College of Engineering & Computational Sciences

Capstone Design@Mines Showcase

MINES™

April 26, 2018

COLORADOSCHOOLOFMINES
EARTH • ENERGY • ENVIRONMENT

A Special Word of Thanks to Our Judges

It is my pleasure to offer a personal welcome to the judges of the Spring 2018 Colorado School of Mines College of Engineering and Computational Sciences Design Showcase. We appreciate your willingness to take time from your normal activities to evaluate our seniors' capstone design projects. The opportunity for our students to get feedback from experienced engineers is invaluable.

CECS Capstone Design@Mines allows our students to demonstrate the engineering knowledge that they have spent four or more years acquiring. We encourage you to spend time with the design teams and to inquire about their projects and their designs. But also ask about their design process, because in the final analysis, capstone design is as much about learning the process of design as it is about creating a design. As these students enter the workforce, it is their ability to use the design thinking methods that they have learned that will serve them most in their careers.

We are proud of our students and their accomplishments and hope you are equally impressed. If you would like to get more involved in our program, we are always in search of more project sponsors. Let us know!

Again, thank you and happy judging!

Kevin L. Moore
Dean, College of Engineering
& Computational Sciences

SUPPORTING THE PROGRAM

The Capstone Design@Mines Program relies on the generosity of our program supporters to fund our intercollegiate competition teams and community development projects, as well as to outfit the Design Laboratory. If you or your organization are interested in supporting these elements of the program, please consider making a financial gift through the Mines Foundation or via giving.mines.edu. Make sure to clearly mark your gift for *CECS Capstone Design@Mines*. Your gift is tax deductible and will make a huge impact on our students.

Colorado School of Mines thanks the organizations, families, and individuals listed below who have provided valuable support to the students presenting today.

PROGRAM PARTNERS $25,000 +	J. Don Thorson
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PROJECT SPONSORS

Colorado School of Mines thanks the individuals and organizations listed below who have served as clients for the student teams presenting today. Your donation of time, talent, and material support to our students are *greatly* appreciated.

Adams County

The ADAPT Center at Mines

Ball Aerospace

Paul Brayford

City of Golden

Creatio

The Denver Zoological Foundation

Division of Energy & Mineral Development, U.S. BIA

Dym Textiles

Dr. William Fleckenstein

Formula SAE Club at Mines

Garlock Pipeline Technologies, Inc.

Gates Corporation

The Greenway Foundation

Haury Farms

Human Centered Design Studio at Mines

The Invictus Initiative

Kiewit Corporation

Mr. Spencer McGinnis

Medtronic

Mines Little Theatre

National Renewable Energy Laboratory

NEI Electric Power Engineering

Playing for Change

Primo Filters

Prosparity Systems

Quality of Life Plus

Shell

Sierra Nevada Corporation

TRS Prosthetics

Dr. Paulo Tabares

University of San Francisco

U.S. National Park Service

Veteran's Affairs

Virtjoule

Woodward, Inc.

BECOMING A SPONSOR

The Capstone Design@Mines Program pushes students to go beyond their classroom training and solve real-world design problems. Every semester the college has over 60 student design teams who need great challenges to engage with. What opportunities does your organization have that could be addressed by a student team?

SPONSORSHIP FEE

Corporate project sponsors pay a sponsorship fee, of which up to half is available to the student team for purchasing materials. The remainder supports program facilities, staff, and overhead. Government agencies, NGOs, and other community groups pay a drastically reduced fee and also cover the cost of project materials.

TIME COMMITMENT

The involvement of the project sponsor is a key factor in the success of the project. Great project sponsors will commit approximately one-hour per week to support the student team. In addition, we also welcome any training or on-site resources that you can make available to the students.

GETTING STARTED

Check out our website at http://capstone.mines.edu/ for additional information on becoming a sponsor or send an email to design@mines.edu to start exploring opportunities with program staff.

General Information – Design Showcase

JUDGE'S AGENDA

Time	Description	Location
7:30 – 9:00	Breakfast reception sponsored by the CSM Foundation	Student Center Ballrooms
8:30 – 9:00	Judge Registration/Check-in	Lockridge Arena
9:00 – 11:00	Design Showcase	Lockridge Arena

FINDING YOUR WAY AROUND

A floor plan of the Trade Fair is available on the back of this program for your convenience.

JUDGES' LOUNGE

Snacks and beverages are available for judges in the Judges Lounge. Please feel free to take a break from talking with the teams and grab a beverage or snack in the lounge at any time.

