GOAL

To design a digital display and optical interface for comfortable two-eye viewing in the confined space of an armored vehicle.

The window of an armored vehicle is the weakest point on the vehicle's exterior. Eliminating the window would improve occupant safety, while allowing other vital information to be overlaid on top of the video feed.

The vehicle biocular digital display viewing system receives a single video source input and displays the information to both eyes of the operator. The visual information sent to the operator is meant to mimic what they would see when looking out the front window of a vehicle. The design incorporates a custom optical design that uses achromatic doublet lenses, flat mirrors, and high-definition displays. The system is mounted in a custom housing consisting of a microcontroller, an adjustable interpupillary distance compensator, custom flexures, and custom lens mounts. The design uses custom software to correct for the inherent distortion of the optical system in real time. The viewing system effectively improves vehicle safety while providing the operator visual data on the environment around the vehicle with relevant vehicle metrics overlaid on the video.



TEAM MEMBERS

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CUBESAT CAMERA SPACE RUGGEDIZATION

Team 18032

UA SCIENCE
LUNAR & PLANETARY LABORATORY

PROJECT GOAL

To design, build and test a space-qualified low-cost camera system to be integrated into a CubeSat.

Premade space-qualified cameras are typically very expensive, and not viable for nanosatellite missions. Limited deep space communication is also a problem for such missions. CatSat will be used in a proof of concept for a high-bandwidth deep space communication system able to achieve high-definition video transmission from low Earth orbit through a novel inflatable antenna. CatSat will also pave the way for the use of affordable commercial off-the-shelf cameras on future missions.

The CatCam camera system will image the deployment of the inflatable antenna and capture video of Earth. The data that CatCam captures will be sent through the inflatable antenna as a demonstration of high-bandwidth communication. CatCam has been designed, built and tested to withstand the harsh environment of space, and has been programmed with camera control software for easy integration into the rest of the CubeSat.

TEAM MEMBERS

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COLLEGE MENTOR

Doug May

SPONSOR MENTOR

Vishnu Reddy



INTEGRATED IMAGE ENHANCEMENT SYSTEM FOR AUTONOMOUS VEHICLES

Team 18033

tusimple

PROJECT GOAL

To design a camera with an integrated graphics processing unit that uses machine learning to enhance processing of image sets.

The sponsor owns and operates autonomous trucks whose behavior is determined by a combination of software and hardware, and which use a single graphics processing unit, or GPU, for all eight onboard cameras. This design requires 1,600 watts to process an image set and represents a single point of failure.

The new design uses multiple redundant GPUs designed to handle up to three cameras. The GPUs provide the server on the vehicle with data about distances to objects and types of objects, as well as images that have been enhanced with respect to their brightness, gamma, contrast, boundaries, and denoising variables. The alleviation of computational power from a central unit allows for faster image processing before the image sets and data are sent to the onboard server responsible for vehicle control. This means the server can focus on vehicle control rather than image processing. If a failure occurs in one of these GPUs, the vehicle can continue moving safely. The system requires only 60 watts to complete the analysis of an image set and total power usage does not exceed 300 watts.

TEAM MEMBERS

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IMAGING POLARIMETER SOFTWARE MODEL

Team 18034

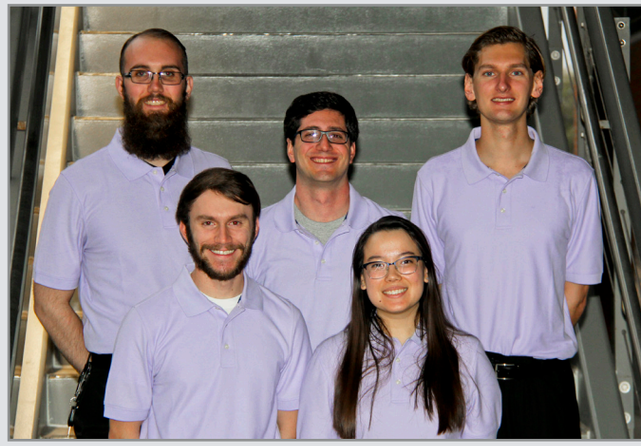
THE UNIVERSITY OF ARIZONA
College of
Optical Sciences

PROJECT GOAL

To build a software model that characterizes an Axometrics RGB950 AxoStep Mueller matrix imaging polarimeter.

The Polarization Laboratory in the UA College of Optical Sciences recently received an RGB950 AxoStep polarimeter. The instrument consists of extremely bright light-emitting diodes, a polarizer, two rotating retarders, a second polarizer, and a camera. It operates at four wavelengths and has a particularly large field of view, so there is some angular variation in the performance, which this project seeks to understand.

The RGB950 polarimeter was used to obtain Mueller matrices based on air measurements at various angles in order to characterize the instrument's angular dependence. Additionally, software models for different optical elements tested by the polarimeter were developed and the Mueller matrix results were compared to Mueller matrix data. This includes models for a nonpolarizing cube beam splitter and a solid corner cube. Each model was built using Polaris-M, a library of polarization ray tracing functions developed by Airy Optics for use in Mathematica. The resulting software characterizing the polarimeter gives the lab a tool for predicting polarimetric measurements and verifying instrument performance.



TEAM MEMBERS

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REUSE OF FUEL CELL BYPRODUCTS

Team 18035

Microsoft

PROJECT GOAL

To design a system that uses byproducts from fuel cells used in data centers.

Microsoft is testing the implementation of fuel cell technology in order to lessen its dependence on traditional power supplies. Through the conversion of natural gas to power, solid-oxide fuel cells give off high-quality heat, highly pure water and gaseous carbon dioxide.

The design created to use the fuel cell byproducts is a closed-loop hydroponic greenhouse system in conjunction with a heat-driven water-treatment system. The system sequesters excess carbon dioxide and provides a water source derived from the data centers. Full-scale implementation of this project will involve building greenhouses directly on top of the fuel cell-powered data centers. This will allow water to be purified at the site of the data centers and fed directly into the greenhouse system, creating a food-source for the surrounding community. The waste biomass from the greenhouse will be composted to create methane that will be fed back into the fuel cells.



TEAM MEMBERS

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COLLEGE MENTOR

Cat Merrill

SPONSOR MENTORS

Nicholas Keehn
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Daniel Higgins *Mining Engineering*
Jonathan Decker Miller *Mechanical Engineering*
Christian Syson *Optical Sciences & Engineering*
Jason Daniel Shirey *Mechanical Engineering*

COLLEGE MENTOR
Steve Larimore

SPONSOR MENTOR
Joe Tabor

LARGE MINING TRUCK OPTIMIZED MIRROR DESIGN

Team 18036

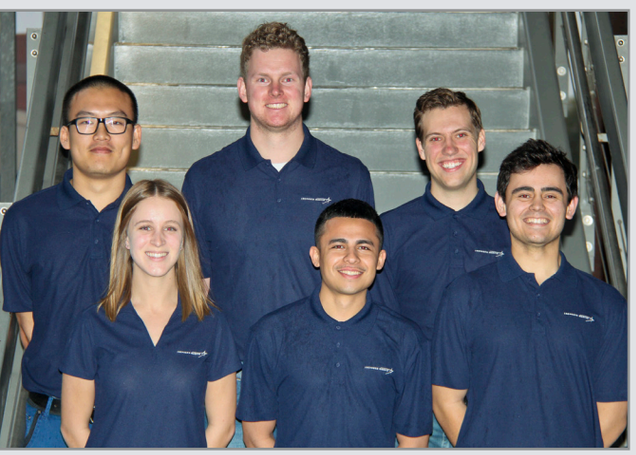
CATERPILLAR®

PROJECT GOAL

To design a side mirror assembly that increases field of view, minimizes debris buildup, and reduces maintenance and adjustment time.

Large mining trucks require a skilled operator who can use various systems simultaneously to operate the truck in a safe and efficient manner. Side mirrors are important for operator vision, particularly while driving in reverse to dump a load or to maneuver beneath loading equipment. Slow or inaccurate maneuvering of the truck results in lost time and money.

The team implemented a mirror system that improves the operator's field of view, tested mirror coatings to reduce cleaning frequency, and designed an adjustable system that reduces the time needed to optimize mirror position. Structural and field-of-view analyses were performed to evaluate the stability and functionality of the system. The new mirror design optimizes time operating the truck and increases driver awareness of the truck's surroundings.



TEAM MEMBERS
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SPONSOR MENTOR
Eric Smith

VEHICLE DETECTION FOR CYCLIST SAFETY

Team 18037

LOCKHEED MARTIN

PROJECT GOAL

To design and build a vision-based portable vehicle detection system that incorporates a deep neural network and can be attached to a bicycle for use while cycling.

The system is designed to help prevent collisions between cyclists and vehicles. It is optimized to work on a midsummer day in Tucson, Arizona. The deep neural network runs on energy-efficient hardware and can perform inference on images captured in real time. The network learned by training on a data set of prelabeled example images. Using what it learned, the network is able to draw bounding boxes around objects it believes are cars and can report a confidence level for each prediction made.

The physical system is composed of a weatherproof enclosure housing the inference hardware the neural network runs on, a battery, and a cooling fan. The camera is mounted on top of the enclosure under a clear dome, positioned to detect vehicles to the rear-left of the cyclist. The enclosure is placed on a bike rack on the back of a bicycle. Images are processed at a rate of at least eight frames per second and the entire system can operate for at least six hours.

ANKLE FUSION JOINT PREPARATION SYSTEM

Team 18038

Exclusively foot & ankle Paragon 28®

PROJECT GOAL

To build a surgical instrument toolkit designed to prepare the ankle joint for fusion by quickly and accurately removing cartilage and bone and increasing fusion success rates.

Ankle arthrodesis, commonly known as ankle fusion surgery, involves removing cartilage and bone of the tibiotalar joint so that bone can grow onto itself, fusing the ankle and relieving pain. This procedure can fail due to inadequate bone mating. Most surgeons hand chisel the cartilage and bone to create a mating surface, which is a lengthy, inaccurate method that risks fusion failure.

A surgical toolkit was designed that includes a reamer, curved guide, and flex mesh device. The tools allow surgeons to work with a patient's unique anatomy and the sterile operating room. The tools attach to existing surgical power tools for surgeons' ease of use and to reduce costs. Each tool is contoured, shaped and sized for use within the narrow surgical site without damaging soft tissue around the joint. Tooling was modeled using computer-aided design and prototyped via custom 3D prints.

This biocompatible tool set greatly improves upon the current preparation system by having the power and precision to quickly and accurately remove both cartilage and bone, which reduces surgery time and risk to patients, and increases the chances of a successful fusion.



TEAM MEMBERS

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Aidan Dolby *Biomedical Engineering*
Jared Thomas Irwin *Mechanical Engineering*
Jake Snyder *Mechanical Engineering*
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COLLEGE MENTOR

Don McDonald

SPONSOR MENTOR

Frank Barmes

AUTOMATED IBUTTON PLACEMENT DEVICE

Team 18039

Roche

PROJECT GOAL

To design a device that will take bulk iButtons and sticky pads as input and create an iButton adhered to a sticky pad as output.

iButtons are flat metal disks with identifying information burned onto them. They are placed on sealed manufactured products for traceability and anticounterfeit purposes. iButtons are first placed onto sticky pads, which are then peeled and placed on products. This process is currently manual and requires roughly 2,000 hours of labor per year.

A device was designed that automatically adheres iButtons to sticky pads for eventual placement onto a sealed product. This was accomplished with mostly 3D custom-printed parts in combination with motors and a Raspberry Pi. The device has a capacity of 3,000 iButtons and one roll of 3,000 sticky pads. It produces strips of iButtons adhered to sticky pads cut into a user-defined length. The number of moving parts was minimized to eliminate as many failure points, and thus device shutdowns, as possible. The machine designed uses a camera module with OpenCV to detect the outline of a sticky pad. When the outline of the sticky pad is detected, an iButton is dropped onto the sticky pad. A signal light attached to the top of the device indicates if the machine needs refilling or if there is an error in the system. A graphical user interface on an LCD screen displays refill alerts and allows users to start and stop the machine and define output length. The system was verified and tested under conditions similar to the operating environment and a user's manual was provided for reference.



TEAM MEMBERS

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COLLEGE MENTOR

Heather Hilzendeger

SPONSOR MENTOR

Ben Blehm



SCOOTER ELECTRIC PROPULSION SYSTEM

Team 18040

TEXAS INSTRUMENTS

PROJECT GOAL

To demonstrate the capabilities of Texas Instruments' high-speed operational amplifiers on an electric scooter.

The Texas Instruments OPA2836-Q1 is a is high-speed, ultralow-power operational amplifier. It was integrated into an electric scooter and fault testing was conducted to show the capabilities of the device.

A customized circuit board and circuit board housing were created to run the scooter using InstaSpin software and to feature the operational amplifier. A customized graphical user interface was created to display the current in real time. Testing was conducted on the scooter system for two faults that can be caused by the user: an over-current electrical fault in which the current exceeds the motor's limit, and a mechanical fault in which a brake is applied to the wheel with the motor still running, which also causes an over-current on the motor. The high-speed operational amplifier detected and shut down the current within 1 microsecond of the overcurrent occurring, demonstrating the operational amplifier's ability.

TEAM MEMBERS

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COLLEGE MENTOR

Claude Merrill

SPONSOR MENTOR

Anthony Vaughan



SIZE, WEIGHT AND POWER OPTIMIZATION FOR AIRCRAFT CABIN AVIONICS UNIT

Team 18042

ACSS®
An L-3 Communications & Thales Company

PROJECT GOAL

To design an enclosure and heat management system to passively cool an avionics unit installed in the crown of an aircraft's fuselage.

The aviation industry continues to make avionics platforms smaller, lighter and more integrable for aircraft manufacturers and their airline customers. The team was tasked with developing a method to cool one of the sponsor's avionics units being moved out of the avionics bay and into the aircraft fuselage itself, where active cooling options are not available. The designed heat management system conforms to industry standards and passively cools the avionics unit while keeping size, weight, power usage and cost low.

The team modeled four thermal management alternatives using computational fluid dynamics simulations and thermal testing before selecting the most appropriate solution. This resulted in the design, validation and implementation of an entirely conductive pathway-based heat management system. The heat from the components is conducted into the electromagnetic interference shielding on the board via thermal standoffs, and then conducted into the enclosure using thermal bridges. The heat in the enclosure is dissipated via conduction into the mounting rails of the aircraft, and by convection from the enclosure surface into the fuselage crown air gap.

TEAM MEMBERS

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COLLEGE MENTOR

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Jay Crossman

TISSUE THICKNESS ANALYZER

Team 18043

PROJECT GOAL

To design a system that collects, stores and analyzes the thickness of tissue and paraffin samples affixed to a glass slide.

The sponsor develops automated staining systems that process tissue samples affixed to glass slides. These systems use defined protocols to create and control an environment that yields accurate and reproducible staining results. While the samples in a given protocol can be processed identically, the samples provided may not be consistent with one another. Varying thickness in the tissue cuts placed on each slide can influence the final staining results. To help correct this factor, the team developed and implemented a tool and process that can determine these slide-to-slide differences in thickness before processing.

