CAPSTONE REVIEW

2023-2024

BYU

CAPSTONE OBJECTIVE

Help students become design professionals who can blend creative, technical, interpersonal, and management skills to develop products that are both desirable and transferable.

A MESSAGE FROM THE DIRECTOR

Welcome to the BYU Capstone Fair!

Please feel free to explore the creative designs assembled by the 52 teams of students this past academic year. As we monitor and measure the program impact, we are continuously reminded of how much effort and enthusiasm the students put into their respective projects.

We are grateful for your feedback, encouragement, and continued support that makes this unique and critical educational experience possible for these hard-working students. They are not only a product of the program and process, but have been taught and sustained by other university colleges and courses. They usually come to the university with a strong educational foundation, work ethic, and have been generally nurtured and taught by exceptional parents, peers, and other influencers.

Capstone is obviously a team effort, starting with our amazing external relations managers who work tirelessly to find high quality Capstone projects, the dedicated Capstone staff who administer the entire operation, the seasoned coaches who come to the university from their "regular engineering jobs" to help mentor and train the students, and the instructors who teach the design coursework as well as review projects several times a semester and provide course correction and feedback. Naturally the program can only succeed when a sufficient number of high quality projects are provided through our generous sponsors. And as the number of students grows each year, the need for more and more projects becomes increasingly challenging.

I hope you will not only enjoy the fair, but might consider other projects and opportunities to support these wonderful students as they prepare for a career and life of service and contribution.

Sincerely,

Dr. Brady Davies
Capstone Director/Associate Professor

PROJECT SPONSORS
2023-2024

- ACUITUS AG
- AIR FORCE RESEARCH LABORATORY
- APPLIED SIGNAL TECHNOLOGY AN RTX BUSINESS
- APTIVE ENVIRONMENTAL
- BURNHAM AND SHIPP ENDOWMENTS
- BYU COSMO
- BYU CROP BIOMECHANICS LAB
- BYU ELECTRICAL AND COMPUTER ENGINEERING
- BYU ELECTROHOLOGRAPHY RESEARCH GROUP
- BYU SOUTH AMERICA COLLABORATION
- EPIROC
- FLEX
- IDAHO NATIONAL LAB
- IMPLEMENTING IDEAS
- INTEGRA LIFE SCIENCES
- ISOSTRAND
- L3HARRIS TECHNOLOGIES
- LAWRENCE LIVERMORE NATIONAL LABORATORY
- LOS ALAMOS NATIONAL LABORATORY
- DR. MATTHEW MADSEN
- MICROCHIP TECHNOLOGY
- MISSION SUPPORT AND TESTING SERVICES/NNSS
- NORTHROP GRUMMAN AEROSPACE STRUCTURES
- NORTHROP GRUMMAN CORPORATION
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- SANDIA NATIONAL LABORATORIES
- SPACE ZERO GRAVITY
- TOYOTA MOTOR NORTH AMERICA
- TRESTLEWOOD
- UTAH DEPARTMENT OF TRANSPORTATION
- VAREX IMAGING CORPORATION
- VELA MOTOR COMPANY
- BYU MECHANICAL ENGINEERING
- BYU ELECTRICAL AND COMPUTER ENGINEERING
- BYU MANUFACTURING ENGINEERING

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01 PCB DEVELOPMENT FOR FARM VEHICLES

PROJECT SPONSOR: ACUITUS AGRICULTURE

COACH: ANDREW KAY

TEAM MEMBERS: Garrett Smith, Max Kimball, Nathan Schafer, Ethan Campbell, Sarah Maia, Elise Kinghorn

DESCRIPTION: Acuitus Ag is a software company with a goal to help farmers be more efficient. Large scale farming is often inefficient due to the human element. It's hard for hundreds of tractors and trucks to be perfectly tracked by hand, even harder when inclement weather shortens harvesting time. Acuitus Ag is working to make this tracking process easier through automation. They currently have a prototype device that sends vehicle information, positioning, and other data to their backend software to be tracked and formatted for farmers. This current device does not meet the demands of modern farming equipment. As the tractors and trucks involved in harvest become more advanced, the hardware they use needs to follow suit. The team came up with a scalable PCB design that accommodates the use of new ports such as ethernet, while still supporting the old ports such as CAN. Along with this, the main processing unit was switched to handle the higher throughput of data from these ports. A supercapacitor bank was also added to ensure no data corruption due to sudden power loss as well as a power management circuit that can cycle individual components.

02 MINI-TENSILE TESTER

PROJECT SPONSOR: AIR FORCE RESEARCH LABORATORY

COACH: OLIVER JOHNSON

TEAM MEMBERS: Ian Morby, Jared Jackson, Isaac Wilson, Luke Freeman, Dean Fitzpatrick, Courtney Payne

DESCRIPTION: The Air Force Research Lab (AFRL) uses mini-tensile testers with optical microscopes to analyze the propagation of microfractures in ceramic matrix composites. By analyzing the damage progression of the samples, AFRL can predict the material's behavior and lifetime leading to more efficient design of jet engines and hypersonic technologies. Their current mini-tensile machine introduces bending strain to the samples, causing additional cracks leading to eroneous predictions. The goal of this project was to design, build, and test a mini-tensile machine that integrates with an optical microscope and reduces ASTM percent bending from the previous team's value of 26% (with a stretch goal of 5%). To accomplish this, the team designed a new clamping system to reduce bending, selected a new motor, wrote LabVIEW software to run it, and redesigned the frame that supports the entire system. The final product interfaced properly with the optical microscope and reduced percent bending to a desirable amount. These results will provide crucial advancements to aerospace research by providing more accurate material properties of high-performance materials and improving the safety and efficiency of aerospace technologies

03 AUGMENTED REALITY RF SIGNAL VISUALIZATION

PROJECT SPONSOR: APPLIED SIGNAL TECHNOLOGY AN RTX BUSINESS

COACH: RICH ZIEGLER

TEAM MEMBERS: Patrick Penalba, Travis Reynertson, Carson Wynn, Jordan Williams, Brady Browerbank, Alex Pierce

DESCRIPTION: Scanning the radio frequency (RF) spectrum to find and localize the presence of RF transmitters is a capability that can be highly valuable to industry and government consumers. This project helps a user visualize these signals in the real-world using augmented reality (AR) while also providing relevant information about the signals. We have designed an AR solution using a Microsoft HoloLens2 that allows a user to visualize RF data collected by an antenna dish in an interactive environment. The primary objective is to accurately describe the location and characteristics of signals provided from a radio scan. This is achieved by creating icons for each signal and placing them in the correct location in the simulated environment. These icons can then be selected to display more data. Additionally, the project is fast, user friendly, and makes it easy for the user to see relevant information about the signals. This project has applications in many different situations, including industrial and regulatory. Its main purpose is to help a user visualize signals in the real-world so the signal source can be accurately located. This increases efficiency and decreases human error in localizing and characterizing these signals.

04 IN SITU ANECHOIC MEASUREMENTS USING A DRONE

PROJECT SPONSOR: APPLIED SIGNAL TECHNOLOGY AN RTX BUSINESS

COACH: ANNETTE STEED

TEAM MEMBERS: Zachary Garner, David Phair, Matthew Trainor, Lars Flores, Nick Towansend, Lucas Silva

DESCRIPTION: Knowing the radiation pattern of an antenna is vital to effective communications; however, characterizing that antenna requires electronically quiet environments typically known as anechoic chambers. These chambers can be extremely expensive, small, and may take a long time to acquire. With funding from, and collaboration with Raytheon, an aerospace and defense company, our teams' goal is to remove cost, time, and size constraints to characterize antenna patterns while maintaining measurement accuracy. To accomplish this, an omnidirectional antenna driven by a Software Defined Radio (SDR) is integrated with an on-board computer and mounted to the bottom of an autonomous drone. The system removes the size, cost, and time constraints an anechoic chamber creates at the expense of signal integrity. To maximize signal integrity and to compare our system with industry, skyward antenna positioning, filtering, and post processing techniques are implemented.