SCORING

We seek to achieve consistency in grading between judges. With that in mind, the Capstone Design faculty have developed the scoring ballot to aid your judging. Each row includes prompting descriptions to guide the evaluation process. Each description has an associated point value.

To completely grade a team, please select a single number from each row of the scoring ballot. Sum the numbers (one from each row) and enter the total team score at the bottom of the ballot. Please return the form to the registration table when it is complete. If you opt to use the electronic ballot, scores will automatically tally; you do not need to provide any additional calculations.

Spring 2018 Design Projects

This semester, we are proud to present the work of **58 design teams** at the 2018 CECS Capstone Design@Mines Showcase. A list of the teams is provided below. In addition, each team has provided a short synopsis of their design challenge, which you will find in the following pages.

Team Number	Project	Team Number	Project
01	Downhole Tractor	**18**	Replicable Water Reuse System
02	Laser Confocal Microscopy for 3D Printed Metal Parts	**19**	Solar Farm Design for Closed Landfill
03	Shell Eco-Marathon Competition	**20**	Nepal School Renovation Project
04	Large Ball Frac Sleeve System	**21**	Net Zero Energy Home Design
06	Transmission Line Design Challenge	**22**	Lightning Suppression with Flange Isolation Monitoring
07	Manual Beach Wheelchair	**23**	Seismic Wall Sleeve Challenge
08	Curb Traversing Wheelchair	**24**	Lena Gulch Floodplain
10	Passive Cooling Project	**25**	Pulse Oximetry Test Device
11	Black Canyon of the Gunnison South Rim Water Supply	**26**	Modular Theater Set Design
12	Recumbent Trike Loading Device	**27**	Water Turbine Test Kit
13a	HCDS: Climbing Holds for Athletes with Visual Impairments	**28**	High-Volume, Portable Water Filtration System
13b	HCDS: Flat Water Kayaking Course for Visually Impaired Veterans	**29**	Service Rover Vehicle
13c	HCDS: TRS JAWS Prosthetic Hand	**30**	Winglet for PC-12 Aircraft
13d	HCDS: More Comfortable Shorty Sockets	**31**	Smart Home Monitoring System
13e	HCDS: Rear Brake Relocation	**32**	Energy Efficiency Retrofit - Guggenheim
13f	HCDS: Osseointegrated Implant Activity Monitor	**33**	Second Gen. Comfort-Sensing Robot
13g	HCDS: Snowmobile Seating System	**34**	Energy Efficiency Retrofit - Chauvenet Hall
14	Chassis Dynamometer Challenge	**35**	RF Antenna Project Part 2
15	Clean River Design Challenge (Team Dream Stream)	**36**	Field Networked Inclinometer
16	Clean River Design Challenge (Team Go with the Float)	**37**	Vibration Reduction Vehicle
17	Ayaviri Household Heating Project	**38**	Zoo Lights Panel Design & Light Structure

Continued on next page

Team Number	Project	Team Number	Project
39	Earthquake Resilient Classrooms in Nepal	**47**	AIAA - Design Build Fly
40	Military Vehicle Testing Platform	**48**	NASA Robotic Mining Competition
41	Food Conveyor Clean-In-Place System	**49**	ASCE Concrete Canoe Competition
42	Pump Conversion Challenge	**51**	AISC/ASCE Steel Bridge Competition (Team Steel Standing)
43	Motorcycle Front Suspension Redesign	**52**	AISC/ASCE Steel Bridge Competition (Team Euler)
45	Portable Electronic Generator	**53**	SpaceX Hyperloop III Competition
46	NASA Mars Ice Drilling Challenge	**54**	Bushing Design for Belt Power Transmission

F17-01 | Downhole Tractor

Team members:
Trevor Antrim
Sean Bell
Christopher Campbell
Christian Peterson
Frederico Rosendo
Trevor Thompson

Advisor & consultants:
Dr. Tom Cilke
Dr. Alfred Eustes

Sponsor:
Dr. William Fleckenstein

SPARROW ONE

Hydraulic fracturing is an increasingly common technique for accessing oil and natural gas reserves. Modern wells are frequently drilled horizontally in order to have greater access to energy resources. Sparrow One was presented with the challenge of building a device that could extend the reach of these horizontal drilling sections by providing forward thrust downhole.