The system uses reflectance confocal microscopy techniques. To obtain measurements, the stage with the tissue slide is moved along the optical axis until the top and bottom surfaces of the sample have passed through the focus of the first microscope objective. The voltage measurement of the photodiode, which converts light into electrical currents, records peaks at the top and bottom surfaces of the sample. The thickness is determined by calculating the distance traveled by the stage between the peaks in the photodiode signal.



TEAM MEMBERS

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Zhouyang Min *Biomedical Engineering*
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COLLEGE MENTOR

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GLUE DISPENSING AUTOMATED GLASS COVERSLIPPER

Team 18044

PROJECT GOAL

To modify the Ventana HE 600 to dispense glue onto slides to be coverslipped rather than using precoated slides for pathologist view.

The coverslipper module on the Ventana HE 600 instrument dispenses an agent that activates precoated adhesive on glass coverslips to encapsulate the stained tissue samples. The manufacturing process for precoated coverslips poses challenges to process and quality control.

The team modified an existing HE 600 coverslipper's software and mounting medium to apply the correct amount of adhesive onto slides, eliminating the need for precoated coverslips. The modification also includes a new system that will prevent curing of the mounting medium, and accompanying buildup and blockage in the nozzle, when the machine is not in use. These modifications will allow for better quality control over the coverslipped slides and lead to long-term cost reduction.



TEAM MEMBERS

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COLLEGE MENTOR

Frank Principe

SPONSOR MENTOR

Ben Blehm



TEAM MEMBERS

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Jesus Mulgado *Biosystems Engineering*
Caroline Schulte *Biomedical Engineering, Electrical & Computer Engineering*
Karli Marie Kochman *Biosystems Engineering*

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Brian Little

DAIRY ANIMAL DETECTION AND ENVIRONMENTAL CONTROL SYSTEM

Team 18045

COLLEGE OF AGRICULTURE & LIFE SCIENCES
Animal & Comparative Biomedical Sciences

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

PROJECT GOAL

To create a system to monitor and optimize the environment dairy cattle are exposed to.

Dairy cattle require a temperature-humidity index range of 72-74 to maximize milk production. The Rovey Dairy in Glendale, Arizona, achieves the required range through a series of cooling mechanisms: a misting system, fans and shaded areas. During the hottest months, utility costs spike as a result of their binary system, in which components are either all on or all off.

The system designed uses a series of cameras and sensors in conjunction with a misting line to divide the dairy into sections where it detects cow presence and sections with ambient temperature. Software analyzes the footage to determine cow presence while sensors measure the environmental conditions in specific areas. If the temperature or humidity is too high, the fans and misters are activated. Water and energy resources are used optimally to cool only the occupied areas. To monitor potential harmful pollutant levels, the system also detects methane, carbon monoxide, isobutane, ethanol and hydrogen. All data is recorded and can be accessed via an online database. Updates are posted to allow the operator continual access and retrieval.



TEAM MEMBERS

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Kevin Nguyen *Systems Engineering*

COLLEGE MENTOR

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SPONSOR MENTORS

Rick Malkin
Rick Church

ROTOR TEMPERATURE MEASUREMENT

Team 18046

Honeywell

PROJECT GOAL

To design a system that measures the temperature of a rotating component and reliably transfers the data to an outside source for display and analysis.

The sponsor has issues tracking and measuring the temperature of the rotor on a wound field salient pole generator without an existing device to do the job. The team designed a system that can take the temperature readings from a resistance temperature detector sensor attached to a field coil and transmit these readings to a data acquisition system for analysis.

The system's microcontroller uses the change in resistance to calculate the temperature in degrees Celsius using programming libraries, and then transmits the temperature readings at a rate of one reading per second to a data acquisition system via a Bluetooth app. This app displays the readings and stores them on the tablet's solid-state hard drive, allowing them to be referenced anytime. The design's capabilities allow the operator to monitor the temperature of a field coil on a spinning rotor, enabling the sponsor to verify its thermal models with test results and create more efficient machines.

WIRELESS BODY TEMPERATURE SENSOR FOR IMPLANTABLE PORTS

Team 18047

PROJECT GOAL

To design, build and test a wireless body temperature sensor and smartphone application for implantable ports.

Implantable ports aid in the administration of chemotherapy drugs. The wireless body temperature sensor monitors the immunocompromised patient's body temperature, detecting and alerting the patient about dangerous temperature spikes via a user-friendly smartphone application. The smartphone application, written in Swift, also allows the patient to view their temperature history. A rise in temperature often correlates with conditions such as neutropenia, which can be deadly if not caught early.

The device is made up of a microcontroller that includes Bluetooth transmission capabilities and a custom mounted temperature sensor accurate within 0.1 degrees Celsius. Additionally, the design operates in low power mode to conserve battery life and ensure it lasts the duration of the patient's chemotherapy treatment. The device is integrated into a modified port design and uses biologically inert silicon. The design meets the International Electrotechnical Commission 60601 and Food and Drug Administration medical industry safety standards.



TEAM MEMBERS

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COLLEGE MENTOR

Bob Messenger

SPONSOR MENTORS

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Peng Zheng

COVERT SHORT-WAVE INFRARED ILLUMINATOR CORE

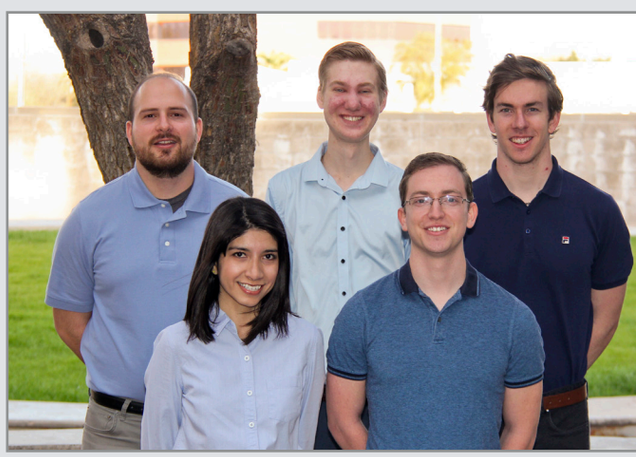
Team 18048

PROJECT GOAL

To design and construct a covert illuminator that operates in the short infrared wavelength range.

Military personnel must be able to observe a target without making that target aware of their presence. The wavelength of light used for this target illumination must be far enough outside the visible spectrum that an inexpensive and common device, such as a simple attachment to a camera phone, cannot detect the light.

The covert short-wave illuminator uses microprocessing to control the system's optical output levels while monitoring its temperature. The device is designed to be used in conjunction with a higher-level system that sends commands to and powers the illuminator, in addition to receiving temperature data. Through a complex arrangement of lenses and the use of highly sensitive electrical equipment designed to power the laser diode, the system outputs a uniform beam in the 1,500 to 1,600 nanometer wavelength range for optimal covert illumination of a target.



TEAM MEMBERS

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TEAM MEMBERS
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CELLULAR SECURE VIDEO TRANSMISSION FROM AN UNMANNED AIRCRAFT

Team 18049

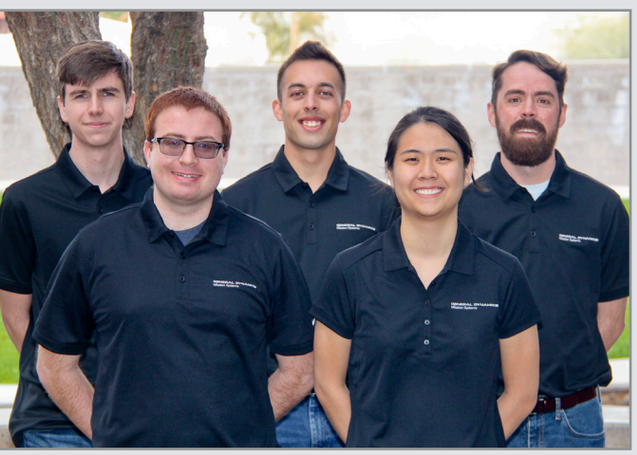
GENERAL DYNAMICS
Mission Systems

PROJECT GOAL

To design a secure communication system for unmanned aircraft using the current 4G LTE, or long-term evolution, cellular network.

The growing capabilities of unmanned aircraft have garnered attention from the commercial and defense industries. Demand for unmanned aircraft that can transmit data over long distances in a secure fashion is on the rise. The designed system can establish a secure connection through the user controller and a camera attached to the unmanned aircraft's flight controller by encrypting and transmitting data over the LTE network in real time.

The system can operate as long as both the user and unmanned aircraft are within range of any LTE network, no matter the distance between them. The secure encryption of both real-time video and unmanned aircraft controls limits the threat of third-party attackers learning more about the system's operations. By connecting the camera to the unmanned aircraft controller, both video stream and commands are encrypted and decrypted over the link to the user's control station. The system demonstrates advanced, commercially available capabilities for unmanned aircraft to transmit data to a user over unlimited range, contingent on each component being within range of popular LTE networks.



TEAM MEMBERS
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SPONSOR MENTOR
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SYSTEM-ON-CHIP VIDEO ENCODING SYSTEM

Team 18050

GENERAL DYNAMICS
Mission Systems

PROJECT GOAL

To evaluate the performance and demonstrate the video encoding and digital signal processing capabilities of the Xilinx Zynq UltraScale+ Multi-Processor System-on-Chip, or MPSoC, device.

This project tests the performance of the MPSoC device by running software, consisting of an algorithm using cross-correlation, on both the MPSoC's processing system and on a comparable device to establish a benchmark. The system demonstration uses the same algorithm to perform Wi-Fi signal detection with a peripheral software-defined radio and directional antenna. The resulting signal correlation value and received signal strength indicator, as well as video feed from a camera, are displayed on a monitor to visualize the signal strength at a specific location.

The benchmark software uses math functions ported over from a C-language software library device to ensure an accurate performance comparison between the new and current systems. The benchmark software measured the total elapsed time taken to correlate one million input signals with one reference signal. The results from this test were delivered to the sponsor so it could compare the devices internally to determine if the MPSoC device should be considered for future products.

GRAPHICS PROCESSING UNIT-BASED HIGH-SPEED DEMODULATION

Team 18051

GENERAL DYNAMICS
Mission Systems



PROJECT GOAL

To develop an optimized demodulation system using a graphics processing unit, or GPU, platform to prove that GPUs can perform as well as, if not better than, the central processing units, or CPUs, and application-specific integrated circuits, or ASICs, used in current demodulation systems.

Demodulation of high-speed, wide-bandwidth waveforms has typically been performed by ASICs or large CPU clusters. However, development times for these technologies can be long and expensive, especially for ASICs.

While general purpose processors are flexible and easier to program, they often lack the throughput required to handle high-speed waveform demodulation. GPUs open up new avenues for flexible demodulators that can be developed quickly and modified and maintained easily. This project seeks to harness the power of GPU processing for high-speed demodulation. To do this, the design uses an industry-leading GPU development environment to optimize the repetitive processes during demodulation. The system can exploit these processes through parallelization while maintaining a modest implementation loss.

TEAM MEMBERS

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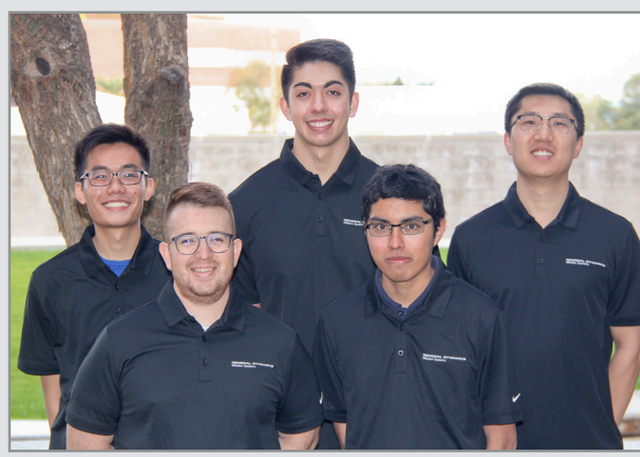
SPONSOR MENTOR

Glen Abousleman

OKL4 HYPERVISOR SOFTWARE DEVELOPMENT KIT

Team 18052

GENERAL DYNAMICS
Mission Systems



PROJECT GOAL

To design a project configuration wizard plugin for the OKL4 Hypervisor system.

The OKL4 Hypervisor system is configured by a system-extensible markup language, or XML, file. This XML file defines each virtual machine – its attributes, features and any devices it should have access to. The process of defining a system can be tedious when done by hand. The plugin designed will provide the user with a wizard that allows them to create a hypervisor system step-by-step while also allowing them to save their projects and import previous ones. Major features of the Eclipse plugin include the ability to design a system by picking and choosing options based on valid configurations. This ensures real-time error checking as a user selects options to ensure they are creating a valid hypervisor system.

Eclipse allows users of the OKL4 Hypervisor to design their system via a user interface and to produce a bootable image. This eliminates the need for a user to become too familiar with the OKL4 software development kit system XML files that currently define a valid hypervisor system.

TEAM MEMBERS

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COLLEGE MENTOR

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TEAM MEMBERS
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UNMANNED AIRCRAFT DISPENSER FOR AUTOMATED DATE POLLINATOR

Team 18054

ELLER COLLEGE OF MANAGEMENT
McGuire Center for Entrepreneurship

THE UNIVERSITY OF ARIZONA
College of Engineering

PROJECT GOAL

To design an autonomous pollen-dispensing system to be mounted on and powered from a commercially available unmanned aircraft, and to provide electrical power to all involved teams.

The date industry has high costs associated with the palm tree pollination process. Since the palms are only pollinated naturally by the wind, laborers must pollinate the trees in date orchards manually to increase date productivity, a practice that is labor intensive, imprecise and can be dangerous, since it involves reaching heights of 50 feet or greater. Taking inspiration from the successful 2017 senior design project, and in conjunction with teams 18055 and 18056, the team designed a system to standardize and improve pollination practices by using autonomous unmanned aircraft technology and additive manufacturing.

The pollen-dispensing system allows a set payload of pollen to be deposited on each tree and is mounted directly to a commercially available unmanned aircraft, while retaining all manufacturer flight capabilities. The system also features a quick-detach mechanism to maximize unmanned aircraft up-time and allow for modularity between unmanned aircraft systems. Using additive manufacturing practices like 3D printing, the team has minimized the pollen dispenser's weight, maximizing pollen carrying capacity and the number of trees pollinated per battery. The multiteam structure of this project has allowed multidisciplinary collaboration in producing a cohesive and modular system.



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UNMANNED AIRCRAFT CONTROL SYSTEM FOR AUTOMATED DATE POLLINATOR

Team 18055

ELLER COLLEGE OF MANAGEMENT
McGuire Center for Entrepreneurship

THE UNIVERSITY OF ARIZONA
College of Engineering

PROJECT GOAL

To design a system that can identify and locate fruit arms, send a signal to dispense pollen and avoid obstacles.

The system, designed in collaboration with teams 18054 and 18056, controls an unmanned aircraft as it flies through a date palm plantation and pollinates the palms. The computational system mounted on the aircraft uses computer vision and artificial intelligence to observe, model and act on its environment to efficiently and safely complete the pollination process. This includes the identification of the palm trees, the command to release pollen, and the detection and avoidance of obstacles.

The system provides the date farmers with a modular product capable of pollinating a field of date palm trees in an industrial-scale farming environment. This allows for significant savings by reducing labor costs and the risk of injury during manual pollination.