05 WHITE BOX SWITCH SECURITY TESTBED

PROJECT SPONSOR: APPLIED SIGNAL TECHNOLOGY AN RTX BUSINESS

COACH: JAY SNELL

TEAM MEMBERS: Garrett Tautkus, Levi Houghton, Weston Smith, Ray Zhang, Anna Pratt, Justin Applegate

DESCRIPTION: Switches are key components in enterprise network architectures that route all traffic on a network. Currently, most organizations use proprietary switches, meaning that the switch comes pre-installed with vendor software. However, white-box switches—switches that can be customized to run whichever software the customer desires—are rising in popularity due to their lower cost and greater modularity. As more enterprises start to use white box switches, cybersecurity standards demand that white box switch security is more heavily tested. In response to this knowledge gap, the team designed a methodology to assess the security of a generic white box switch to discover, identify, and replicate vulnerabilities in the switch. The findings of the project are of particular interest to the sponsor, Applied Signal Technology (AST), which is an RTX Business. As a defense contractor, AST helps defend the nation against technological threats. The results of the security assessment will assist AST in developing and maintaining a strong security posture regarding enterprise networking equipment.

06 DRONE BASED PEST CONTROL

PROJECT SPONSOR: APTIVE ENVIRONMENTAL

COACH: STEVE WILSON

TEAM MEMBERS: Ethan Evans, Jonathan Monk, Aisea Vainuku, Nathan Allen, Mason Harris, Julia Johnson

DESCRIPTION: Aptive Environmental provides pest control treatments to over half a million homes nationwide. They envision a future where routine exterior treatments are automated, allowing technicians to focus on building relationships with customers. The capstone team was challenged with proving the feasibility of a quadcopter drone accomplishing two tasks: cleaning spiderwebs from eaves and spraying the foundation of the home with pesticide. The capstone team designed subsystems for the cleaning and spraying tasks that could be attached to a small quadcopter. The team succeeded in designing a spray subsystem that could consistently apply pesticide to the treatment area. For cleaning, an arm with a motorized brush was designed that would reach the target areas along the eaves. The development of these subsystems proved that the tasks were within the capabilities of a quadcopter, paving the way for further development of the automated treatment system.

07 AGRICULTURAL SPOILAGE PREVENTION

PROJECT SPONSOR: BURNHAM AND SHIPP ENDOWMENTS

COACH: DALLAS HAUETER

TEAM MEMBERS: Isaac Murri, Nate Cruz, Sam Badstubner, Didi des Rosiers, Jonathan de Gaston, Jacob Brown

DESCRIPTION: A common problem in warm, humid climates is the growth of toxin-producing fungi, Aspergillus, inside of grain storage systems. Impoverished communities often have no choice but to consume this contaminated food, and this is a health risk. An answer to this problem is to detect the Aspergillus before it spreads throughout the grain; however, existing solutions for monitoring grain spoilage are expensive and unfeasible in lower economic areas, so few facilities use them. This project aims to deliver a grain silo sensor system at a lower price. The system consists of a central hub, sensor nodes, and an Android app, all working together to deliver CO2, temperature, and humidity data to the user. The operation is simple: the central hub periodically powers-on the sensor nodes, requests measurements from them, and stores the readings. A user can then use the Android app to receive and view the readings from the central hub over Bluetooth. The CO2, temperature, and humidity data are used to detect possible areas of Aspergillus growth, allowing steps to contain the growth to be taken. The result is less spoiled grain and a healthier population.

08 PORTABLE COSMO STUNT PLATFORM

PROJECT SPONSOR: BYU COSMO

COACH: JOHN SALMON

TEAM MEMBERS: Weston Blocker, Bryan Poulson, Will Newbold, Joshua Santos, Bond Headlee, Grant Ostergaard, Collin Klomp

DESCRIPTION: The goal of this project was to design a unique stunt system for Cosmo the Cougar, aimed at elevating his performances during football and basketball games. The challenge was to create a design that was not only impressive but also reusable and safe, even in the event of failure. The team came up with a versatile platform that interfaces with a variety of stunts, designed for easy transportation to and from sports venues. This innovation enables Cosmo to execute more complex stunts safely. Additionally, the platform's adaptability ensures it can accommodate an extensive array of future stunt structures, paving the way for ongoing innovation. This platform is also designed to attach to Cosmo's trailer, facilitating mobility and allowing him to bring his dynamic performances to different locations with ease.

09 RAPIDLY MEASURING MAIZE STALK STIFFNESS & STRENGTH

PROJECT SPONSOR: BYU CROP BIOMECHANICS LAB

COACH: DOUG COOK

TEAM MEMBERS: Caleb Price, Nate Ludlow, Landon Beutler, Jeremy Read, Ryan Hall, Gustavo Oliveira

DESCRIPTION: With support from the BYU Biomechanical Lab, the team embarked on a mission to tackle the significant issue of crop destruction caused by storms, particularly in the corn industry. The objective was straightforward: to develop a device capable of swiftly assessing the stiffness of corn stalks, offering farmers vital insights into their crop's resilience against inclement weather. Billions of dollars worth of corn crop are destroyed every year due to storms, highlighting the urgent need for a solution to mitigate these losses. Employing cutting-edge technology, the team engineered a device capable of assessing the stiffness of a single corn stalk in just one second. This innovation enables farmers to efficiently test large samples of corn stalks, empowering them to make informed decisions to protect their crops from storm damage.

10 AUTONOMOUS BYU CAMPUS TOUR VEHICLE 2

PROJECT SPONSOR: BYU ELECTRICAL AND COMPUTER ENGINEERING

COACH: PREVIN MENON

TEAM MEMBERS: David Weber, Steven Boggess, Nate Taylor, Adam Taylor, Noah Bailey, Rami Arafeh, Joshua Kelley

DESCRIPTION: Sponsored by BYU's Electrical and Computer Engineering Department, our capstone project endeavors to revolutionize campus tours with a self-driving golf cart. Our primary aim is to elevate visitor experiences while offering students invaluable exposure to autonomous vehicle technology. The project's core objective is to develop a sophisticated system achieving level 2 autonomy, emphasizing time-synchronous operation and utmost safety. Through meticulous implementation, our team successfully integrated LiDAR and cameras and enabled actuation of steering and pedals. This project benefits the ongoing development of the project by laying a robust foundation for future enhancements such as incorporating machine vision.

11 OPTICAL TRAP DISPLAY KIT

PROJECT SPONSOR: BYU ELECTROHOLOGRAPHY RESEARCH GROUP

COACH: DANIEL SMALLEY

TEAM MEMBERS: Nathan Bennion, Dallin Smith, David Reinhardt, Madison Jones, Christina Thorley, Wesley Collyer

DESCRIPTION: The Electroholography Research Lab at BYU is on a mission to make the holograms and other visual displays of science fiction a reality. Some of their current research has focused on developing a 3D volumetric display that uses a laser beam to trap particles of matter in the air, and one of the current issues they are working on is finding the best particle to use. This capstone team developed a particle trapping kit that can test the "trappability" of a particle to determine whether or not it could be used to make a hologram. This kit will allow students in middle and high school to get involved with this ongoing research through the Hunt for the Hologram program.

12 QUINOA TOAST AND MILL SYSTEM

PROJECT SPONSOR: BYU SOUTH AMERICA COLLABORATION

COACH: DARRELL GOFF

TEAM MEMBERS: Drake Allen, Trevor Remund, Paul Moon, Isaac Weaver, Dallon Miskin, Jeffrey Taylor

DESCRIPTION: For centuries, quinoa has been a vital staple for the Andean people, renowned for its high protein content and nutritional value. Traditional quinoa processing includes hours toasting the quinoa in tiny batches and then traveling up to two hours to grind the quinoa in a commercial flour mill. In cooperation with the Bolivian organization PROINPA (PROmociòn e INvestigaciòn de Productos Andinos), BYU Global Engineering Outreach challenged the team to revolutionize quinoa processing for rural communities. PROINPA prioritizes affordable solutions that are sourced primarily from local vendors in Bolivia. The team has developed two compact devices to increase accessibility to quinoa by reducing the processing time. The first is a simple-to-use quinoa flour mill that empowers individuals to grind their own flour reliably, eliminating the need for arduous journeys to commercial mills. The second is a continuous-flow toaster that replaces hours of active labor. Both devices prioritize affordability and utilize locally sourced materials. These innovations enhance accessibility to nutritious quinoa, promote sustainability through local sourcing, and empower rural communities economically.

13 WHEELCHAIR HAND TRIKE IMPROVEMENTS

PROJECT SPONSOR: BYU SOUTH AMERICA COLLABORATION

COACH: JEFF NIVEN

TEAM MEMBERS: Sadie McGinn, Nathan Stearns, Bradon Thomason, Jacob Lowe, Logan Marks, Allison Crane

DESCRIPTION: The Church of Jesus Christ of Latter-Day Saints provides hand-trike wheelchair attachments to impoverished wheelchair users with needs for long distance travel. Since this wheelchair attachment was originally designed, about 200 have been given away annually. Several design issues have become apparent during use, specifically related to user interface difficulties, difficulty travelling up inclines, and part wear/rigidity. The objective of this project was to modify the existing hand trike design to eliminate issues with the original design and improve the user experience without significantly increasing cost. The TRYKE Capstone team made several modifications to the original attachment design, and created a design with improved efficiency, less part wear, greater ability to ascend inclines, and easier initial assembly. These changes will improve the lives of those that receive these wheelchair attachments.

14 FLEET DRILLING MONITORING SYSTEM

PROJECT SPONSOR: EPIROC

COACH: TOM ATKINS

TEAM MEMBERS: Jacob Anderson, Allan Howe, Shiloh Mangus, Jared Johns, Josh Taylor

DESCRIPTION: Epiroc rents drill rigs to customers in over 150 countries. Costly damage occurs to the drills when either the drill shaft overheats, or when it is operated with low accumulator pressure. Epiroc tasked the team with developing a system that can measure and report both the accumulator pressure and the drill shaft temperature to Epiroc and the drill operator. The solution consists of a pressure sensor switch that alerts the operator when pressure drops below a certain value and an infrared temperature sensor that constantly reports the drill temperature to the operator. Epiroc is notified over a celular network when critical values of pressure or temperature are reached. Havign this real-time information will decrease repair costs, improve drill operator alertness, increase the longetivity of each drill, and reduce the waste and environmental impact of Epiroc.

15 COMPUTER VISION/ML PCB INSPECTION

PROJECT SPONSOR: FLEX

COACH: DJ LEE

TEAM MEMBERS: Ali Day, Darren Scruggs, Ben Orr, Julie Weller, Gracie Simpson, Jason Nielsen

DESCRIPTION: When a printed circuit board assembly (PCBA) is created, there are many possible sources of error including bad components, improper assembly, or soldering problems. If a PCBA has one of these issues it can take a long time to detect with the human eye, but using computers can dramatically speed up the process and help a company save money. Flex, a multinational manufacturing company, challenged our team to design and build a computer vision prototype that could be easily trained to automate the detection of physical damage to both sides of a PCBA with detection software running in under 3 seconds and with a 98% success rate. At the conclusion of our project, we were able to use two cameras and a light box to take clear pictures of both sides of a Dual In-Line Memory Module (DIMM). First, we take pictures of a "golden" sample, which is a board without any defects and then take pictures of a damaged DIMM. Afterwards, using OpenCV, we developed an algorithm to compare the two DIMMs pixel by pixel to locate any possible defects and display them on a computer for a person to easily know where to look for damages.

16 PRODUCTION MANAGMENT SYSTEM

PROJECT SPONSOR: FLEX

COACH: SCOTT CUTLER

TEAM MEMBERS: Josh Haviland, Dallin Wake, Spencer Teeples, Matthew Schwendiman, Daniel Vallejo, Glen Malan

DESCRIPTION: Flex is the third-largest global electronics manufacturing service by revenue. To keep their clients updated on the status of the Salt Lake facility's production lines, Flex conducts daily meetings. Prior to these meetings, the facility's upper and lower management meet to gather information about the production lines and resolve any issues. The team built a custom Alexa skill to optimize daily communication for teams at Flex by accessing database information via Alexa Voice Services in real-time. Streamlining this information saves management time, allowing them to focus on more critical issues.

17 INDUSTRIAL CONTROL SYSTEM TRAINING APPARATUS

PROJECT SPONSOR: IDAHO NATIONAL LABORATORY

COACH: RICH ZIEGLER

TEAM MEMBERS: Garrett Cooper, Isaac Teuscher, Jay McArthur, William Pendleton, Eric Pressler, Samuel Horsley

DESCRIPTION: Idaho National Laboratory (INL) develops cybersecurity trainings for the critical infrastructure workforce. Recent hacks such as the attack on Colonial Pipeline and hacks against Ukraine have highlighted the urgent need for hands-on cybersecurity trainings focused on the energy and communication sectors. The capstone team collaborated with INL cyber experts to develop a mobile industrial controls cybersecurity training kit. The project included creating an instructional manual, curriculum guidebook, and designing hardware including routers and PLCs. Modeled after a real-world incident, the kit was created and tested for effectiveness in teaching key cybersecurity principles. The project will contribute to strengthening cybersecurity preparedness in vital infrastructure sectors in the US and support US national security efforts.

18 LIGHTED SPRINKLER HEAD

PROJECT SPONSOR: IMPLEMENTING IDEAS

COACH: PHILIPPE PASSERAUB

TEAM MEMBERS: Dylan Bekker, Josh Katzenbach, Adam Cook, Phillippe Passeraub, Alec Cahua, Isaiah Clemons, Lindsay Akagi

DESCRIPTION: Implementing Ideas LLC is a local company that excels in PCB manufacturing. The owner of the business, David Zopetti, is working on expanding his business through designing and creating his own ideas, rather than solely manufacturing the ideas of others. This project develops one of these ideas- a new type of outdoor lawn light. We were tasked with creating an autonomous and waterproof yard light that will illuminate the water leaving spray sprinklers. Our device sits at the base of the sprinkler, automatically triggering when the sprinkler turns on and illuminating the water stream during each watering session. We were able to maximize battery life to last more than 40 hours and keep LED brightness significant, while keeping the device compact and inexpensive. This project will not only give David a new category of income for his business, but could also improve water conservation, as currently up to 30% of water is lost during daytime watering. This device can encourage people to water their lawns once it is darker outside.

19 CRANIAL ACCESS KIT CHUCK CLEANING PROCESS

PROJECT SPONSOR: INTEGRA LIFE SCIENCES

COACH: DOROTHY TAYLOR

TEAM MEMBERS: Michael Merrell, Haakon Hunsaker, Adam Rose, Henry O'Bryan, Michelle Browne, Shane Kaiser

DESCRIPTION: The Cranial Access Kit is a life-saving device produced by Integra LifeSciences. In emergency situations, this device aids in relieving intercranial pressure by drilling into the skull. Integra LifeSciences asked the team to design and build a device that cleans the chuck used in these kits. The team has designed an automated cleaning device that improves the ergonomics, decreased the decibel level, and decreased the cleaning time while maintaining Class 8 clean room standards. This device will improve the operators' experience as it will increase efficiency and the ergonomics to prevent repetitive strain injuries within their wrists and hands.

20 FLOW THROUGH DEVICE WITH RAPID HEATING

PROJECT SPONSOR: ISOSTRAND

COACH: EMILY ZHAO

TEAM MEMBERS: Evan White, Giovanni Ruiz, Jarron Gage, Madi Ursenbach, Erica Straddeck

DESCRIPTION: Isostrand is a newly formed startup and has tasked our Capstone team with designing and creating a proof-of-concept rapid heating flow through device. Our solution uses a specially engineered porous medium component housed within a custom 3D-printed housing capable of heating 60°C quickly. Our design optimizes the medium's porosity to maximize heat transfer efficiency.