UNMANNED AIRCRAFT FLEET MANAGEMENT FOR AUTOMATED DATE POLLINATOR SYSTEM

Team 18056

ELLER COLLEGE OF MANAGEMENT
McGuire Center for Entrepreneurship

THE UNIVERSITY OF ARIZONA
College of Engineering

PROJECT GOAL

To design a robust management system that allows for continuous communication with multiple unmanned aircraft through the use of a user-controlled graphical interface, supplemented with autonomous mapping and weather analysis.

Date trees can grow to over 80 feet tall and, in their natural habitat, have only the wind to depend on for pollination. Traditionally, agricultural workers pollinate date trees using large, hose-like machines, sometimes in conjunction with a lift table or similar machine to get closer to the date flowers.

The team developed an unmanned aircraft pollination approach to increase the efficiency of this process. Teams 18054 and 18055 developed the dispenser and ground control systems. This project focuses on the communication between the unmanned aircraft and the operator, using a new "internet of things" product, the Hologram Nova, to give the unmanned aircraft LTE, or long-term evolution, capabilities virtually anywhere in the United States. The team developed a web application to autonomously create paths for each unmanned aircraft, while giving users the ability to control the unmanned aircraft and view common analytics during and after the pollination process. The team added weather analysis to the system using a portable ambient weather station to calculate live wind offsets for the unmanned aircraft during pollination.



TEAM MEMBERS

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SPONSOR MENTOR

David Dillon

NAVAL DRONE RECOVERY SYSTEM

Team 18057

Raytheon

PROJECT GOAL

To design and demonstrate a system capable of safely recovering small fixed-wing unmanned aircraft on smaller naval vessels.

There is currently no safe method for recovering a small fixed-wing unmanned aircraft while at sea on smaller naval vessels. The team created a system, deployable from small watercraft, that can capture a fixed-wing unmanned aircraft without the use of landing gear. The system is easily stowed and deployed, and able to weather the wide range of operating conditions typical of a maritime environment. The design uses a structural frame with nylon netting to safely arrest drones that fly into the netting.

A frictional braking system attached to the net dissipates momentum to minimize potential damage to the drone. The system also includes lighting that allows unmanned aircraft pilots to detect and align with the capture net during night operations. A three-man crew can erect or stow the system in 15 minutes. The system was tested against International Organization for Standardization and military standards to ensure it met all of its requirements and could survive a wide range of operating environments.



TEAM MEMBERS

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Axton Oliva *Electrical & Computer Engineering*
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SPONSOR MENTORS

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Ryan Wahl
Huy Le



GROUND-BASED OPTICAL TARGET TRACKING

Team 18058

Raytheon

PROJECT GOAL

To provide portable, real-time optical tracking of suspicious vehicles at critical entry points of domestic infrastructure sites.

The ground-based optical target tracking system is an autonomous tracker designed to be used by two or more persons. The system tracks a full-size target vehicle moving at approximately 28 kilometers per hour at distances ranging from 100 to 300 meters. The system is composed of six principal parts: a camera, a PC, a microcontroller, a motor driver, a stepper motor and a laser pointer.

The camera sends target images to the PC for image processing while the target remains in the camera's field of view. The image-processing algorithm determines changes in target position between two separate images and converts this to an angle that the pointer must move to remain pointing at the target. The microcontroller receives the angle input and converts it to a frequency value to send to the stepper driver – while incorporating error values like time delay into the final frequency. The driver reads this value and produces a frequency pulse to drive the stepper motor. The stepper motor then rotates a turntable that the pointer is mounted to. The pointer remains on the target vehicle until it exits the camera's field of view.

TEAM MEMBERS

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SMART DISTRIBUTED ENVIRONMENTAL BEACON

Team 18059

Raytheon

PROJECT GOAL

To create a deployable mesh network of beacons to blanket remote areas, to be used to rescue lost or injured hikers without access to Wi-Fi or cellular networks.

The mesh network envisioned uses unmanned aircraft to deploy solar-powered beacons in regions lacking Wi-Fi or cellular coverage. Designing the beacons required analysis of battery life using solar panels, mechanical housing survivability and longevity of electronic components. The team prototyped and tested six beacons, all with minimal size and weight so they could be dropped by drone. A mobile application allows users to send emergency requests, display their location, and receive and display incoming responses from the main station.

The main station is responsible for receiving and responding to emergency requests, monitoring the beacons and keeping a log of the system. The beacons are responsible for handling these requests. With no cellular service, the main station communicates with the beacons over the radio mesh network.

TEAM MEMBERS

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AUTOMATED INSPECTION POINT MEASUREMENT AND DOCUMENTATION

Team 18060

Raytheon

PROJECT GOAL

To create an automated system to measure and document mandatory inspection points to ensure the quality of 3D-printed parts.

Raytheon conducts rapid prototyping on a large scale, so it needs a way to quickly test the quality and reliability of its newly fabricated parts before use.

The team developed a fully automated scanning system that measures and documents mandatory inspection points as defined by Raytheon's part specifications. The system does this by creating a 3D model of the product, comparing it to an optimal model and finding significant differences between the models. This allows for identification of defects in real time and minimizes human error by cutting out touch-intensive processes, all while achieving equivalent accuracy to current industry practices. The user uploads a 3D model of the ideal part into Autodesk, then places their 3D-printed part onto the rotary table. The rotary table spins 360 degrees, and the structure sensor generates a 3D model of the part. The 3D scanner then communicates this model to Autodesk so that the software can compare the two models. After comparison, the system generates a data package to send to the user's PC detailing how similar the actual product is to the ideal model.



TEAM MEMBERS

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William Alberto Sweetser *Electrical & Computer Engineering*
Colton Joe Lloyd *Mechanical Engineering*

COLLEGE MENTOR

Mark Brazier

SPONSOR MENTOR

Dean Booher

WIDE AREA DRONE SITUATIONAL AWARENESS

Team 18061

Raytheon

PROJECT GOAL

To design an optical system that detects the presence of an unmanned aircraft and alerts the user of its location.

The increase in the availability and popularity of hobby unmanned aircraft has become a dangerous security issue for small private airports and concert arenas. The designed drone-detection system detects unmanned aircraft within 35 seconds and notifies system operators via PC so they can act to avoid the unmanned aircraft. The system displays the location of unmanned aircraft by giving the height and azimuth bearing of the unmanned aircraft relative to the system. The system covers a full 30-degree field of regard at up to 400 meters.

The system uses a lidar rangefinder as the beam source and distance-measurement device for unmanned aircraft detection. Two motors scan the detecting beam across a 30-degree field of regard. The system sits atop an electrical box housing the microcontroller and support circuit used to power and steer the motors, as well as collect recordings from the lidar. The position and readings are output from the microcontroller to the user's PC for verification and display on the graphical user interface. The software package is written in C++ and inputted into a Matlab script which generates a user-friendly display and interface for field use.



TEAM MEMBERS

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TEAM MEMBERS
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Dalton Lee Thomas *Mechanical Engineering*
Michael David Wilcox *Environmental Engineering*
Gil Antinous Wondrak *Mechanical Engineering*
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Philip James Ciuffetelli

SOUTHWEST GAS NATURAL GAS AERATOR

Team 18062

SOUTHWEST GAS

PROJECT GOAL

To design a natural gas aerator that is vertical, noise efficient and lightweight.

The purpose of the natural gas aerator is to remove any potential harm that saturated gas can cause if left untapped. This project integrates new ideas in vacuum generation and noise mitigation to efficiently and safely remove the natural gas using only compressed air. The design uses the Venturi effect to create a vacuum strong enough to pull trapped natural gas from the ground.

The aerator is designed to be modular, allowing for the use of different nozzles the team designed and tested using computational fluid dynamics software. The project focuses on delivering safe-to-handle materials, accessible and compatible auxiliary equipment, a powerful nozzle design for vacuum generation and noise mitigation, and a design that uses fully developed flow to lower noise emissions and provide optimal diffuser angles.



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RECLAMATION AND REUSE OF 3D ABS PRINTING WASTE

Team 18063

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

PROJECT GOAL

To design and build a machine to recycle acrylonitrile butadiene styrene, or ABS, and polylactic acid, or PLA, 3D-printing waste.

3D printing using ABS or PLA produces waste that is typically thrown away and presents an environmental issue. The designed plastic waste recycler is composed of a grinder that shreds the plastic waste and an injector that melts and injects the plastic shreds into a removable mold. The injector's heating bands adjust to user input to maintain the user's desired temperature. This allows the user to set melting temperatures besides those of ABS and PLA. The injector also features a display of the measured temperature of the heating bands. The mold is exchangeable, with a universal nozzle.

Proper safety standards are set in place with multiple emergency stops, temperature regulation of both the grinder and injector, and LED indicators. The team built a prototype of the plastic waste recycler and tested it on campus with several molds, creating usable products from nonrecyclable waste.

‘LAST MILE’ UNDERGROUND CONSTRUCTION COMMUNICATION

Team 18064

HEXAGON MINING

PROJECT GOAL

To design a wireless mesh communication network for use in underground mines near the advancing face to provide reliable, near-real-time communication.

Underground mines require continuous communication with mine equipment and personnel. Fiber optic or other wired communication infrastructure works in most mines, but for the advancing face, or “last mile,” it is difficult to provide effective and reliable coverage due to the close proximity to drilling and blasting events. A lack of reliable communication results in delayed reactions to unexpected events, safety concerns and slowed production.

The team created a small, easy-to-install communication network that can be readily deployed to the “last mile” between blasting events without changing the end devices’ software. Taking into consideration the mines’ environmental conditions and possible signal interference underground, the team developed a portable mesh network that consists of various battery-powered nodes that act as gateway devices, transmitters and receivers in a network based on Wi-Fi and Zigbee. The mesh network is self-configuring and self-healing in the event that a node fails. This ensures that the relay of data and communication is not interrupted. The combination of Wi-Fi and Zigbee in each node allows for minimal power usage and maximum signal amplification for the entire mesh system.



TEAM MEMBERS

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Hunter Michael Hartley *Mining Engineering*
Kory Staab *Electrical & Computer Engineering*
Oscar Leonel Villasana *Electrical & Computer Engineering*
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COLLEGE MENTOR

Bob Messenger

SPONSOR MENTOR

Johnny Lyons-Baral

MULTIFUNCTIONAL MINING MACHINE BOOM AND CONVEYOR SYSTEM

Team 18065

CATERPILLAR®

PROJECT GOAL

To design a mining machine capable of processing a minimum of 200 tons per minute using a self-contained machine boom and conveyor system.

This project is a continuation of a 2018 senior design project to replace the Caterpillar 7495 electric rope shovel as the primary method for surface mining excavation. The new design focuses specifically on the machine’s material removal (boom, stick and bucket) and material transport (conveyor and feeder) subsystems. The design optimizes the mining process, reducing the time spent in the swing cycle by existing rope shovels by introducing continuous mining methods.

The machine’s primary requirement was to achieve a material loading rate of 200 tons per minute while operating in an environment requiring a 70-foot horizontal reach and a 30-foot vertical reach. The team conducted extensive research, trade studies, CAD modeling and analysis to verify the system design and performance. They demonstrated the machine geometry of structural components with 3D models.



TEAM MEMBERS

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Osama Abdulhafeez Qari *Mechanical Engineering*
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WITH SUPPORT FROM: GORE Creative Technologies Worldwide

DYNAMIC BIOREACTOR FOR ENGINEERED CARTILAGE TISSUE

Team 18066

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To design and develop a dynamic bioreactor that can produce tissue-engineered cartilage exposed to multiple types of controlled mechanical forces.

There are no current medical or surgical treatments to restore osteoarthritic joints to their native condition, and osteoarthritis patients commonly require joint replacement. Scientists have used stem cells to produce cartilage-like tissues as a new treatment for damaged cartilage. One approach to improving the quality of tissue-engineered cartilage is to apply a load to the engineered tissues while they are developing. The team analyzed and modeled a variety of force applicators (primarily motors and gear systems) to develop a final optimized system that ensures the application of exacting and controllable forces.

Additionally, the team developed a strain gauge and microcontroller feedback system to provide even more precise control of the forces. The system designed produces axial and shear loads that replicate the pattern of strain that occurs in vivo. An Arduino board and some other microcontroller components control the system. The system's forces, torque and accuracy exceed all requirements. The system also supplies a sterile environment in which cells can grow. This will allow further testing of methods to improve the quality of engineered tissues via the application of mechanical loading.



TEAM MEMBERS
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Emily Monroe *Biomedical Engineering*
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WITH SUPPORT FROM: GORE Creative Technologies Worldwide

PORTABLE MEDICAL DIAGNOSTICS IN DEEP SPACE

Team 18067

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To design a portable and cost-efficient whole-blood analyzer for medical diagnostics on a microliter scale, for possible use in harsh, potentially zero-gravity environments such as deep space.

The team designed a noninvasive medical diagnostic device that uses a spinning platform to conduct medical diagnostics on a microliter scale. This device can accept a whole blood input, separate whole blood into plasma and cellular components, conduct a white blood cell differential count and detect protein biomarker concentrations.

The microfluidic channels on the disk can conduct the required analyses with minimal manual intervention. A direct-current motor rotates the assay disk to create centrifugal force that manipulates blood flow through the microfluidic architecture. A magnetic bead-based purification method isolates the desired cells (granulocytes and lymphocytes), which are then channeled into their respective imaging chambers. Protein biomarkers are detected using enzyme-linked immunosorbent assay in a lateral-flow immunoassay and imaged separately. The captured images are then exported and processed to yield cell and protein biomarker counts. The analyzer features a user-friendly graphical user interface.

AUTONOMOUS SELF-DRIVING SOLAR RACE CAR

Team 18068

RESEARCH, DISCOVERY & INNOVATION
Transportation Research Institute

THE UNIVERSITY OF ARIZONA
TECH PARKS ARIZONA

PROJECT GOAL

To create an autonomous driving kit for a solar-powered go-kart.

The autonomous driving system designed can make steering calculations using a proportional-integral-derivative controller and a servo motor. The system uses a GPS to detect its position in real time. These components, in combination with a lidar and linear actuator, allow the system to detect objects in its front view and stop accordingly to avoid collisions.

The user is also able to deactivate and turn off the system with a kill switch. An Arduino Mega microcontroller controls the system. The kit manufactured allows a solar-powered go-kart to drive autonomously. There are plans to integrate this kit into the Racing the Sun competition.



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ELECTRIC VEHICLE MOTOR AND INVERTER DESIGN AND INTEGRATION

Team 18069

NMIC NANO MATERIALS INTERNATIONAL CORPORATION
Innovators of Nanomaterials and Nanocoatings

PROJECT GOAL

To create a functioning electric vehicle from salvage parts collected from different manufacturers and integrate them into an existing controller area network bus system.

The sponsor wants to assemble an electric vehicle using commonly sourced components from salvage vehicles. These salvage parts, though functional, require extensive work to integrate due to their proprietary controller area network, or CAN, bus systems. Correct CAN bus codes are required to operate these components in the system. The design approach for this project required integration and assembly of these components into one cohesive electric vehicle system that can be controlled by an operator.