21 REAL-TIME SPECTRUM ANALYZER

PROJECT SPONSOR: L3HARRIS TECHNOLOGIES

COACH: JOHN SNOW

TEAM MEMBERS: Daniel Ross, Ethan Monlux, Jason Rollins, Trace Meyers, Daniel Kemp, Tyler Pearson

DESCRIPTION: Spectrum analysis is important across various fields such as communications, medical imaging, and radio astronomy. Real-time spectrum analyzers play a crucial role in detecting signals and noise and displaying them in the frequency domain. In their production of tactical radios, avionics, electronic systems, antennas, and wireless equipment for both defense and commercial sectors, L3Harris relies on real-time spectrum analyzers for design and verification. However, high-end commercial options are costly, bulky, and often come with unnecessary features, while cheaper, portable alternatives lack essential capabilities. To address this gap, this Capstone team developed a real-time spectrum analyzer using readily-available commercial components and software that leverages optimized open-source code. The device bridges the performance divide between expensive, feature-rich models and limited, portable ones. It maintains affordability, offers necessary functionality, and is sized practically for desktop use.

22 UAS CRASH RECOVERY SYSTEM

PROJECT SPONSOR: LAWRENCE LIVERMORE NATIONAL LABORATORY

COACH: BRADY DAVIES

TEAM MEMBERS: Ashton Smith, Gavin Bendixsen, Mitchell Zoolakis, Michael Stone, Dallin Wood, Carter Ristine, Sydney Ngatuvai

DESCRIPTION: The Lawrence Livermore National Laboratory Flight Test group routinely deploys multi-rotor drones in ocean environments. Given the nature of these operations, drones occasionally crash into the ocean. The goal of this project is to design, build, and test a system that can be used to track and keep afloat a drone lost in ocean environments. Our Capstone team has developed a system that deploys three flotation devices which are inflated with CO2 once the drone is fully submerged in the water. These flotation devices will keep the drone system afloat for at least 48 hours. The system uses an off-the-shelf satellite communication device (RockFLEET) which receives GPS coordinates and transmits them using the Iridium satellite network. These transmitted coordinates are accessible through a web-app called the CORE. This allows LLNL to use the CORE to see the location of the fallen drone at any point during the 48-hour recovery window. This system will help LLNL to recover the lost drone and payload used to gather crucial data for their projects.

23 STREAK CAMERA SLIT PROJECTION SYSTEM

PROJECT SPONSOR: LOS ALAMOS NATIONAL LABORATORY

COACH: JEFF HILL

TEAM MEMBERS: Sam Roper, Ammon Gallart, Sam Davis, Sam Erickson, Hannah Koford, Alex Millett

DESCRIPTION: Los Alamos National Lab (LANL) specializes in strategic research for U.S. national security, including oversight of the nuclear stockpile. The Q-6 Detonator Science and Technology group at LANL conducts high precision testing with a Cordin Streak Camera but requires an updated alignment system. Our project objective was to develop a precise, manufacturable, and user-friendly alignment system for LANL's Cordin streak camera. This involved creating a light source capable of shining down the camera barrel and retracting when necessary. To achieve this, we collimated the light source and integrated a 45-degree mirror mechanism for optimal alignment. Our solution streamlines the alignment process, allowing for quick and efficient operation by a single LANL employee. The design enables easy replacement of the light source and electronics with sufficient lumen output for clear visibility at 15 feet. Custom parts were designed for rapid 3D- printing. This project enhances LANL's efficiency, enabling them to focus more on critical tasks. With streamlined operations, LANL can advance nuclear solutions more rapidly, contributing to national security efforts.

24 RANGELAND MICROSITE SEED DRILL

PROJECT SPONSOR: DR. MATTHEW MADSEN

COACH: DAVID BARKER

TEAM MEMBERS: Jackson Wilcox, Luk Dean, Thomas Grover, Liz Robinson, Dallin Woodbrey, Brandon Page, Patrick Shimbashi

DESCRIPTION: Utah and the American West rangelands have been plagued with wildfires in recent years, and current attempts to replant native seeds have not been successful (<5%). Our sponsor tasked us with modifying a seed drill for rangelands to improve success rates through increasing the seed depth- control and the reliability of furrow shape. To do this, we designed a furrowing implement to create U-shaped furrow, which has been proven by Dr. Madsen to improve planting success rates. Our challenges were debris buildup, inconsistent furrow shape, and uneven terrain. The project challenges were resolved by modifying the seed drill with a new furrower and relocating the coulter wheel onto a new toolbar. These results offer opportunities to enhance the success rates of restorative planting initiatives, and therefore, restore biodiversity and prevent future wildfires.

25 SECURE INDUSTRIAL NETWORK

PROJECT SPONSOR: MICROCHIP TECHNOLOGY

COACH: GARY MANGUM

TEAM MEMBERS: Kaleb Bates, Nate Tingey, Andrew Burton, Solomon Olmstead, Brian Smith, Jonathan Wilson

DESCRIPTION: Manufacturers make use of assembly lines, which often include some type of sorting mechanisms. It can be complicated to design solutions for this and obtain the parts from various vendors to implement those solutions. The project, sponsored by Microchip, is to design a proof-of-concept industrial sorting line that utilizes their MPUs, capable of implementing high quality protocols and security for an industrial network. The team designed 3 custom PCBs to meet these purposes, implementing Profinet (and industrial, low-latency network protocol) and secure boot using Microchip's SAMA7G54 MPU as well as several ethernet chips (PHYs, switches, etc.). The PCBs are used to manage a simple cube-sorting line. This solution provides to other companies a one-stop-shop to buy circuit components and follow PCB designs by Microchip, making it more convenient for vendors to find and integrate industrial lines while profiting Microchip since they would be the primary customer.

26 DUAL ANOGE X-RAY DETECTION

PROJECT SPONSOR: MISSION SUPPORT AND TEST SERVICES FOR NEVADA NATIONAL SECURITY SITE

COACH: MATT JONES

TEAM MEMBERS: Josh Hoffman, Tanner Scherwinski, Gabe Snow, Joseph Nielson, Rebecca Lane, Laura Boehm

DESCRIPTION: Explosive plumes can be difficult to analyze due to the speed of particle movement. Flash radiography is an X-ray based technique that allows observation of the content of explosive plumes. In one method, two different X-ray images are taken and compared to measure a tracer element, such as zinc. The Nevada National Security Site tasked the Capstone team with refining their dual X-ray system. The team designed and built 2 fixtures for X-ray data collection and developed a novel algorithm for extracting tracer element densities and compositions. This system was documented, and the fixtures were prototyped and shipped to the NNSS for testing. The software successfully calculated the density of the zinc tracer with an average error of 11%. This tracer element composition can be used by the NNSS to further research in national security.

27 MODULAR OPTICAL DETECTOR DEVELOPMENT

COACH: CHRIS DILLON

TEAM MEMBERS: Tyler Adams, Colten Brown, Ian Unick, Brandt Bashaw, Elisa Robert, Helaman Flores

DESCRIPTION: Nevada National Security Site (NNSS) is a collection of testing facilities tasked with providing technical solutions to support national security through classified experiments. To support some of these tests in the near infrared and visible light spectrums, this capstone team was tasked with improving an existing optical detecting system. By developing a modular optical housing capable of operating in each desired light spectrum, the team provided NNSS with the ability to run more specialized testing through modularity and improved signal output. The team was also able to remove ringing due to an impedance mismatch and enhance signal quality through thermal regulation. With the developed solution, NNSS has the capacity to run experiments with the desired precision to fulfill their mission of supporting national security.