The team created new software and modified existing software to read, interpret and forward CAN codes throughout the components of the system. The system incorporates microcontrollers that work in conjunction with the CAN codes and receive input from the operator. The team developed software and hardware to control and display voltage, temperature and power-sensing systems. The system is fitted into an existing frame and configured to run a cooling system that regulates temperatures across sensitive components based on logic created by the team.



TEAM MEMBERS

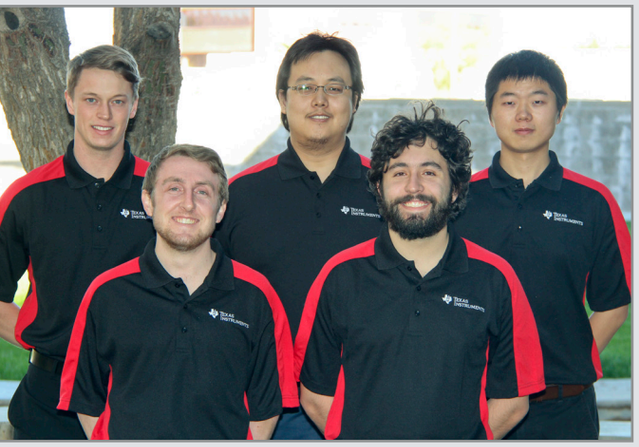
Steven Bracamonte *Mechanical Engineering*
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Jorge Jesus Santiago *Electrical & Computer Engineering*
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POWER SUPPLY EFFECT ON IMAGE QUALITY

Team 18070

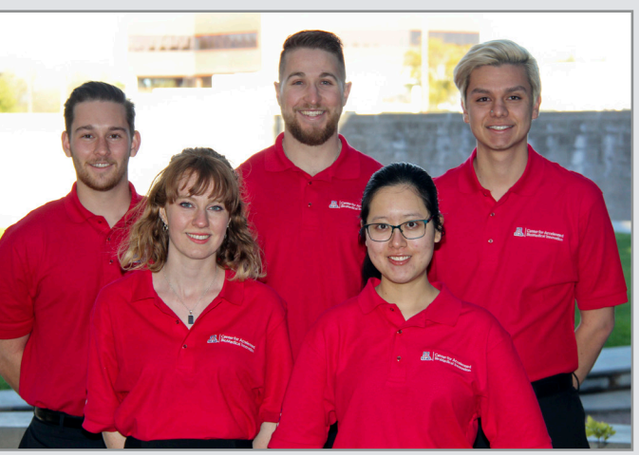
TEXAS INSTRUMENTS

PROJECT GOAL

To explore the effect of different power supply configurations on image quality and determine which configuration produces the highest quality image.

Image capture is a very sensitive process. Any noise induced during the process lowers the quality of the image captured. A common type of noise is electrical noise from the power supply. The sponsor asked the team to determine how different power supply configurations can affect image quality of a complementary metal oxide semiconductor image sensor. To perform the tests, the team designed a camera system with a modular power supply to allow easy switching between different power supply configurations. Test configurations designed included linear, switch-mode, and a combination of linear and switch-mode power supplies.

The team qualitatively assessed the captured images with each configuration and quantitatively calculated the signal to noise ratio, or SNR, with Matlab. The image with the highest SNR was considered the highest quality image. The power supply with the highest quality image was recommended for further use in any image-capture applications. The test configuration with the highest presence of noise should be investigated further to more thoroughly understand the root cause of the noise.



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WITH SUPPORT FROM: GORE Creative Technologies Worldwide

MICROFLUIDIC SYSTEM FOR DETERMINATION OF PLATELET STIFFNESS

Team 18071

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To design and build a point-of-care device capable of subjecting platelets to electrodeformation using dielectrophoresis, imaging the cell deformation and displaying the stiffness on an easy-to-use graphical user interface.

Medications and implantable devices can adversely affect the mechanical properties of platelets when physical stresses are introduced. Applied stresses, such as shear forces, pressure and acoustic-mediated vibrations, can activate the circulating cells driving blood clot formation, which may lead to ischemia, heart attack and stroke. By measuring cell stiffness, the likelihood that cells will activate under applied stresses can be determined.

The designed system induces the electrodeformation of platelets by dielectrophoresis, which uses a nonuniform electric field to trap and measure cells' mechanical properties, such as stiffness, without causing activation. As the voltage is varied and the cells are deformed, the system images and tracks the parameter changes that occur in each of the visible platelets. The measured changes in platelet parameters are sent to the system's programmed algorithms to calculate the mechanical properties of each individual cell. The images and cell properties can be monitored through a user-friendly graphical user interface.

VIRTUAL REALITY SYSTEM FOR REALISTIC CARDIOPULMONARY RESUSCITATION TRAINING

Team 18072

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To design a cardiopulmonary resuscitation compression virtual reality system for improved CPR training.

More than 350,000 cardiac arrests occur outside of hospitals in the United States annually. Many people routinely perform CPR to increase blood flow and deliver oxygen, but it must be performed correctly to be effective.

The system designed immerses the user into a CPR scenario in virtual reality, or VR, using Leap Motion hand-tracking technology and an HTC Vive tracker to integrate a CPR mannequin into VR. The user wears a glove containing an accelerometer, programmed with an Arduino Micro worn on an armband, to detect the depth, frequency and acceleration of their compressions on the mannequin. For more effective CPR training, the user is provided with real-time auditory and visual feedback to correct CPR compressions. Speech recognition programming allows the user to communicate with a nonplayable character in the scenario, who will recognize key phrases such as "call 911."

The system provides the user with a comprehensive score at the completion of a training session to track their improvement as they do additional training in accordance with the American Heart Association's guidelines.



TEAM MEMBERS

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WITH SUPPORT FROM:

GORE
Creative Technologies Worldwide

VIRTUAL REALITY TREATMENT SYSTEM FOR EATING DISORDERS

Team 18073

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To design and create virtual reality software as a way to treat eating disorders.

Approximately 30 million individuals in the United States suffer from eating disorders. Current treatments include physiological therapy and nutrition education. The system designed is a novel treatment approach that contains a progressive, self-directed software exposure experience to "desensitize" and acclimate individuals suffering from anorexia.

The software exposes users to different scenarios through a virtual reality program created in Unity and displayed on the Oculus Go, a head-mounted VR display. The software contains nine modules that increase in difficulty while incorporating various scenarios with food, people and environments. Analog biosensors and an Arduino processor record skin impedance, pulse rate and respiratory rate to characterize the user's stress response. The physiological data collected is displayed in real time in the Oculus Go to enhance the user's understanding of their physical response to the virtual reality environments.



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Sean Patrick Moore *Biomedical Engineering*

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WITH SUPPORT FROM: GORE Creative Technologies Worldwide

COMPONENT SOUND ANALYSIS FOR EXTRACTING AND ANALYZING MEDICAL INFORMATION FROM PATIENT ENCOUNTERS

Team 18074

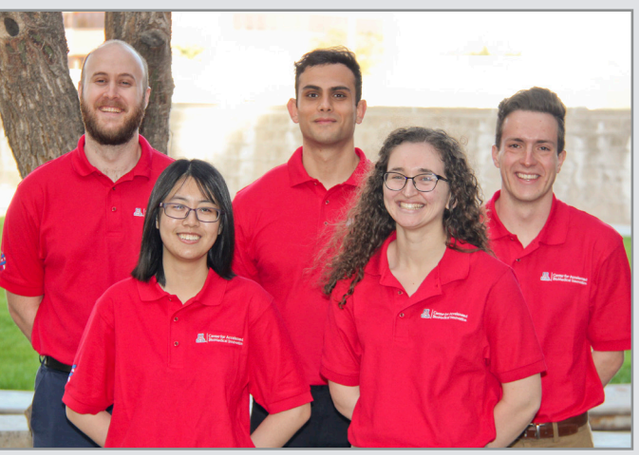
COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To develop software capable of recording audio data, analyzing sound, performing speech-to-text analysis and using natural language processing to provide physicians with more information and streamline their documentation.

Sounds associated with health and illness are vital for health care diagnoses and therapy. This project focuses on developing a system capable of processing and extracting additional features from sound and speech during a health care encounter. This recording and analysis may help with the treatment of a variety of diseases.

The sound capture system uses high-fidelity microphones positioned around the room to record, store, analyze and display sound components of speech and other sound-generating aspects associated with the physical examination, such as breath sounds. The system also includes speech-to-text analysis to produce a transcript of the encounter. The system incorporates natural language processing to analyze conversations and organize useful information by helping with documentation of the patient's condition. The final product provides the user with valuable data that may be incorporated into the electronic medical record system within the context of a digital "wired room." This system can improve efficiency in medical care, improve diagnoses and reduce the time a physician needs to spend with each patient.



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VISUAL NATURAL LANGUAGE PROCESSING OF MEDICAL IMAGES FOR ENHANCED VALUE

Team 18075

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To design and build a proof-of-concept image processing and analysis tool that classifies histological images of human cells and interprets correlative relationships among an image's features.

Medical imaging is a critical component of disease diagnosis in medical practice. Although health care providers have used advances in medical imaging technologies to implement more effective point-of-care strategies, the analysis of medical images remains inefficient and highly subjective.

The solution developed is a full image classification, feature extraction and feature analysis tool called FractalEyes. The system can classify an input image, perform application-specific feature extraction and analyze the features to provide health care providers with a more quantitative measure of diagnosis. The software uses a mutual information classification algorithm from the scikit-learn Python library. The program communicates both graphically and quantitively which features of the image are useful in the image's classification. The team used this proof-of-concept system to classify histological images of human cells. The idea can be extended to applications ranging from disease diagnosis to counterfeit item detection.

SMART EMILY TRANSMITTER

Team 18076

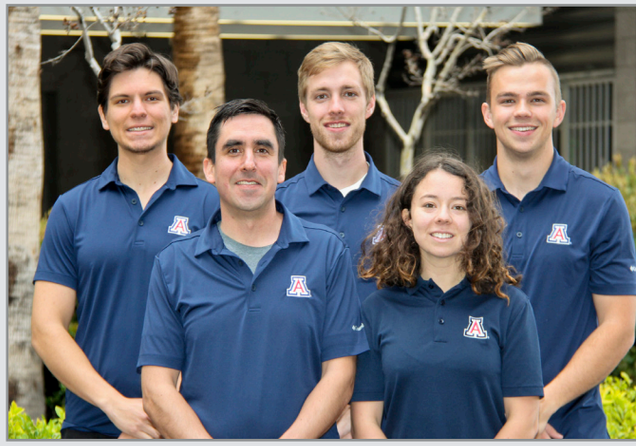
HYDRONALIX

PROJECT GOAL

To design, build and test a remote control transmitter for the Emergency Integrated Lifesaving Lanyard, or EMILY, that can meet or surpass the current market quality of remote control transmitters.

The sponsor manufactures the EMILY lifeboats used remotely in various lifesaving rescue missions across the globe. The remote controllers used to operate the EMILY buoys are no longer in production, so the team designed and fabricated a new controller that meets the performance benchmarks of previously used controllers while adding some new functionality.

Operating within the 2.4 GHz industrial, scientific and medical band, the controller sends control signals to EMILY and receives battery telemetry back. The control channel sends throttle, rudder direction and engine polarity controls to EMILY. The controller is powered by an AA battery and can operate at a distance of 1 mile over calm water while maintaining a strong battery life of two hours. The controller has a waterproof rating of International Protection, or IP, 67, meaning that the device can be submerged in water for up to five minutes at a depth of 1 meter.



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Jaime Lara

ROBOTIC GAIT SIMULATOR

Team 18077

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To design and implement additions to the robotic gait simulator to increase physiologic accuracy and model fidelity.

The continuing evolution of orthopaedic solutions to common foot and ankle problems means engineers and clinicians need increasingly complex and physiologically correct models of human movement.

The design uses new parts and improved methods designed to interface with current machines and operating procedures that simulate the movement of human walking. The team added three additional tendons to the foot-ankle model and replaced the current tendon actuators with more robust models, capable of larger forces and faster movement. These additional tendons resulted in the design, validation and implementation of additional actuators, load cells and accompanying electronics.

Adding these components required designing a spacing flange to maintain physiologically accurate tendon pull direction while providing the necessary space for the movement systems. The team overhauled the electrical system so it could provide necessary power to all components. The sponsor can use these new additions to the robotic gait simulator to better model orthopaedic solutions to gait defects, such as poor posture and injury.



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WITH SUPPORT FROM:

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BRUISE AGE MEASUREMENT SENSOR

Team 18078

COLLEGE OF ENGINEERING
Biomedical Engineering

PROJECT GOAL

To design a device to collect and store spectroscopic measurements from bruised skin to be used in determining the age of a bruise.

In 2016, 70 percent of all child fatalities in the United States caused by physical abuse occurred in children younger than age 3. This unfortunate truth is reinforced by the fact that children under 3 may not be able to communicate verbally, or to easily and reliably report the details of their situations to authorities, physicians or social workers without prompting. For these reasons, there is a need for a device that can measure the reflectance of bruised skin over time. This reflectance data can be coupled with bruise physiology research to develop mathematical models that estimate the age of a bruise.

The designed bruise age measurement sensor is a portable device that collects skin reflectance data using a miniature spectrometer and stores it on a micro SD card for further analysis. It uses lights at specific wavelengths to detect and isolate the reflectance of bruise metabolites, such as hemoglobin and bilirubin. Physicians or social workers can take measurements easily by lightly applying the device on the affected skin. The gentle application is achieved via feedback from the device's two force sensors. The portability of the device allows physicians and social workers to visit multiple patients and victims, and aids in the process of early intervention in cases of physical abuse.

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Urs Utzinger

WITH SUPPORT FROM:

GORE
Creative Technologies Worldwide



AIR-LIQUID HEAT EXCHANGER IMPROVEMENT THROUGH ADDITIVE MANUFACTURING

Team 18079

PARAGON
SPACE DEVELOPMENT CORPORATION

PROJECT GOAL

To design and produce a liquid-to-air heat exchanger that, taking advantage of additive manufacturing, implements novel geometries and performs in extreme conditions.

Heat is one of the most crucial issues in many engineering design products. High surrounding and operating temperatures can severely damage a product. One way to mitigate or avoid these issues is to transfer the heat away from the system using cooling applications. Space and defense equipment operate in even more extreme environments.

The design developed and produced is an additively manufactured heat exchanger, allowing greater design flexibility from superalloys that can operate in extreme environments and meet rigorous sponsor parameters. The system is designed to remove heat, through a cross-flow, between hot fluid and coolant. The team tested the system performance at low (90 degrees Celsius) and high (400 degrees Celsius) temperatures and compared performance to that of a traditionally manufactured heat exchanger. The sponsor will use this product, which has characteristics not found in a traditional heat exchanger, as a prototype for further research and development.

TEAM MEMBERS

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PAYMENT TRANSACTION SYSTEM USING QR CODES

Team 18080

Microsoft

PROJECT GOAL

To develop a payment transaction system that uses QR codes to send payments.

A study conducted by Microsoft indicates that many people no longer carry cash, which makes it harder to donate money or give tips. The application designed allows the user to generate and print a QR code from either a smartphone or a computer that can be used to pay other people. Speed, convenience and security of transactions are priorities for this project.