This work was done by Mission Support and Test Services, LLC, under Contract No. DE-NA0003624 with the U.S. Department of Energy.
DOE/NV/03624--1651

28 HIGH TEMPERATURE CAPABLE CONTAINER

PROJECT SPONSOR: NORTHROP GRUMMAN AEROSPACE

COACH: ANDY GEORGE

TEAM MEMBERS: Brad Murray, Donovan Sanchez, Ben Gonzalez, Zach Skinner, Nash Phenix

DESCRIPTION: Northrop Grumman Corporation is an American aerospace and defense technology company that solves the toughest problems to meet global needs. This capstone project focused on aiding the research department with its goal of bringing new designs and products onto the market. A process that bridges the design stage to the prototype phase is the curation of composite components within an industrial autoclave. The curing process is susceptible to bubbling due to the high temperatures. Once the bubbles on the material burst the component becomes damaged and is no longer a viable prototype. The pressure sensors within the autoclave alert the employee when there is a significant change in the environment due to bubbling, unfortunately this alert comes too late, after the material bursts. To aid with the curing process, this Capstone project aimed to provide live visual data of the component that allows the employee to adjust the temperature and pressure settings as needed. This was accomplished by designing a high-temperature and high-pressure container that houses a camera livestreaming the entire curing process. By utilizing both a water glycol and air-cooling system the container can withstand temperatures of up to 700 °F and pressures of 200 psi.

29 AUTOMATED COMPOSITE ROD SORTING

PROJECT SPONSOR: NORTHROP GRUMMAN CORPORATION

COACH: JASON CARLING

TEAM MEMBERS: Taylor Anderton, Ammon Shaw, Austin Erickson, Zach Driskill, Layne Haskell, Braden Wagstaff, Gail Hludzinski

DESCRIPTION: Northrop Grumman is an aerospace company that, among many other things, manufactures rocket motors. The manufacturing process requires the use of thousands of long, thin rods that need to be inspected between uses. The rods are currently inspected by hand, which is a slow and time- consuming process. The team was tasked with designing an automated process for the inspection and organization of these rods. We designed a machine that uses computer vision to get data from a rod as it rolls down a table, and then classify the rods as good or bad and sort them accordingly. This design proved to be an inexpensive solution that Northrup Grumman will continue to develop until it is completed. When this system is fully implemented it will increase the accuracy of rod sorting, increase the productivity of the manufacturing process, and free up engineers to spend their time on more difficult tasks.

30 FIBER WEAVING INSPECTION SYSTEM

PROJECT SPONSOR: NORTHROP GRUMMAN CORPORATION

COACH: KENNETH BEAN

TEAM MEMBERS: Vance Radford, Caleb McDougal, Brayden Salisbury, Don Cromarty, Rowan Rhees, Ryan Watson

DESCRIPTION: Northrup Grumman manufactures three-dimensional carbon fiber preforms, using an old machine that tends to bend the rods that hold the fiber in place. Bent rod defects can lead to system downtime and fiber voids. Quantifying rod deflection is extremely reliant on operator intuition to identify. The team's project was to research the validity of using a vision system to inspect rods and quantify deflection in the rods. This was done by constructing a replica test bed of the machine that could house a camera and lighting system, allowing the team to develop a vision system for rod inspection. The team also developed a visual output for the data, a radial chart, allowing for easy identification of rods with large deflection.

31 ACRYLIC AWARD SANDING AUTOMATION

PROJECT SPONSOR: OC TANNER

COACH: ALMY HOLLIS

TEAM MEMBERS: Parker Topham, Ethan Hall, Andreas Lehmann, Camilla Cave, Taylor Owens

DESCRIPTION: O.C. Tanner is a company in Salt Lake City that promotes employee satisfaction through manufacturing a variety of custom employee recognition awards. A popular award is acrylic numerals. These acrylic awards begin as blocks that are CNC milled into a number, sanded on one side, laser engraved, then printed on. An evenly sanded surface is critical to the printing process and allows the printing ink to stick to the surface of the acrylic piece. The team's objective was to automate the sanding portion of this process, which is currently done by hand, so that the operator only needs to load a part and click the start button. Through various prototypes and testing, as well as gathering operator input, the team designed, built, and tested an automated sanding process that meets the sanding quality requirements and runs with just one button. The machine sanding time is comparable to the manual sanding time but allows operators to complete other tasks while the machine is running. An emergency stop and other safety considerations were included to maintain a safe working environment.

32 PROJECT SOOTHE

PROJECT SPONSOR: OWLET INC.

COACH: HANS OTTOSSON

TEAM MEMBERS: Nathan Jones, Ben Boyack, Eric Christie, Emma Frost, Ashley Quinn

DESCRIPTION: Owlet Care has developed the Dream Sock which helps parents monitor their child's health while they sleep. Nocturnal (Team 32) was asked to create a sound and light machine with a capacitive touch interface that can be integrated with the Dream Sock 's Base Station. Our team's new product can play a variety of soothing sounds and display over 256 colors of light to help babies sleep well at night. Users can change the current song, volume, color, and brightness using the capacitive touch user interface. This interface makes it easy for parents to hold their baby in one hand and control the device in the other. The device is built around Owlet Care's Dream Sock architecture and will be integrated into Owlet Care's Base Station to create a new product.

33 ORTHODONTIC PALATE EXPANDER MECHANISM

PROJECT SPONSOR: DR. MICHAEL PAYNE

COACH: STEPHANIE ARGYLE

TEAM MEMBERS: Matty Davis, Hailey Jones, Braden Trejo, Stuart Storheim, Alison Thurman

DESCRIPTION: Adults that need upper palatal expansion have a choice between the current Miniscrew Assisted Rapid Palatal Expander (MARPE) or expensive and invasive surgery. People who would most benefit from the less expensive MARPE are those with exceptionally narrow palates. However, they are unable to utilize this device because it is too wide to fit into their narrow palate. The team was tasked by Dr. Michael Payne to design a new type of expander specifically tailored for this group of people. The team successfully developed an expander that has a starting width of 8mm and has an expansion capability that surpasses the original device. This will significantly help adults who require this procedure but are limited by the narrowness of their upper palate. It will offer an alternative to surgery, mitigating potential complications associated with surgical procedures and reducing costs for individuals involved.

34 AMBIENT CRYOGENIC FLUID VAPORIZER

PROJECT SPONSOR: RAWHIDE LEASING

COACH: BRAD ADAMS

TEAM MEMBERS: Matt Parry, Adam Niver, Hunter Smart, Spencer Larson, Julia Borsky, Greg Hirst

DESCRIPTION: Rawhide Leasing provides temporary and portable natural gas for customers. The natural gas is transported as a liquid but must be quickly turned into a gas by running it through a vaporizer. The team was challenged to design and manufacture a portable, unpowered vaporizer that transitions cryogenic liquids into gas. The team introduced an innovative fin cross-section design that allowed for easier assembly, more robust interfaces, and maximized heat transfer. A specialized die was designed and produced, tailored to the unique vaporizer design, streamlining the production process. One of the most significant advancements in the project was the integration of 3M VHB Tape as a replacement for traditional aluminum welds. This strategic decision reduced costs and significantly decreased assembly time. The 3M VHB Tape was tested under extreme conditions by the team, including at temperatures as low as -300°F, ensuring its reliability for the cryogenic vaporizer. The team also followed all applicable ASME and NFPA codes, as the vaporizer is pressurized at approximately 400 psi. A full test system was also designed, which included pressure gauges, temperature sensors, a volumetric flow meter, and a manifold to connect to a cryogenic fluid supply.

35 SMART HOME NO BOIL-OVER POT

PROJECT SPONSOR: REAL-TIME COLLABORATION INC.

COACH: TERRI BATEMAN

TEAM MEMBERS: Christian Hales, Zach Hilton, Shule Thoreson, Jason Finch, Sarah Bradshaw, Julia Routh, Bailey Naatjes

DESCRIPTION: Real Time Collaboration acknowledges the common challenges individuals face in the kitchen, particularly risks and problems that come from pots boiling over. To address this issue, our team developed a system to prevent boil-over and automate the cooking process. Our innovative design incorporates a precise burner dial and lid control system, which enables the user to cook food without constantly monitoring it. The lid incorporates a smart handle equipped with sensors to collect data during the cooking process. This handle then talks to the burner dial which regulates the stove's heat input to maintain water at boiling without the risk of boiling over. Our primary focus is to create a design that prioritizes ergonomics, utilizes food-safe materials, and seamlessly integrates into any household. With our system, we aspire to revolutionize cooking by automating it, thus ensuring safety, and enhancing the overall cooking experience for everyone.