The design has three major components: the front-end user interface consisting of the mobile application and website, an Azure database to store information for all users, and a server backend to communicate with Stripe for handling transactions. As with all financial apps, security is very important. The application will only store encrypted information for the user's account on this service – not any financial information. The database will store the minimal amount of financial details necessary to process transactions via Stripe.



TEAM MEMBERS

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STANDARD OPERATING SHEETS MANAGEMENT SYSTEM

Team 18081

Continental
The Future in Motion

PROJECT GOAL

To design a document-sharing application that customers can embed in their companies' employee websites.

The sponsor uses a manual process for document control on its production line. The production floor depends on the industrial engineering staff to supply cycle type, standard work and equipment usage documentation. Each document supports the day-to-day operational questions that affect the line's ability to work. Since industrial engineers do not have visibility into all aspects of the production floor, there are frequent delays on the floor that directly contribute to process waste and inefficiencies.

The purpose of the project is to create a document-sharing platform for the industrial engineers to share production documents with the production teams. The system consists of a database on the back end, a website on the front end and controllers to connect the back end with the front end. The platform will simultaneously allow industrial engineers to upload and update files and the production team to view, download and offer feedback. Customers can integrate the website onto their employee webpages and operate it via the local network.



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MANUFACTURING EXECUTION SYSTEM SELF SERVICE

Team 18082

Continental
The Future in Motion

PROJECT GOAL

To create an optimized, web-based system that overlays the sponsor's manufacturing execution system and increases its efficiency and control.

The sponsor assembles radios for use in commercial cars. Engineers use printed production schedules to stay organized, requiring them to manually track each radio component by hand during the assembly process, including any update to the schedules.

The team developed software to improve the web application tool the sponsor currently uses to control the production floor schedule. The new software can instantaneously track unit movements by creating requests to, for example, transfer, stop or hold units. This approval flow automatically sends notifications to proper personnel regarding any requests to change the schedule, uses a ratification process that quickly processes scheduling requests to any department, and creates department-level schedule reports for engineers. This software substantially improves the factory floor management and allows full access to data from web-based platforms, not just from internal computer monitors.



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AUTONOMOUS MULTIAGENT GUIDED VEHICLES IMPLEMENTATION

Team 18083

Continental
The Future in Motion

PROJECT GOAL

To design a software interface that connects multiple databases and software for operator control of autonomous multiagent guided vehicles.

The sponsor operates a system that controls two autonomous guided vehicles individually to move materials in a warehouse. The system cannot function without constant operator input and does not allow tracking of deliveries over time. An operator must look at multiple screens and interact with different software to perform a single delivery.

The software interface design streamlines how operators control and receive data from the autonomous guided vehicles. It is a centralized system that interacts with the sponsor's existing databases and software. The system localizes all the information an operator needs for production line deliveries into a user-friendly interface application that allows data tracking over time and simultaneous control over multiple autonomous guided vehicles.

VIRTUAL MAPPING OF DATA CENTERS WITH ROBOTS

Team 18084

Microsoft

PROJECT GOAL

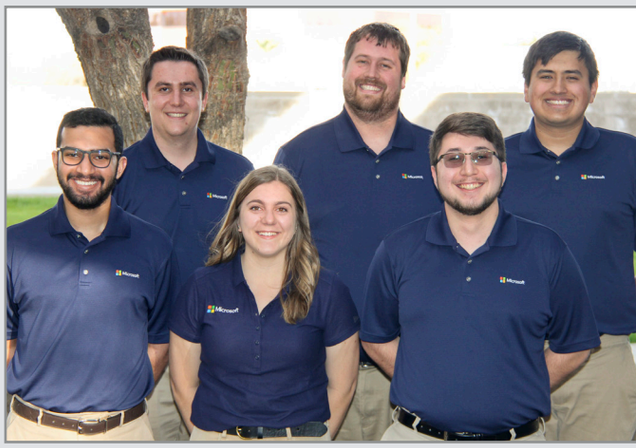
To design a camera system that uses photo stitching technology to take 360-degree images of data centers to provide virtual tours and live video feed monitoring.

Microsoft owns and operates over 50 data centers around the world. The size of these facilities makes it difficult for operators to monitor and maintain them securely while still being able to give tours to prospective customers.

This project integrates a camera system that can take 360-degree stitched images and send back live footage through an interactive graphical user interface via a robot designed and built by a previous senior design team. With this camera system, a user can step through data centers virtually, giving a similar experience to Google Street View.

The camera system operates in two modes. In the first, the processor takes raw images from the eight GoPro cameras mounted on the robot, and then uses OpenCV programming libraries to stitch them together. These stitched images are stored with Azure, allowing them to be referenced at a later date. In the second, a live video feed comes from one of the eight cameras, and allows the user to move the robot to the desired viewpoint.

These two system capabilities allow the operators to easily give a prospective customer an immersive experience of the data center, and ensure its safety and security.



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Holly Beale

WASTE AIR RECAPTURE STUDY

Team 18085

REGENESIS

PROJECT GOAL

To test the relationship between revolutions per minute, air flow and energy recaptured by the Regenesis system.

The Regenesis system has shown high potential in harvesting manmade wind by reducing power consumption for HVAC systems, and by helping the motor propel air outward. The design uses a three-phase eco-saver motor driven by a variable frequency drive and a more efficient, retrofitted propulsion blade.

The mounted recapture blade spins in the opposite direction of, but in unison with, the HVAC unit's original blade. The two blades face each other and create a propeller vortex, giving a 2-1 ratio between both fans and a consistent airflow, delivering a consistent energy output. Overall, the Regenesis system managed to recapture close to 15 percent of the energy.



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Chenrui Zhu *Mechanical Engineering*
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LIGHTING INSTALLATION USING FULL-SPECTRUM WHITE LIGHT EMITTING DIODES

Team 18086

GEOST

PROJECT GOAL
To design full-spectrum white-light LED installations for four existing sponsor products.

The project team designed white-light LED installations for a photographic lightbox, a floodlight, a microscope light ring and a softbox lightbulb. The designs match or exceed the luminosity and light quality of existing products while remaining economically viable for manufacturing. The emittance requirements for each product were determined through radiometry data from existing products and their intended use. LED arrays were created based on the lumen requirements.

The LED arrays are powered through a newly designed dimming-capable LED driver. The controller and driver board provide constant voltage and an input-controlled current to the LEDs, allowing dimming control in each luminaire. An AC-DC power supply converts AC input into constant DC that goes to the controller boards. Housings for each product were 3D modelled and 3D printed before the designs were sent to fabrication facilities for mock-up production.



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Zachary Schiefelbein *Mechanical Engineering*
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COLLEGE MENTOR
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Eric Zuercher

SUBMERSIBLE BREATHER VALVE

Team 18087

agm CONTAINER CONTROLS INC.

PROJECT GOAL
To design and build a mechanical device that can stop infiltration of water and be adapted to current breather valve technology.

Breather valves are used on a variety of containers to protect equipment or instrumentation from the elements while maintaining equalized pressure between the inside and outside of the container. The problem with current valve design is that the valve does not distinguish between whether the pressure differential is related to air or water.

Team 18087 has designed an apparatus that uses properties of fluid dynamics and material choices to modify the breather valve to prevent water infiltration. During submersion, the water pressure outside of the apparatus causes a pressure actuator to deflect, which pushes a plunger into a magnetic field, which draws the apparatus shut, sealing the breather valve from the water.

AUTONOMOUS ORBITING EARTH CAMERA

Team 18088

GEOST

PROJECT GOAL

To design and 3D-print a CubeSat capable of taking a picture from space.

The orbital Earth camera design can control its attitude and temperature with about two rack units, or 20 by 10 by 10 centimeters, of room for a camera and optics. The camera has a self-sustaining power system (solar cells and battery), thermal control (radiator panels), an attitude control system, a communications system, and an imager to take pictures. The imager computer stores and transmits images as required. The computer uses a ground radio and star-tracking system to receive positioning and image capture commands.

This design will help greatly reduce the research and development time for building future CubeSats for imaging and optics.



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SPONSOR MENTOR

Tony Gleckler

UAS-SENSOR INTEGRATION AND IMPROVEMENT

Team 18089

COLLEGE OF ENGINEERING
Systems & Industrial Engineering

PROJECT GOAL

To integrate the FLIR Vue Pro thermal imaging camera with the Matrice 100 UAS system and capture thermal data to evaluate soil salinity and plant temperatures.

The project objective is to promote research of soil salinity and crop temperature to determine proper irrigation schedules and efficiency. The system will support the United States Department of Agriculture's Agricultural Research Service resource data collected by NASA's Earth Observing System, manned aircraft, and an eddy covariance system.

The team integrated a FLIR Vue Pro 336 thermal imaging sensor and a 3DR PX4 Pixhawk autopilot system into a DJI Matrice 100 unmanned aircraft to collect and georeference thermal images of agricultural fields. The system outputs a collection of georeferenced thermal images and a spreadsheet file with complete flight metadata. Georeferences are projected in the Universal Transverse Mercator coordinate system for each image. The team tested the system in an experimental agricultural field where the system will be implemented.



TEAM MEMBERS

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YUMA INTERNATIONAL AIRPORT BAGGAGE SYSTEM IMPROVEMENT

Team 18090

COLLEGE OF ENGINEERING
Systems & Industrial Engineering

PROJECT GOAL

To analyze and simulate alternative baggage carousel configurations for Yuma International Airport.

The baggage carousel at Yuma International Airport is nearing the end of its usable life. The sponsor requested two replacement alternatives be selected and analyzed. One is the best alternative for least initial cost to transition to the new system. The second is the best alternative for cost savings over the projected service life.

Requirements were defined for the replacement, and then multiple viable alternatives were identified. A trade study was performed to determine which alternative was the best fit.

Simulations included projected annual operating costs and service life of the new system, and demonstrated different inputs and outputs, and variations as business conditions change over time. Variations considered included bags per flight, number of arrival flights per day, and baggage weights. Simulating these different variables has shown how the system will function in different operating environments and allows the sponsor to make an educated decision on the future system before the integration phase.

TEAM MEMBERS

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OPEN PIT MINE LIFE DESIGN

Team 18091

HEXAGON MINING

PROJECT GOAL

To design a feasible mine plan for an aggregate operation based on constraints given by the SME/NSSGA Student Mine Design Competition committee.

The Society for Mining, Metallurgy and Exploration, in conjunction with the National Stone, Sand and Gravel Association, hosts an annual international mine design competition for undergraduate students. An aggregate company provides data from one of its sites, and students work in teams to develop a feasible overall mine design plan.

A 3D geological block model was created from the provided drill-hole data using Hexagon's MineSight software. A life-of-mine plan was developed based on environmental and regulatory restrictions. The optimal operating schedule and equipment fleet were determined based on economic analysis and production requirements. Multiple ore processing scenarios were evaluated to ensure the ideal haulage plan. A postclosure reclamation plan was developed to donate the mining property as a recreational area to the neighboring community.

The project design was submitted in 2018, and the team has been selected to present at the annual Society for Mining, Metallurgy and Exploration conference as one of the top six international teams.

TEAM MEMBERS

Cayley Crosby Brooks *Mining Engineering*
Steven Jeremiah Cole *Mining Engineering*
Fernando Alan Gomez *Mining Engineering*
Christopher Patrick Liddle *Mining Engineering*
James Darren Verbois *Mining Engineering*
Edson Alfredo Salgueiro Guebe *Mining Engineering*

COLLEGE MENTOR

Brad Ross

SPONSOR MENTOR

Erik Anderson

COPPER MINE LEACH PAD DESIGN

Team 18092

COLLEGE OF ENGINEERING
Mining & Geological Engineering

PROJECT GOAL

To design a set of leach pads that can be used to process a specific copper ore body.

Mining companies use a leaching process to extract copper minerals from waste material generated during mining. Leaching requires a leach pad, an area that can account for all the material that comes from an ore body. The pad must be large enough to contain the millions of tons that will be stacked on it, it must be safe, and it needs to be practical.

Two leach pads were designed for a specified ore body. The two designs account for the ore body having two different copper prices: $2 and $2.50 per pound. The starting surface areas were 12.3 million square feet for the $2 design and 15.6 million square feet for the $2.50 design.

The pads were designed with 12 different levels, each 20 feet tall. The $2 design will account for 2.1 million tons of material and the $2 design will account for 2.7 million tons of material. The designs included certain slope parameters that allowed for safety, and several ramps for accessibility and efficiency.



TEAM MEMBERS

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SAN XAVIER MINE TRAINING TUNNEL DESIGN

Team 18093

COLLEGE OF ENGINEERING
Mining & Geological Engineering

PROJECT GOAL

To design two underground tunnels for Border Patrol training in the San Xavier Underground Mining Laboratory.

To prepare for highly strenuous situations dealing with monitoring and protecting international borders, it is necessary to train border agents in an environment that simulates potential conditions.

Two underground tunnels will be constructed 100 feet underground in the San Xavier Underground Mining Laboratory to be used for the training of present and future Border Patrol agents. A 3-by-5-foot tunnel was designed to simulate underground conditions in which agents could move on foot.

A second tunnel, 3 feet by 2 feet, was designed to mimic underground conditions that would require agents to crawl. MineSight and Rocscience RS2 were used to produce the excavation design and stability analysis, respectively. Ventilation design was created in VentSim.



TEAM MEMBERS

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TEAM MEMBERS
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IMPACT OF HAUL ROAD WIDTH TO OPEN PIT MINING COSTS

Team 18094

KOMATSU

PROJECT GOAL

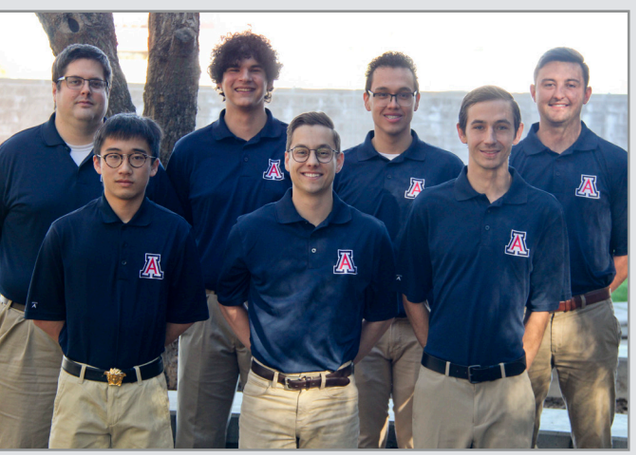
To analyze the financial impact on a typical large-scale open pit mine when reducing haul road widths.

Haul road width can greatly affect the mineable volume requirements in large-scale open pit mines, so a reduction in road width is expected to reduce direct costs by minimizing mining tonnage.

Slide 2 software determined that narrower roads did not affect safety for the effective pit slope angles. The original design of a large-scale mine was replicated in MineSight, and a volumetric report was generated for the road width standard of 3.5 times the width of the largest truck. Two alternative road widths were evaluated: three times the truck width and 2.5 times the width.

A volumetric comparison found that mines with narrower haul roads were smaller, more selective and ultimately did not require moving as much material. Financial analyses were then completed regarding savings on less material movement, reduced drilling and blasting costs, and savings on road maintenance.

Direct mining cost savings could exceed millions of dollars in large-scale operations. Safety concerns due to narrower roads can be mitigated by using existing autonomous haul systems that do not require manned vehicles.



TEAM MEMBERS
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Jekan Thanga

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GLACIAL RESEARCH CUBESAT

Team 18095

COLLEGE OF ENGINEERING
Aerospace & Mechanical Engineering

PROJECT GOAL

To design a CubeSat with a sounder radar and camera for glacial research.

Radar sounding of Earth's glaciers and ice sheets is performed on the surface or in the air, but current techniques provide limited data pertaining to subsurface and bed topography. Data gathering is time consuming, and land coverage is limited by weather and costs. A CubeSat design with a sounder radar and camera systems can provide full coverage of glaciers and ice sheets.

The CubeSat will be placed in a low Earth polar orbit for four months, and will provide radar sounding in the dark side of orbit and camera data in the light side. The subsystems maximize the performance of the system as a whole while minimizing mass and volume and providing sufficient power and a high data transfer rate. The four 1.5-meter antennas have a low mass and volume to allow simple deployment with minimal effects on the rest of the system.

CUBESAT RADAR FOR ICE OBSERVATION

Team 18096

COLLEGE OF ENGINEERING
Aerospace & Mechanical Engineering

PROJECT GOAL

To design a CubeSat infrastructure concept that supports a radar sounding instrument to provide data about ice sheets.

Scientists at UA's Earth Dynamics Observatory monitor climate change by studying ice sheets. They hope to create new comprehensive maps of the Antarctic and Greenlandic ice sheets using a small satellite-mounted sounding radar system. This system will use 50-megahertz radar pulses to detect layering and depth information over immense swaths of ice.

To support the sounding radar, subsystems for power, interface and communications were designed. Specific considerations were accounted for through trade studies comparing commercial off-the shelf options. Analysis of component performance against system requirements was conducted using Matlab, Solidworks and STK software.

Custom-built prototypes of nonreadily available components, the instrument interface and the antenna deployment system allowed hardware testing to prove conceptual readiness. Integrating these components together created a CubeSat concept that accommodates the requirements of a sounding instrument that could survive over 60 days of operation in space.



TEAM MEMBERS

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DESIGN/BUILD/FLY AIRCRAFT DESIGN COMPETITION

Team 18097

PROJECT GOAL

To design a short takeoff unmanned aircraft to represent the UA at the 2018-2019 AIAA Design/Build/Fly competition.

This design team developed a remote-controlled unmanned aircraft for the 2018-2019 American Institute of Aeronautics and Astronautics Design/Build/Fly competition April 11-14 in Tucson, Arizona, pushing the design of a short takeoff portable vehicle capable of handling diverse payloads.

The team developed a minimum-sized, twin-engine flying wing design with a custom power source. The design features a control surface layout consisting of elevons and an independent elevator with differential thrust introduced for directional control. The vehicle was designed to embrace the lift-producing advantages of propeller downwash over its top surface.

The design was put through an aggressive flight-testing and prototyping schedule. Initial tests validated stability and control predictions and final tests evaluated and optimized the vehicle's mission scoring capabilities.



TEAM MEMBERS

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FIREFIGHTING UNMANNED AIRCRAFT

Team 18098

THE NEW NOSE COMPANY, INC.

PROJECT GOAL

To design an unmanned aircraft that can deliver fire retardant safely while qualifying for permits to use registered airfields.

Airplanes have been used to create firebreaks to combat forest fires for many years, but many are older designs unsuitable for most airfields.

Team 18098's unmanned aircraft design is a blended-wing body with two forward-mounted turbofan engines. With a 73-foot wingspan, the unmanned aircraft can fly into the majority of registered airfields. The design features a gravity-fed dispersal system with a nozzle that reduces the chaotic spread of fire retardant.



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MAGNETIC FIELD READINGS WITH LUNAR CUBESAT LANDER

Team 18099

UA SCIENCE
LUNAR & PLANETARY LABORATORY

PROJECT GOAL

To develop the first fully autonomous CubeSat system capable of landing on the moon and gathering magnetic field data.

The proposed spacecraft will study the magnetic field properties on the far side of the lunar surface. The CubeSat will capture high-resolution images during lunar descent, and measure magnetic fields by magnetometer during descent and after touchdown.

The CubeSat is made of aluminum and Kevlar, with aluminized Mylar blankets to reflect solar radiation. The guidance, navigation and control system will use a star tracker, an inertial measurement unit and reaction wheels to orient the CubeSat. A laser rangefinder will determine the distance from the moon's surface, the camera will guide the CubeSat during landing, and two deployable solar panel arrays will convert sunlight into useful energy to be stored by the main battery.

Four engine modules provide up to 24 newtons of adjustable thrust for maneuvers and attitude control support, combined with a modular array motor system for lunar descent and eventual touchdown. Two onboard computers will house software to autonomously control the hardware and instruments on board. The data will be relayed to the Lunar Orbital Platform-Gateway via X band and ultrahigh-frequency transmission systems for analysis.

AUTONOMOUS LUNAR CUBESAT LANDER

Team 18100

COLLEGE OF ENGINEERING
Aerospace & Mechanical Engineering

PROJECT GOAL

To land a modified CubeSat lunar lander on the far side of the moon to photograph the surface and collect a soil sample.

The far side of the moon is largely unexplored due to risk and cost. Team 18100's CubeSat will land on Mare Moscoviense, a lunar sea on the far side of the moon, to conduct scientific research.

The 24-kilogram CubeSat has custom software and advanced hardware to navigate from the Lunar Orbital Platform-Gateway at the second Lagrange point to the surface, including a star-tracking navigation system, an inertial measurement unit, and a monopropellant system. During the 53-hour flight, the CubeSat will deploy solar panels to power the system.

The landing legs – made from nitinol, a shape memory alloy that can be deformed for storage and deployed as the parent shape with a heat source – will secure and stabilize the craft for a soft drop from 1 meter above the lunar surface. After landing, the CubeSat will take pictures of the lunar surface and transmit its location back to the Gateway.

A nanodrill will collect approximately 10 grams of soil from the surface, and the CubeSat will continue to transmit its location until all power systems eventually run out, shutdown occurs, and it awaits retrieval.



TEAM MEMBERS

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SONAR EMILY AUTOPILOT SYSTEM

Team 18101

HYDRONALIX

PROJECT GOAL

To develop an autopilot for an unmanned surface vessel that supports sustained vehicle operation and ensures functionality of the vessel's sensor payload.

Hydronalix produces several unmanned surface vessels for civilian and military use. The sonar variant of its Emergency Integrated Lifesaving Lanyard, or EMILY, is equipped with a Humminbird Helix-9 chirp transducer that transmits acoustic imagery for underwater surveying and recovery missions.

For the transducer to generate accurate imagery, the vessel must travel below 4 knots. This project implements an autopilot that steers EMILY between waypoints through the Helix's ground station interface. With this autopilot, the operator can plot and initialize a search track while maintaining the ability to take immediate control as mission conditions demand.

The autopilot functions on a closed feedback loop by reading heading information from the GPS, determining heading error, and then calculating the rudder deflection to correct course. An additional inertial measurement unit measures EMILY's vertical accelerations, which the autopilot integrates to determine the sea state condition before transmitting the data to the operator.

The autopilot runs on an Arduino processor chip and its algorithm is based on open source autopilot code libraries published by Arduino and Adafruit. The autopilot enables EMILY to autonomously complete a search pattern at speeds compatible with its sensor payload.



TEAM MEMBERS

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STEAMPUNK COLD BREW COFFEE MACHINE

Team 18102

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design and build a steampunk-style machine that brews, filters and chills eight cups of cold brew coffee faster than traditional methods.

Cold brew coffee is an emerging trend due to its comparably less bitter and acidic taste. Typically, cold brew coffee is made by immersing ground coffee beans in water and steeping them at or below room temperature for 12-36 hours.

Team 18102's design employs chemical engineering fundamentals to optimize extraction, filtration and chilling of the coffee. The machine reduces the steeping period, and adds some whimsy for users and onlookers. The machine is styled in the steampunk motif – a form of historical science fiction where fantastical machinery is powered by clockwork and steam – and features characteristics such as tarnished metal, glass and gauges.

The team evaluated methods such as agitation in a stirred tank reactor, agitation by bubbler, gravity drip through a bed of coffee grounds, and steeping in a pressurized vessel. Filtration methods included mesh and paper, vacuum, and French press filtering techniques. Gel, ice and commercial refrigerants were explored for cooling media.



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MICROBIAL FUEL CELL

Team 18103

Pacific Northwest NATIONAL LABORATORY

PROJECT GOAL

To design, test and build a cost-effective microbial fuel cell that can power a 40-watt equivalent LED bulb.

The team designed and constructed a microbial fuel cell that harnesses the energy produced through the oxidation of glucose by E. coli.

Experimentation involved two key parameters of the microbial fuel cell: optical density of the bacteria and the electrode material. Different optical densities were tested using different anode and cathode materials to find the optimal energy output for the cell.

The selected design maximizes electron transfer between the microbes and the anode to produce the most electricity to power a 40-watt equivalent LED bulb.

WATER INDEPENDENCE: NEAR ZERO LIQUID DISCHARGE

Team 18104

RESEARCH, DISCOVERY & INNOVATION
Water & Energy Sustainable Technology Center

PROJECT GOAL

To design a facility to produce potable water with zero liquid discharge from treated wastewater effluent from Tucson's Agua Nueva Water Reclamation Facility.

Water reuse is being explored to meet increasing demand for sustainable potable water. Tucson, Arizona, already treats its wastewater, but releases it into the Santa Cruz River to replenish the natural reservoir. The city draws primarily from the Central Arizona Project to fulfill potable water demand.

Social, economic and environmental impact analyses were performed to provide the best process. The facility designed in this project is optimized to treat Agua Nueva's effluent with the latest treatment processes and computer modeling, and incorporates desalination and advanced oxidation to lower salinity and trace organic compounds below drinking water standards. The removed contaminants are concentrated, separated from the water, and discharged from the facility.



TEAM MEMBERS

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Phillip Ziqi Yang *Materials Science & Engineering, Chemical Engineering*
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NASA CHALLENGE: CONVERSION OF CARBON DIOXIDE TO GLUCOSE

Team 18105

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To inorganically convert carbon dioxide to glucose to manufacture organic molecules not naturally occurring on other planets.

A nonbiological process and scalable apparatus were developed using physicochemical and catalytic reaction to produce selected carbon-based sugar molecules using only carbon dioxide as a carbon source.

The process consists of a multistep reaction pathway in which carbon dioxide molecules are photochemically converted to formaldehyde, and then catalyzed via a formose reaction scheme to produce four to seven carbon sugars. Complex sugars such as D-glucose and six-carbon sugars (hexoses) are most useful to NASA, so the process includes a separation phase in which six- and seven-carbon chains are output as products and smaller molecules are recycled as substrates to the formose reaction to form longer carbon chains.

Multiple design alternatives were evaluated to determine which reaction conditions produced the greatest yield and efficiency. The system was designed to have low power, mass and volume requirements, and to be feasible for future space missions.



TEAM MEMBERS

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SLUDGE-HANDLING PROCESS PROMOTING ENERGY RECOVERY

Team 18106

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

PROJECT GOAL

To design a small 10-million-gallon-per-day wastewater treatment plant operating at 60 percent capacity and focused on increasing the efficiency of the sludge-handling process.

A preliminary cost analysis comparing two different sludge-handling processes to conventional anaerobic digestion was conducted. The wastewater treatment plant consists of a primary clarifier, a secondary clarifier, a two-stage biological nutrient removal process, and a filtration and disinfection process.

Team 18106's plant design contains chemical and environmental engineering applications such as calculating mass balances, sizing equipment based on flow rates, filtration processes, disinfection processes and optimization.

The final design was simulated through BioWin, a wastewater program commonly used in the industry. A detailed preliminary design, cost analysis, and 20-year life cycle cost have been completed for the best overall sludge-handling process and the wastewater treatment plant design.



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SOLID ROCKET PROPELLANT AND LIQUID OXYGEN MANUFACTURING

Team 18107

R3 Aerospace

PROJECT GOAL

To design a large-scale rocket fuel manufacturing facility to supply the growing interest in space exploration and private space travel.

The focus of the design effort was on production and manufacturing processes for liquid oxygen and a custom solid propellant.

The liquid oxygen manufacturing was modeled as a tonnage plant with a high-output capacity of liquid oxygen to meet market demand. The solid propellant design was modeled after a propellant researched by the UA student chapter of the American Institute of Aeronautics and Astronautics.

This propellant is made of ammonium perchlorate, aluminum powder, hydroxyl-terminated polybutadiene and dioctyl adipate. The solid propellant was mixed and degassed under a vacuum, and cast in tubes for later use. It was validated through a static fire conducted with a single fuel grain on a remote test range.

Data was collected with a pressure transducer and load cell to verify preliminary calculations for the specific impulse and thrust of the fuel. Economic analysis of the cost to build and operate both plants was completed to show economic viability.

VODKA DISTILLERY AND INFUSION

Team 18108

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design a vodka distillery that includes an efficient flavor infusion process.

A still is used to heat fermented starches and produce a high-proof "shine." The shine is then diluted with water or flavor additives. Contemporary vodka manufacturers use a time-intensive batch process to infuse their product with flavor.

To develop a rapid infusion process for the liquor, this project uses vacuum distillation to obtain the high-proof shine, which requires less energy to evaporate ethyl alcohol. Impurities, such as methyl alcohol, are also easier to separate from the mixture with this method, unlike with column distillation, in which impurities are on the top tray and tend to decrease the purity and flavor of vodka. Another positive aspect of vacuum distillation is the higher recovery of ethyl alcohol from the fermented mash – above 98 percent, which is higher than column distillation's 92-96 percent recovery rate.

The infusion process is based on a packed bed reactor in which vodka flows through a pipe full of fruit that gives the desired flavor. Typically, the infusion process is done in a vessel full of fruit, and then low-proof vodka is added and left for days until the desired flavor is achieved. A packed bed reactor process can take less time and uses high-proof vodka to accelerate infusion.

The new process will reduce water and electricity usage, and repurpose or recycle depleted feedstocks to address sustainability concerns.



TEAM MEMBERS

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REMOTE RESTROOMS

Team 18109

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

PROJECT GOAL

To identify and solve problems with human waste handling in remote areas by developing new waste-handling methods to increase standards of living.

In urban areas, sewer systems and water reclamation facilities are common solutions, but are not feasible in areas that are remote or have low population density. A waste-handling system was designed for remote areas that focuses on increasing standard of living and sanitation.

These remote restrooms include a constructed bathroom with separation toilets and a water source, a storage system, a transportation system, and a waste-handling system. The waste-handling system has two modes: one for solid waste and one for urine. Black soldier flies are used to cultivate the solid waste, and ammonia production is used to recycle the urine into fertilizer.

The restrooms are designed to run year-round and easily adapt to environmental changes while being low waste, low cost, low energy and low maintenance.