36 CAMERA-AIDED INERTIAL MEASUREMENT UNIT

PROJECT SPONSOR: RINCON RESEARCH CORPORATION

COACH: LINCOLN JACOBS

TEAM MEMBERS: Joshua Nicoll II, McKay McFadden, Jake McCoy, Erik Villa, Kevin Richins, Riley Kirkwood

DESCRIPTION: Rincon Research Corporation has been developing a doppler-based geolocation platform to help locate radio frequency transmitters. This single platform mounted to a drone allows for the quick detection and pinpointing of lost hikers, natural disaster victims, and active emergency services. While the doppler-based system is more cost effective than other approaches, it is highly sensitive to changes in position and orientation. Our team's objective was to help mitigate sensitivity error by providing more accurate position data. Using a hobby-grade inertial measurement unit (IMU) commonly used on drones, we were able to correct the position data with camera-based position estimation through a Kalman filter. Verification of this data was achieved through a custom gimble platform designed to simulate drone movement with high accuracy.

37 HIGH FREQUENCY EXTENSION FOR BASE EXCITATION SHAKER

PROJECT SPONSOR: SANDIA NATIONAL LABORATORIES

COACH: MATT ALLEN

TEAM MEMBERS: Joel Gibb, Corry Price, McKaelin Edralin, Nick Harris, CJ Johanson, John Paul

DESCRIPTION: Sandia National Laboratories, the nation's premier science and engineering laboratory for national security and technology innovation, conducts vibration testing of components to qualify designs for transportation on vehicles such as rockets, aircraft, and automobiles. The testing demonstrates that the designs will survive the vibration environments they will be subjected to. Electrodynamic shakers, a device that generates controlled vibration through electromagnetic force, currently have a frequency limit of roughly 2000 Hz. Trying to test above that limit can lead to catastrophic failure of the shaker hardware. The objective of this project was to design, build, and test a configuration that integrates high frequency piezoelectric actuators into an existing electrodynamic shaker, enabling high-frequency vibration testing. The Capstone team designed an assembly which allows for a four to twelve piezo actuator configuration. Piezo actuators are sensitive to strain. The team simulated the test configuration in MATLAB and ANSYS as design tools to prevent overstraining the piezo actuators and mounts during vibration excitations. Incorporating a variable piezo actuator configuration allows for tailoring of the test configuration to achieve the desired frequency range depending on the test article.

38 READY-FOR-LAUNCH CUBESAT

PROJECT SPONSOR: SPACE ZERO GRAVITY

COACH: DAVID DRAPER

TEAM MEMBERS: Marshall Butler, Jacob LeFevre. Mike Olson, Jonathan Davis, Will Hart, Woodson Parker, Trevor Wiseman, Giovanna Nuccitelli, Kimi Wright

DESCRIPTION: Small satellites, especially "CubeSats" are becoming popular projects among universities and small companies because of their relatively low cost for development as well as recent creation of CubeSat standards that aid the design process. The team's task was to design an affordable and reliable CubeSat in conjunction with Space Zero Gravity to be launched into space at the end of 2024. The team built a mechanical structure to house the onboard computer, programmed a radio to communicate with a ground station, and custom designed solar panels to power the spacecraft. In addition, the team coordinated with US regulatory agencies to get the satellite officially licensed and ready for launch. Once launched, the satellite will act as a beacon and HAM radio repeater so amateur radio operators from around the world can communicate with it as it orbits over them. The team chose low power flight hardware with proven flight heritage to mitigate risk and allow for a variety of payloads to be flown in the future. The design can be easily reproduced and adapted to various payloads, allowing Space Zero Gravity engineers to develop their own missions without having to restart a design from scratch, saving significant time and money on development for future projects.

39 CUSTOMIZED PART AUTOMATION

PROJECT SPONSOR: TOYOTA MOTOR NORTH AMERICA

COACH: ARON MADSEN

TEAM MEMBERS: Wyatt Johnson, Jake Sutton, Mark Thomas Watson, Kaden Gehrke, Ryan Chiang, Gavin Goodson, Cooper Tribett

DESCRIPTION: Toyota Motor Company has a long-standing reputation for reliability and durability in the automotive industry. Toyota aimss to continue to lead the future of mobility by allowing customers to put an imprint of their images and logos on various car parts. The team's objective is to create an automated software program that vectorizes a customer's image, allows for image positioning and sizing adjustments (scaling), and generates a customized CAD model. This was accomplished this by creating an Autodesk Fusion Add-in that allows the user to upload the desired image or logo and place it within a specified customization zone on an existing Toyota car part model. This Add-in will eliminate 6 hours of Toyota employee work time per customized image and allow Toyota to fulfill the North American market demand for mass customization.

40 DISPENSED BEAD INSPECTION SYSTEM

PROJECT SPONSOR: TOYOTA MOTOR NORTH AMERICA

COACH: ROB CLOWARD

TEAM MEMBERS: Eduardo Ibanez, Jordan Penfold, Preston Draper, Michael Sampson, Sam Kochevar, Isaac Parker

DESCRIPTION: Toyota Motor North America is committed to making great cars and trucks. In the manufacturing of a vehicle, it is necessary to apply a variety of dispensed sealants and adhesive materials to achieve part joining, noise and vibration management, etc. Automated (robotic) dispensing systems are a widely used application method for these materials in the automotive industry. Confirming the correct location and quality of these dispensed materials is an important requirement to ensure customers receive high-quality products. In a typical automotive welding shop, manual inspection of dispensed materials is a time-consuming task due to the large number of robots and the substantial amount of material used. The team's project was to design, prototype, and test an automated vision-based inspection system to inspect beads of dispensed material and assess their suitability in real time directly after the bead has been dispensed. Our in-line automated inspection system offers several advantages: it is cost-effective compared to current commercially available inspection solutions, it can accurately inspect the width, height, and presence of adhesive beads; and it can analyze three millimeters of applied adhesive per second. This system saves time and enables more continuous monitoring of production conditions.

41 AUTOMATED DUPLEX NAIL PULLING MACHINE

PROJECT SPONSOR: TRESTLEWOOD

COACH: KEN HARDMAN

TEAM MEMBERS: Blake Crosby, Jonathan Baird, Christian Olsen, Robert Macdonald, Ben Ellis, Parker Gillins

DESCRIPTION: Trestlewood is a company that sells Nature-Aged wood for use in architecture and design. As part of their process many planks of wood are crafted into pallets of varying lengths using duplex nails. The company found a bottleneck in the process as they went to remove the duplex nails to prepare the planks for sale. This was the task for the team, to create a machine that can automate and speed up the nail removal process. The team needed to create a machine that could remove nails that had multiple changing variables. The nails could be at different heights, angles, and even positions. To accomplish this, the machine incorporates a compliant system to handle the position with a live sensor to detect when the compliant system has led the machine head to a nail. The head of the system is then used to pull the nails through a pneumatic cylinder. This machine will help Trestlewood by allowing them to both reduce the personnel required to complete the task, without slowing down the process. The design can also be easily reproduced allowing Trestlewood to run multiple in parallel. This reduces Trestlewood's bottleneck on their signature Nature-Aged wood.

42 BATTERY BACKKUP FOR TRAFFIC CONTROL SYSTEMS

PROJECT SPONSOR: UTAH DEPARTMENT OF TRANSPORTATION

COACH: RICHARD GEE

TEAM MEMBERS: Aaron Merrill, Dallin Funk, Gage Jensen, Lily Prusso, Michael Nielsen

DESCRIPTION: The Utah Department of Transportation's (UDOT) Traffic Management Division oversees the deployment of advanced integrated traffic system (ITS) technologies to enhance transportation mobility, safety, and customer satisfaction. As part of a consultant-led study aimed at improving ITS devices, the division is seeking a reliable Battery Backup System (BBS) and a dashboard for battery monitoring software for various traffic sites, with a particular emphasis on Closed Circuit Television (CCTV) and Traffic Management System (TMS) combined sites. The objective of this project was to ensure the uninterrupted functionality of ITS sites in Utah during significant power outages, thereby bolstering public safety. Our design uses a supercapacitor and uninterruptible power supply (UPS) to serve as a backup power system for these sites. The use of a supercapacitor greatly reduces costs and increases run time after outage to double the requirement given to us by UDOT. Our team developed a sophisticated dashboard for real-time battery monitoring, facilitating efficient oversight of multiple sites. This user-friendly interface offers advanced search capabilities, supporting proactive maintenance and resource optimization. Benefiting UDOT and the community, our project enhances public safety and operational efficiency. By ensuring uninterrupted functionality, we contribute to smoother traffic flow and technological advancement in transportation infrastructure.