TEAM MEMBERS

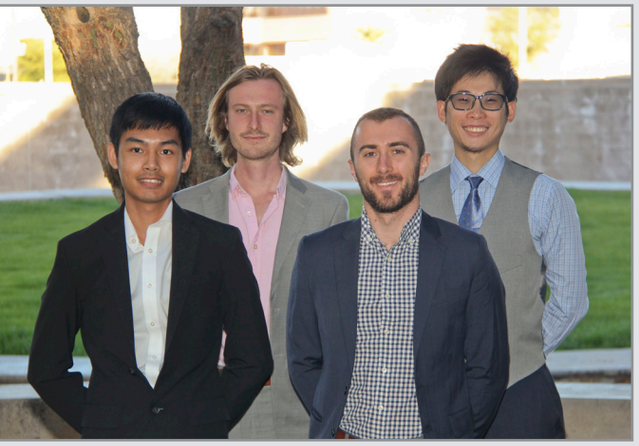
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LIQUID NATURAL GAS TERMINAL DESIGN

Team 18110

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design a terminal capable of receiving, storing and vaporizing liquid natural gas.

Low density and compression difficulty make direct piping of natural gas over long distances inefficient and costly. The liquid form of natural gas is favored by international importers due to its energy density and ease of transport. However, liquid natural gas must be vaporized before it can be used as an energy source.

The essence of this design is to create a terminal capable of vaporizing 1.05 billion cubic feet of liquid natural gas per day for continuous pipeline transmission. The liquid gas is offloaded from tankers to storage tanks that maintain cryogenic conditions of -259 degrees Fahrenheit. Some liquid gas in these tanks vaporizes spontaneously, and a portion of this excess gas is routed back to the tankers, while the rest of it is recondensed for vaporization.

Liquid natural gas from the storage tanks is compressed to 1,350 pounds per square inch absolute before vaporization to prepare for requisite piping conditions of 1,250 pounds per square inch and 40 degrees Fahrenheit. Heat for vaporization is supplied from the ambient environment, using either seawater or air (both options are explored in this design). In winter months, ambient conditions provide insufficient heat, so a portion of natural gas is burned to make up for this difference.



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DISTILLATION MODELING AND SIMULATION

Team 18111

DIRECT automation

PROJECT GOAL

To create a fully functional simulation of a dynamic distillation column.

Dynamic simulations can improve early stages of research and testing and can be used to help operators train, allowing them more freedom to learn from mistakes.

Integrated Modeling of Dynamic Distillation Simulations, or iMODDS, is a fully functional distillation column simulation that communicates with a distributed control system. The simulation automatically responds to input and output communications from the control system like a real distillation unit while minimizing runtimes.

The simulation uses the Skogestad method for dynamic distillation. The distillation column was modeled using the rigorous tray model involving a linearized approach to tray hydraulics using Laplace transforms. The project encompasses only a single stage in ethanol production: the rectifying column and associated equipment. The simulation has the ability to interpret inputs and parameters, and communicates the appropriate outputs to control system software.

NET ZERO WATER USE AT DATA CENTERS

Team 18112

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design a membrane distillation system to purify and reuse cooling tower water used in data centers.

The increasing demand for cloud storage has resulted in major growth for the data center industry. Cloud service providers, such as Microsoft, generate large amounts of heat at data centers, which must be removed through cooling. Microsoft currently removes heat from its data centers by cycling water between cooling towers and data centers, but contaminant buildup can cause fouling in the water. This process is not sustainable because there is no current reclamation of contaminated cooling water discharge.

The team's design uses a system of membrane distillation units that use low-grade heat from the data centers and cooling potential from a local freshwater source. Design considerations included cost comparisons with current water treatment process, total utility usage required to power the units, and water purity.



TEAM MEMBERS

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COLLEGE MENTOR

Kerri Hickenbottom

SPONSOR MENTOR

Kerri Hickenbottom

PRODUCTION OF DIMETHYL ETHER AS AN ALTERNATIVE AUTOMOTIVE FUEL

Team 18113

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To develop an economical and environmentally friendly process to produce 250,000 gallons per day of ASTM fuel-grade dimethyl ether.

Global climate change, depletion of fossil fuels and a growing energy demand have created a need for reliable, safe and clean fuel alternatives to fossil fuel. Dimethyl ether is an appealing option due to its high cetane number and its low-polluting combustion.

A manufacturing plant was designed and cost-evaluated for the conversion of biosolids into dimethyl ether. Biosolids, such as firewood and agricultural waste, are reformed at high temperatures to generate syngas, a mixture of hydrogen gas, carbon dioxide and carbon monoxide. A reactor was designed to react the syngas over a catalyst to produce methanol. The catalyst is bifunctional and also aids in dehydration of methanol to produce dimethyl ether within the same reactor.

A separation process design was created to purify dimethyl ether to ASTM fuel standards and to capture unreacted methanol for process recycling. This design is a cost-effective, safe, green alternative to fossil fuels.



TEAM MEMBERS

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Malec Joseph Sleiman *Chemical Engineering*
Joseph Aaron Harwin *Chemical Engineering*

COLLEGE MENTOR

Gregory E. Ogden

SPONSOR MENTOR

Harry Patton



TEAM MEMBERS
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Brewster Theodore Bray *Chemical Engineering*
Lauren Esham *Chemical Engineering*
Brooke Anita Weber *Chemical Engineering*

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Ryan Kanto

VODKA DISTILLERY DESIGN UPGRADE

Team 18114

QUANTUM SPIRITS

PROJECT GOAL

To design a facility to produce 95 percent pure ethanol to be diluted and distributed for vodka production.

Ethanol production begins with finely ground whole grains that are then mixed with diluted acid and cooked at high temperatures. The acid aids in the hydrolysis of the starches within the grain and provides the proper pH environment for enzymes during the saccharification process. Cooking the starches prior to saccharification further optimizes enzymatic starch breakdown into sugars. These sugars are then consumed by yeast in a fermentation process to produce ethanol.

The process of enzymatic degradation and yeast fermentation yields a solution that contains approximately 16 percent ethanol. This solution also contains undigested starches, sugars and other byproducts. To produce a 95 percent solution of ethanol, this mixture goes through a distillation process whereby ethanol is separated from the remaining solution to achieve high purity. The finished product is then shipped to be diluted and distributed at an outside facility.



TEAM MEMBERS
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Kevin Dam *Chemical Engineering*
Trevor David Johnson *Chemical Engineering*
Nathaniel Rodriguez *Chemical Engineering*

COLLEGE MENTOR
Dominic Gervasio

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Dominic Gervasio

TEN-KILOWATT POLYMER ELECTROLYTE MEMBRANE FUEL CELL

Team 18115

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design a high-temperature polymer electrolyte membrane fuel cell with an integrated reformer that can supply 10 kilowatts.

There are several benefits to hydrogen polymer electrolyte membrane fuel cell technology, including a high power density and a relatively low weight. However, hydrogen gas storage can be problematic and hazardous. In addition, low-temperature fuel cells often require relatively large water-cooling systems to run efficiently.

To eliminate these issues, the team's design uses a high operating temperature and an integrated reformer, which removes the need for hydrogen storage. The reformer uses methanol and steam to produce high-purity hydrogen gas through a methanol-steam reforming reaction, and the introduction of a catalyst. The high activation energy of the reforming reaction allows easier integration with the high operating temperatures of the fuel cell: around 180 degrees Celsius.

The hydrogen gas can then be isolated using a palladium membrane and fed to the polymer electrolyte membrane fuel cell stack, where hydrogen gas and oxygen come in contact with a platinum catalyst. Positive hydrogen ions are transferred through an electrolyte membrane to create power output. Potential uses of this technology include primary or secondary energy sources for residential and industrial applications.

BIOSPHERE OCEAN LIFE SUPPORT

Team 18116

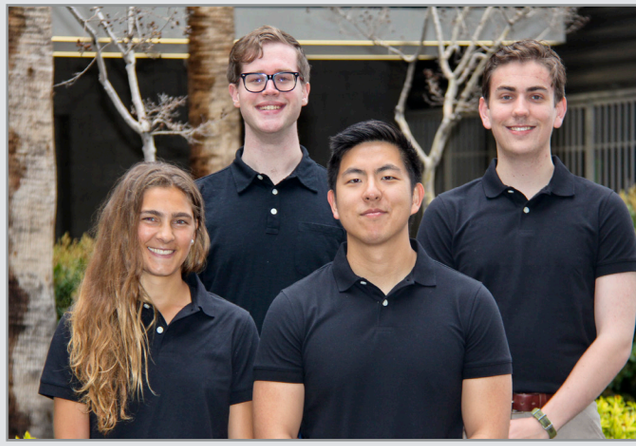
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Chemical & Environmental Engineering

PROJECT GOAL

To design a water-treatment process for backwash used by the Biosphere 2 life-support system.

The 30 micron primary drum filters in the Biosphere 2 life-support system required backwash because they were failing to remove dissolved and suspended organic material from the Biosphere 2 ocean.

The goal of the backwash treatment was to identify optimal conditions for reuse while simultaneously minimizing any potential waste stream. This required multiple mass balances, process train designs, and ocean chemistry knowledge. Mechanical processes such as rapid sand filtration and ultrafiltration were used to remove turbidity, and chemical processes such as ozonation and ultraviolet treatment removed harmful microbes within the backwash.



TEAM MEMBERS

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Edmond Jinho Song *Chemical Engineering*
Keegan Corley Franklin *Chemical Engineering*

COLLEGE MENTOR

Robert Stea

SPONSOR MENTOR

Robert Stea

HEAT EXCHANGER NETWORK

Team 18117

COLLEGE OF ENGINEERING
Chemical & Environmental Engineering

PROJECT GOAL

To design and fabricate an all-in-one heat exchanger network cart for the UA Department of Chemical and Environmental Engineering.

Numerous heat exchanger designs are used in industry to balance heat transfer rate, robustness and cost through specification of materials, designs and flow regimes. The heat exchanger network cart will be used by the Department of Chemical and Environmental Engineering for undergraduate students to facilitate learning and understanding of the operation and variation of heat exchangers.

The network cart encompasses a system with four heat exchangers that compare the effects of heat transfer rates due to differences between materials and form factors. The network is made with corrosion-resistant materials, a self-contained electrically heated hot water system and a set of standard operating procedures for ease of maintenance with a guaranteed minimum service life of 15 years.



TEAM MEMBERS

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Wyatt S. MacDonald *Chemical Engineering*
Adam Michael Weber *Chemical Engineering*
Michael Robert Barnes *Chemical Engineering*

COLLEGE MENTOR

Gregory E. Ogden

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TEAM MEMBERS
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Juliana Santos Ordine *Chemical Engineering*
Claudia Gabriela Rascon *Chemical Engineering*
Jessica Arlene Nordby *Chemical Engineering, Environmental Engineering*

COLLEGE MENTOR
Gregory E. Ogden

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Razhan Kareem

CAVE CREEK WATER REHABILITATION PROJECT

Team 18118

PROJECT GOAL

To design remedies and upgrades that allow reactivation of the Cave Creek Water Reclamation Plant by 2025.

The Cave Creek Water Reclamation Plant in Arizona was closed in 2009 because of slow population growth. Current population growth has created an opportunity to reopen the plant.

Design improvements will start with water intake at the influent pump station, which passes through a series of screens and through the grit removal station. At the primary clarifier, most of the water will pass through to the aerator, while the rest will go to the sludge holding tank to be dewatered. The water from the sludge will be returned to the influent pump station and sent back through the process, and the dry sludge will be taken to a landfill.

After passing through the aerator, a second sludge step will be conducted in which most of the water will pass through sand filters, and the rest will be transferred into the sludge holding tank. From the sand filter, the water will make its way through ultraviolet disinfection. The ultraviolet lamps will include quartz sleeves for reduced maintenance, and low-pressure lamps will be used to reduce energy use and carbon footprint.

After disinfection, sodium hypochlorite will be injected to further disinfect the water. The finished product will be stored in the effluent storage tanks and then sent down to the wastewater treatment plant for further treatment.



TEAM MEMBERS
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Hernan Oviedo *Chemical Engineering*
Michael Jordan Whiteside *Chemical Engineering*

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Andrea Achilli

SPONSOR MENTOR
Razhan Kareem

ARIZONA WATER COMPETITION

Team 18119

PROJECT GOAL

To rehabilitate the Cave Creek Water Reclamation Plant and provide a design for its reopening.

Arizona's Cave Creek plant was removed from service in November 2009. The plant is now being redesigned to improve efficiency and handle the town's growing population.

For this reopening project, a preliminary design and hydraulic profile were created, design flow rates were determined, recommendations for potential effluent uses were made, and overall economic evaluation of capital and operational costs were completed. Several design alternatives were made initially, and the final design was chosen based on an analysis of population, cost, environmental factors and efficiency.

The major changes made to the plant include addition of several screens, a completely updated secondary treatment section and a different disinfection technique. Cost of implementation – including equipment, construction and installation, cost of maintenance, and total cost of electricity to run the plant – were the main factors in the cost analysis. Several recommendations for the treated wastewater effluent were made based on the water quality provided by the plant. This project will optimize the Cave Creek plant and provide a clean alternative method for providing freshwater to Arizona.

MIXER-SETTLER DESIGN

Team 18120

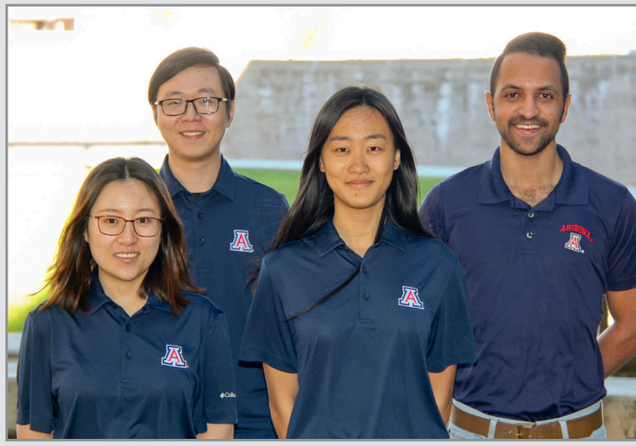
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Chemical & Environmental Engineering

PROJECT GOAL

To design a device that can cost-effectively separate sufficient metal from aqueous media by solvent extraction.

The device designed is a mixer-settler that mixes hydrophobic solvent with an aqueous media that contains the metal needing to be extracted. The mixer-settler can separate a large amount of metal from the aqueous mixture in a relatively short amount of time.

Calculations were carefully made to scale and optimize the function of the device. A 3D-printed plexiglass model helped with observing the mixing process and making appropriate changes. Testing and analysis improved the device's capability.
Extraction entraining with hydrophobic fluid is expensive. The mixer-settler design uses less hydrophobic fluid and shows a lot of promise for use in the future of mining.



TEAM MEMBERS

Abdulaziz Abdullah Alejairi *Chemical Engineering*
Rebecca Sheng *Chemical Engineering*
Tingting Wei *Environmental Engineering*
Peien Shao *Chemical Engineering*

COLLEGE MENTOR

Gregory E. Ogden

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Justin Neal

WEST SPEEDWAY BOULEVARD RECONSTRUCTION

Team 18121

COLLEGE OF ENGINEERING
Civil & Architectural Engineering & Mechanics

PROJECT GOAL

To design a functional, safe, visually appealing and efficient multimodal transportation facility for the Speedway Boulevard corridor.

In Tucson, Arizona, a new engineering design improves the Speedway Boulevard corridor, from Camino de Oeste to Painted Hills Road, from a two-lane road to a modern three-lane urban collector roadway with paved shoulders. Improvements include horizontal and vertical geometry, intersection realignments, traffic control elements, improved drainage conveyance, pedestrian and bicycle facilities, a new bridge over an existing wash, and ADA accessibility.