43 HIGHWAY SHOULDER DROP-OFF ESTIMATION

PROJECT SPONSOR: UTAH DEPARTMENT OF TRANSPORTATION

COACH: KEVIN RUST

TEAM MEMBERS: Christopher Santos, Derek Ward, Xan Johnson, Jared Landetta, Jessa Robinson, Ashlyn Bell

DESCRIPTION: Utah Department of Transportation (UDOT) oversees assessing shoulder drop-off conditions throughout Utah to mitigate the risk of injuries when drop-off conditions exceed a safe threshold. These conditions are currently being examined visually or by hand, which is time-consuming and inaccurate. UDOT has partnered with a vendor to collect light imaging data (LiDAR Data) for all the roads in Utah with hopes of being able to use some of the features to assess all roads digitally. The team's project was to determine if this LiDAR data could be used to develop a framework to analyze sections of road, section it off, detect where the road drop-off is, and classify the severity of drop-off so that it can be projected as a heat map. This framework has been proven to work with common-case roads throughout Utah and shows that this type of data can be used to greatly increase UDOT's efficiency when it comes understanding road conditions at-a-glance to make the best corrective actions.

44 ENGINEERING DESORPTION CHAMBER

PROJECT SPONSOR: VAREX IMAGING CORPORATION

COACH: TYLER JENSEN

TEAM MEMBERS: Bryant Jepsen, Tyler Hutchinson, Ryan Hanson, Will Mickelson, Caio Farias, Kaleb Ho Ching

DESCRIPTION: Varex Imaging is a leading supplier and manufacturer in X-ray tubes. All components used in X-ray tubes must be high quality materials and remain extremely clean. A part that has been contaminated with water, manufacturing fluids, fingerprints, or any other contaminant will inhibit the correct function of the tube. To ensure only properly clean parts are used in each assembly, an automated desorption chamber will test the level of contamination on each part before assembly. The desorption is facilitated using six Quartz-Tungsten emitters to heat the part with IR radiation to 650oC (about 1200oF) and a two stage Pfieffer vacuum pump system to achieve a system pressure of 1x10-8 Torr (about 1x10-11 atm). The automation is handled by a custom LabView program to monitor and control the heating, vacuum, and measure the molecular composition of the contaminant gases as they are removed. Our system provides specific data on what contaminant is present using a residual gas analyzer, which is integrated into our program's user interface. This is estimated to save Varex Imaging $30,000 per tube assembly saved from contamination due to the material waste and the cost of reassembly.

45 TUBE CONDITIONING MOTION DRIVER

PROJECT SPONSOR: VAREX IMAGING CORPORATION

COACH: RICHARD GEE

TEAM MEMBERS: Javin Gudmundsen, Chandler Boss, Joshua Hollis, Jordan Porter, Aldo Chipana, Stockton Antczak

DESCRIPTION: Varex Imaging specializes in the manufacture of components for x-ray imaging systems. Part of the manufacturing process for the x-ray tubes involves conditioning (breaking in) the bearings by placing the x-ray tubes on processing stands and manually orientating them on two axes while the bearings are spinning. The team was tasked with creating an automated motion system that can be mounted to the x-ray tube processing stand to automate the positioning of the tube during the conditioning process. The team's solution involved two motors that mount to the processing stand's two axes of rotation. The system is controlled by a user interface that allows the user to input the desired conditioning settings. This allows the cart to be left unattended until the conditioning process is complete. This design eliminates the need for operators to manually reposition the x-ray tubes and reduces the time that the tubes are run in an already-conditioned orientation. This ultimately boosts the efficiency of the tube-conditioning process and reduces the overall time of conditioning the x-ray tube bearings.

46 SMART STROKE, OPTIMIZED CONNECTING ROD

PROJECT SPONSOR: VELA MOTOR COMPANY

COACH: RICH SMITH

TEAM MEMBERS: Joe Moore, Kai Jeffery, Wyatt Graham, Teighan Smyth, Darin Tietjen, Michael Linder

DESCRIPTION: In the last hundred years there has been little improvement in the internal combustion engine (ICE). ICEs operate inefficiently, leaving significant room for improvement. The Vela Motor Company focuses on creating a new piston and connecting rod design to increase these efficiencies. Approximately two years ago, Luis Velazquez did just that when he made a breakthrough in piston technology by moving where the connecting rod connects to the piston for an improved mechanical advantage during the power stroke. Unfortunately, two weeks later he passed away. Our mission was to understand and verify Luis's current design and improve upon it by reverse engineering his connecting rod. We have found that it lengthens the period of the power stroke and increases the compression ratio. This combination increases temperature and pressure allowing the fuel to combust more fully, improving efficiency and emissions.

47 LEVEL TWO HYBRID ROCKET MOTOR TEST STAND

PROJECT SPONSOR: BYU MECHANICAL ENGINEERING

COACH: NATHAN MCMULLIN

TEAM MEMBERS: Riley Brown, Derrick Walker, Clayton Armstrong, Joshua Taylor, Blake Jensen, Noah Cahill, Matt Bozer, Dallan Trentman, Scott Tuley

DESCRIPTION: This project was to create a hybrid rocket motor and a test stand to provide a secure test set-up for this and future motors. This project lays the foundation for the development of hybrid motors, eventually to be used in the hybrid category of the Spaceport America Cup, an intercollegiate rocketry competition. The test stand was designed to safely secure the motor and accurately collect thrust, temperature, and pressure data throughout the system. Additionally, test software was developed to collect data, actuate all valves, and provide safety abort protocols. A hybrid Rocket motor uses a solid fuel and a liquid oxidizer. Our motor uses Nitrous Oxide as the oxidizer and paraffin wax as the fuel. The motor was static fired two times, achieving an impulse and average thrust of 1990 Ns and 110 N for the first fire and 2597 Ns and 170 N for the second fire. The variation is attributed to ambient temperature difference between test days. This project helps the BYU Rocketry Club to ultimately develop a hybrid flight vehicle to compete at the Spaceport America cup.

48 WIND TURBINE DESIGN

PROJECT SPONSOR: BYU MECHANICAL ENGINEERING

COACH: STEVE WILSON

TEAM MEMBERS: Jefferson Santos da Silva, Joseph Hewett, Ethan Cluff, Dillon Jensen, Kolby Smith, Hunter Pitchford, Davi Ferrazza Cavinatto, Olivia Salton, Juan Cuevas, Hannah Ireland, Katie Price

DESCRIPTION: The Collegiate Wind Competition (CWC) is a nation-wide competition that encourages undergraduate students to learn and apply principles regarding wind as a renewable energy source. With the sponsorship of BYU Mechanical Engineering professor, Dr. Andrew Ning, the BYU Wind Energy Team and Club participated in CWC by building a functioning model wind turbine, recording design decisions, making a proposal for a mock wind farm, and reaching out to schools and industry professionals to learn and teach wind energy principles. The BYU Wind Energy Capstone team focused on the turbine design and split into four different sub teams. The teams were focused on foundation durability, efficiency of blade design, control of turbine functions, and power generation and output. Our goal was to design a turbine that would score 80% of the possible points in turbine testing, as outlined in the CWC rules handbook. We accomplished this goal by creating an auger type foundation that is reinforced by vibration of the sand around it, designing blades that have a coefficient of power of 34%, implementing a feed back control loop, and making a variable resistive load. This design challenge helped prepare members of our team to be better prepared to enter the wind energy industry and helped advance the BYU Wind Energy club in its goal of excellence in the CWC.

49 UNIVERSITY ROVER CHALLENGE

PROJECT SPONSOR: BYU ELECTRICAL AND COMPUTER ENGINEERING AND BYU MECHANICAL ENGINEERING

BYU Electrical & Computer Engineering

BYU Mechanical Engineering

COACH: BRAD ADAMS

TEAM MEMBERS: Ross Beeson, Mihai Stanciu, Jacob Moore, Ben Wright, Ian Reid, Joey McConkie, Joseph Heal, Brandon Sutherland, Noah Peterson, Spencer Stowell, Spencer Mosley, John Carmen, Luke Zollinger, Trevor Reay, Ben Duncan, Cameron Stoker, Carson Moon, Marc Killpack (Coach), Ben Broce, Ethan Smith, Phineas Jensen, Aaron Thomas, Jackson Harwood, Caleb Betteridge, Grant Thompson

DESCRIPTION: The BYU Mars Rover Team is a multidisciplinary group consisting of Software, Mechanical, Electrical, Computer, and Manufacturing Engineers. We participate in the annual University Rover Challenge at the Mars Desert Research Station in Hanksville, Utah alongside 35 other universities from around the world. The four competition tasks include Science, Equipment Servicing, Extreme Retrieval and Delivery, and Autonomy. This year our team has enhanced the rover's ability to complete these tasks through a variety of technical solutions. For example, we completely redesigned the Science module to enable sub-surface sample collection at depths up to 15 cm, built a custom drone to decrease the search time required for the Retrieval task, and did a ground-up redesign of the mock lander to enhance our ability to practice for the Equipment Servicing task. Nor has Autonomy been left out – some of our most groundbreaking work has been developing new obstacle avoidance and object detection algorithms required for this software-heavy task. Through these and dozens of other small but significant improvements, our rover is more prepared than ever to show how capable, consistent, and competitive the engineers are at BYU.

50 SAE FORMULA ELECTRIC ACCUMULATOR SYSTEM

PROJECT SPONSOR: BYU MECHANICAL ENGINEERING

BYU Mechanical Engineering

COACH: MARK COLTON

TEAM MEMBERS: Max Romney, Zach McKell, William Whiteley, Landon McNeil, Alex Gold, Nathan Butler, Grant Swenson, Evan Lazalde, Cole Clawson, Barrett Wilson

DESCRIPTION: BYU Racing competes in Formula SAE, an international collegiate motorsports and design competition. At the team's last competition in 2012, they achieved victory in the Hybrid category. This year, BYU Racing returns, now competing in the Electric category. The capstone team has developed a high voltage battery (Accumulator) to provide power to the vehicle at competition. This battery was developed with the goal of passing all event technical inspections, conforming to BYU safety standards, allowing for safe and simple function, and providing enough power to complete every dynamic event at competition. The battery is made up of 480 Lithium-ion cells and has been custom designed and fabricated to meet stringent competition rules. Each cell is connected using custom fusing. The pack is made up of 8 50-Volt modules, which allows them to be handled safely during maintenance and transport. Modules are monitored and controlled by an Orion 2 Battery Management System, along with significant safety circuitry. The battery system is housed in a custom aluminum container and is cooled by industrial-grade Noctua fans. Overall, the pack weighs 125 pounds and provides 7.8 kWh of capacity to drive the race car.

51 SUPERMILEAGE ENGINE IMPROVEMENTS

PROJECT SPONSOR: BYU MECHANICAL ENGINEERING

BYU Mechanical Engineering

COACH: CARL SORENSEN

TEAM MEMBERS: Ben Taylor, Parker Nunley, David Leavitt, Josh Sheffield, Adam Allinson, Garret Smith, Austin Kofoed

DESCRIPTION: The Capstone Supermileage Performance Team designed and built a highly efficient engine to improve the performance of the BYU Supermileage competition vehicle. The competition vehicle is used for the Shell Eco-marathon Americas Competition, where students compete to create the most efficient vehicle. The higher the engine efficiency the higher the MPGs. To achieve this goal, the team used a test stand to measure key parameters such as engine power, friction, volumetric efficiency, and shaft output efficiency. These parameters aided in narrowing the design concepts best improve engine performance. The design concepts selected this year were an offset cylinder, a new intake manifold, and an optimized cylinder head. The offset cylinder shifted the cylinder hole 8.3 mm from center to reduce the thrust force therefore minimizing the friction in the engine. The new intake manifold was optimized by changing the radius of curvature of the flow path to reduce intake losses and adjusted the fuel injector location to improve fuel mixing. The cylinder head was altered to best utilize the improvements of the intake manifold. Implementing the above design changes, the efficiency of the engine improved from 17% to 20.3%.

52 BAJA POWERTRAIN AND REAR SUSPENSION

PROJECT SPONSOR: BYU MECHANICAL AND MANUFACTURING ENGINEERING

BYU Manufacturing Engineering

BYU Mechanical Engineering

COACH: YURI HOVANSKI

TEAM MEMBERS: Joshua Forsgren, Jeff Peterson, Ryan Jurges, Kalon Gluch, Denver Toner, Yuri Hovanski, Joe Broadhead, Tanner Lowe, David Word, Dallin Gariety, Garrett Tapia

DESCRIPTION: Baja SAE is an annual competition with five major events: acceleration, maneuverability, rock crawl, hill climb, and endurance. Teams are awarded points within each event with the most points being awarded to the endurance race. Our objective was to build subsystems that would have competitive acceleration, maneuverability, and durability as well as integrate with the BYU Baja club's current car design. We decided to redesign the suspension and powertrain subsystems because we believed it would have the largest impact on our acceleration and durability. We have incorporated a gearbox that would more efficiently transfer torque and increase our acceleration. We have incorporated a three-point suspension design to reduce weight in the rear, thereby increasing maneuverability, while also making the subsystem more durable through redesigned mounting points. Also, we have incorporated reverse gears to further increase maneuverability all while maintaining the car's initial weight. The suspension subsystem is also symmetric to further streamline manufacturing and ease of installation into the vehicle.

CAPSTONE TEAM SUPPORT NETWORK

INSTRUCTING PROFESSORS

Four engineering professors serve as instructors for the course, providing technical oversight to every team. They teach lectures, lead design reviews, and oversee all teams.

FACULTY COACHES

Each team is mentored by a dedicated faculty coach. Coaches provide mentorship and leadership, assisting teams with soft skills, pointing them to technical resources as needed, and guiding them through the product development process.

EXTERNAL RELATIONS MANAGERS

External Relations Managers are seasoned engineers who work with sponsors to define projects, advocate for sponsors throughout the project, and assist student teams to ensure sponsor needs are met.

SUPPORT STAFF

Capstone teams are supported by a full-time staff who manage purchasing, arrange travel, plan and carry out events, and handle the day to day details of administering the Capstone course.

SPONSOR LIAISON ENGINEERS

Each Capstone sponsor designates a liaison engineer (or engineers) to work with the Capstone team. The liaison engineer communicates with the team about an hour each week, usually remotely. Liaison engineers assist the team in understanding the changing needs of the sponsor, the technical needs of the project, and the sponsor's priorities.

SPONSORS

Sponsors form the foundation of our Capstone program. Real-world projects provide experiential learning that cannot be duplicated in the classroom. Sponsors provide functional requirements and technical challenges that inspire students to investigate, experiment, and evaluate solutions.

READY TO SPONSOR?

HERE'S WHAT YOU NEED:

1. $22K SPONSORSHIP FEE payable as an educational grant.

2. A LIAISON ENGINEER who communicates with the team regularly.

3. A REAL PROJECT that is specific in outcome but open-ended in process that would take approximately 400-600 hours in-house.

CURIOUS? VISIT CAPSTONE.BYU.EDU

TO DISCUSS YOUR PROJECT IDEAS OR INITIATE A PROJECT, PLEASE CONTACT:

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