The new design vastly improves public safety with the elimination of substandard curves and line-of-sight conditions, the addition of a continuous center turn lane for improved access and reduced traffic congestion, bicycle-accessible paved shoulders, and an ADA-accessible pathway.

Engineering work addressed 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 civil engineering senior capstone project involves 39 students (listed under the photo, which features most of them) split into four teams. One team will represent the senior class at Design Day.



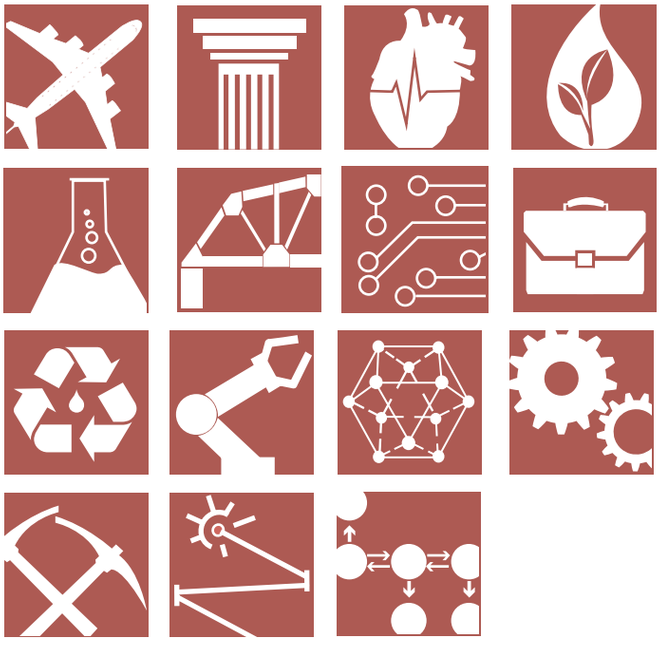
TEAM MEMBERS

Brandon James Ahlers, David Araiza, Jason Christopher Boley, C.J. Chinbold, Yen Thi Kim Do, Jayme Flamm, Amy Michelle Forsythe, Alan Alejandro Gomez, Charly Brice Guefack, Gustavo Michael Guerrero, Eric James Huettner, Jess Jibrin, Jason Jimenez, Elyas Kamyab, Blair Thomas Kessler, David Allen Klebosky, Tyler D. Lehto, Chengkai Lim, Cole Otis Lockwood, Jesus Edgardo Martinez, Margaret Miezio, Joe Millick, Ben Mitchell, Alexia Acevedo Navarro, Ryan Nelson, Matt O'Brien, Kyle Robert Patterson, Erik Joseph Petersen, Absalon Pineda, Dan Recker, Alayna Nicole Roberts, Emily Katherine Roberts, Mohammad A.S.M. Salman, Ethan Conrad Schuchmacher, Ross Marlin Shipley, Byron Jay Shorty, Dalton Chase Thorpe, Daylan Toledo, and Oscar Leonardo Vazquez

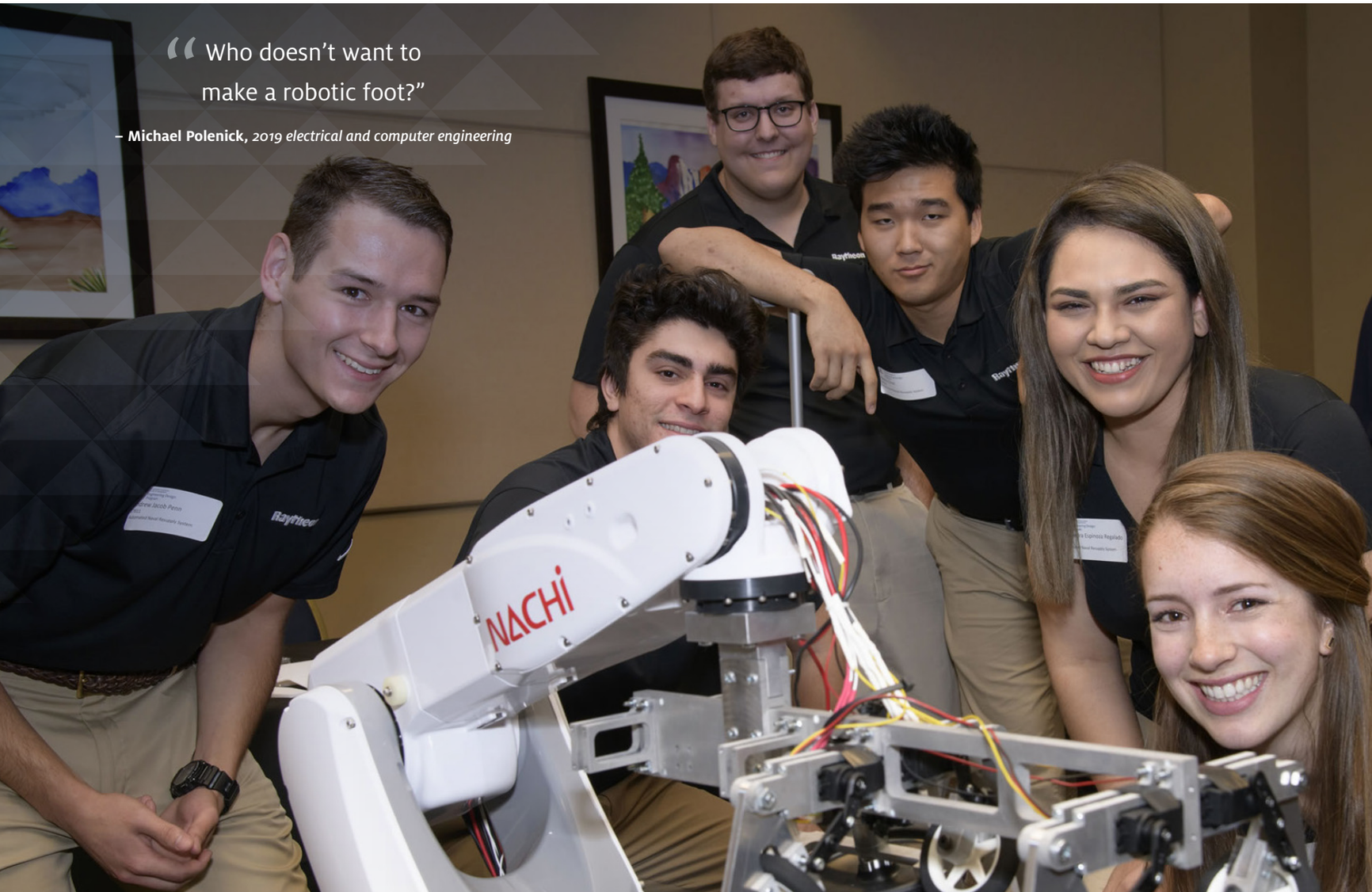
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ENGINEERING DEGREE PROGRAMS



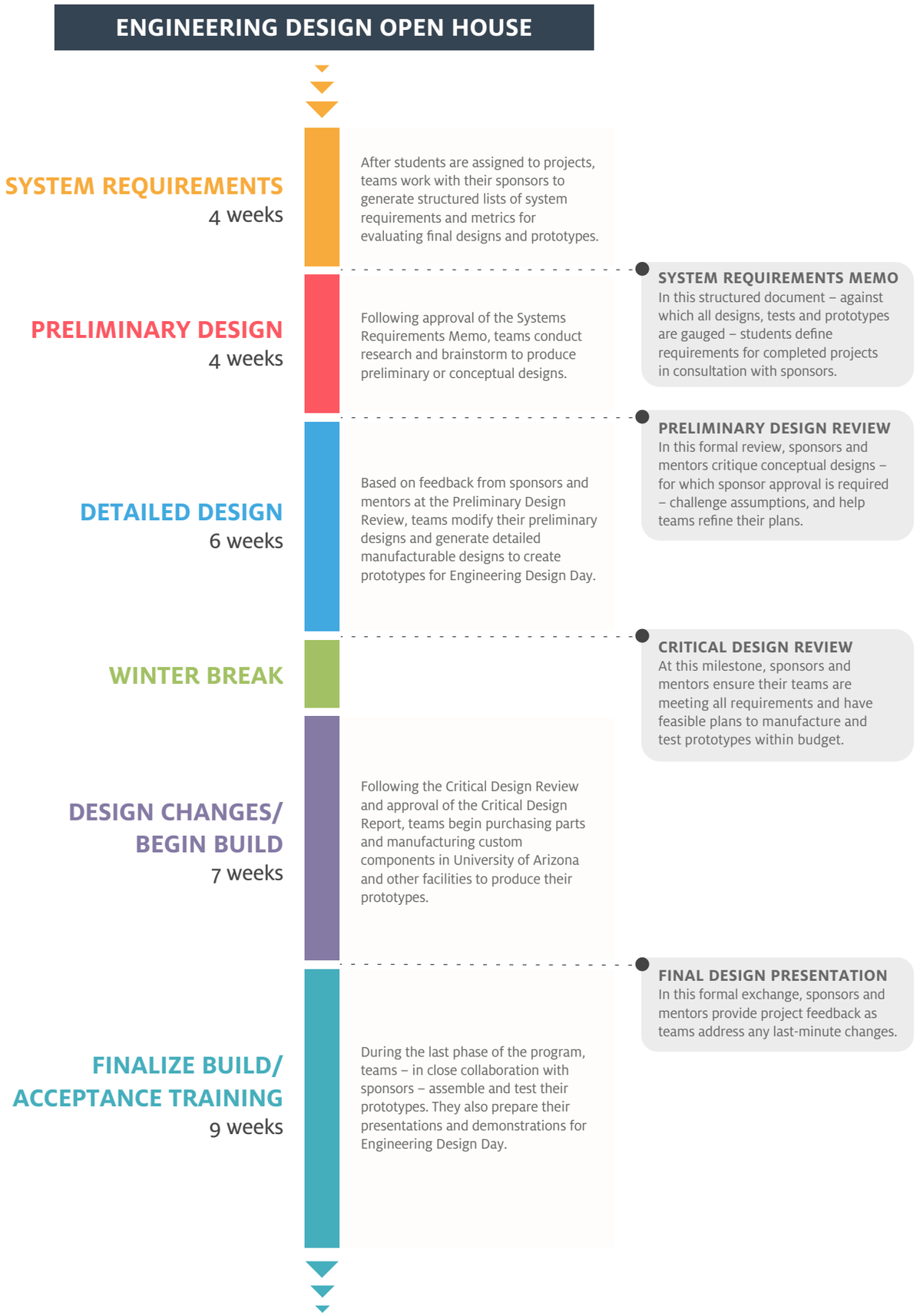
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“Who doesn’t want to make a robotic foot?”

– **Michael Polenick,** *2019 electrical and computer engineering*

ENGINEERING DESIGN PROGRAM
YEAR AT A GLANCE



ENGINEERING DESIGN DAY
ACKNOWLEDGMENTS

STUDENTS

Projects exhibited today are the culmination of a year's worth of work. Students have applied knowledge from the breadth of their undergraduate education, exercised outside-the-box thinking and spent hundreds of hours producing the best solutions for their sponsors. We applaud your dedication and professionalism and congratulate you on your achievements.

MENTORS

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

SPONSORS

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

JUDGES

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

STAFF

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





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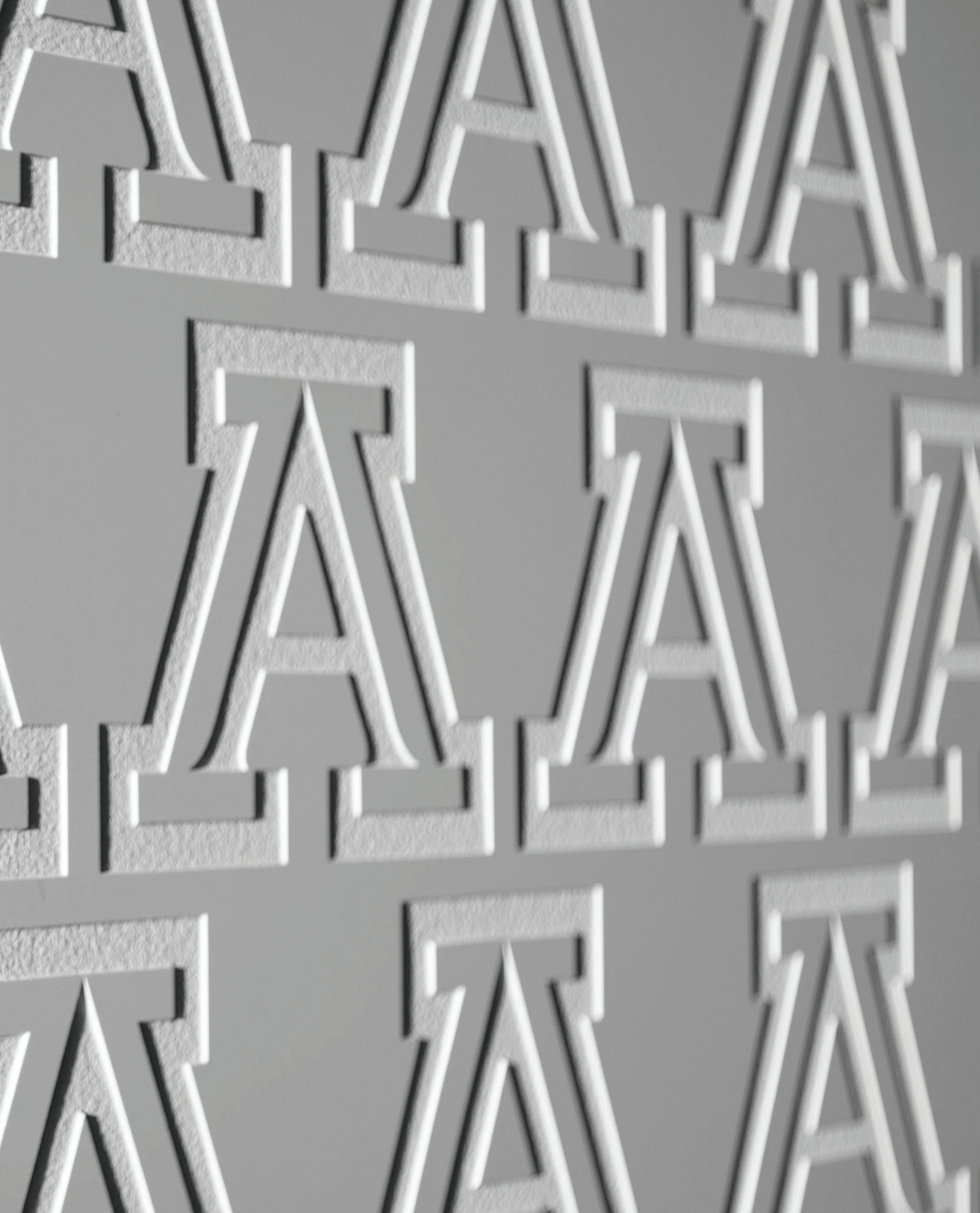
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KEEP UP WITH DESIGN DAY EVENTS, TIMES AND DEMONSTRATIONS WITH THE APP

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