The most common practice for shale development is “plug and perf” which involves dividing the horizontal well into multiple stages separated by plugs. After stimulation, these plugs must be drilled out in order to produce the oil and natural gas. Current tractors that may be used to drill out these plugs are slow, lack continuous motion and have difficulty dealing with cuttings.

Sparrow One developed a downhole tractor that uses a unique system in order to provide linear continuous force through the downhole environment. The device is designed with a patent pending method to accomplish this.

The tractor is equipped to provide the additional force and traction required during the drilling operation and still allow fast movement when not in drilling mode.

F17-02 | Laser Confocal Microscopy for 3D Printed Metal Parts

In 3D printing, fabricated parts rarely match the CAD models due to thermal stresses, surface roughness, and warping. To characterize non-molten particles and surface features, a high resolution is necessary, particularly for metal 3D printed parts. Commercial microscopes with this resolution are limited within a few inches of travel and a small field of view, but 3D printed parts are often built in 12” x 12” x 12” dimensions or larger, leading to a plethora of parts that cannot be characterized. Our team was tasked with building a microscope for these surface metrology measurements. Working alongside the Mines Physics Department, our team recreated the state-of-the-art laser imaging system called the Spatial Frequency Modulation for Imaging (SPIFI) laser. This system encodes a spatial frequency over a 1-D laser line which allows more accurate and faster imaging over significantly larger parts. The SPIFI laser system was integrated with a 4 axes mechanical stage that manipulates the large 3D printed parts within a custom-built laser safe housing to create a fully operational microscopy system with movement ranges exceeding 12 inches in all directions. The controls and software are user-friendly, and well documented for future developments. This multidisciplinary project brought together computer science, physics, mechanical and electrical engineering into an operational system superior to anything on the commercial market.

Team members:
Brennen Burke
Keith Mody
Keaton Scheffler
Caleb Schelle
John Strang
Samuel Vaughn
Hannah Wright

Advisor & consultants:
Dr. Aaron Stebner
Dr. Branden Kappes
Dr. Jeffrey Schowalter
Dr. Jeff Squier

Sponsor:
ADAPT (The Alliance for the Development of Additive Processing Technologies)

adapt

F17-03 | Shell Eco-Marathon Competition

Team members:
William Austin
David Boldt
David Borkert
Korinna Copley
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Samuel DeAngelo
Jennifer Kendall
Alyssa Mendoza
Nicholas Poulter
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Chamai Shahim
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Kody Von Holdt
Tyler Perko
Garet Gavito

Advisor & consultants:
William Sekulic
Kyle Hilberg

Sponsor:
Shell Corporation

Every year, Shell sponsors a competition to encourage college and high school teams to develop innovative technologies that maximize car efficiency. Over four days, teams attempt to travel a course at Sonoma Raceway in California using the least energy possible. At the end of the competition, the team that completes the course with the highest efficiency wins the competition.

Team No Resistance from Mines designed and built a vehicle from scratch based on the guidelines in the 2017-2018 Shell Eco-marathon global rules. Our car, the Volts-Wagon, competed in the battery electric prototype class and is three wheeled with an aluminum chassis and fiberglass shell. A brushless-hub motor drives the rear wheel of the car forward and is powered by battery packs. Our goal was to complete seven laps for a total distance of 6.4 miles with an average speed of 15 mph around a road track with a vehicle efficiency of 213 miles/kWh. The Volts-Wagon is unique in that we encapsulated the wheels inside of the shell. This decreases the drag coefficient and allows our car to travel more efficiently. We also integrated a foot brake into our design in anticipation of future changes to the Shell Eco-marathon rules. In every subsystem the main focus was design function, weight reduction, and adherence to the global rules.

F17-04 | Large Ball Frac Sleeve System

There are currently two different ways to fracture a reservoir. The first is called plug and perf, where explosives are sent downhole to open the pipe to the reservoir so frac fluid may be sent out to open cracks in the rock formation. The second way requires a string of fracturing sleeves to be sent downhole, organized with the smallest inner diameter downhole and increasing diameters towards the surface. Specially sized frac balls are typically sent down sequentially to plug specific sleeves, causing the sleeve to open to the reservoir and allow fracking fluid to access the rock formation.

Team Frackenstein worked on a frac sleeve that can allow a uniformly-sized ball to pass through at high pressures, but catch the ball and activate the inner sleeve at low pressures. The design was based on a previous patent, FracOPTIMAL2.This design would allow multiple sleeves of the same diameter to be placed in succession, allowing only one size, dissolvable ball to be sent downhole. Having sleeves of the same diameter allows for a longer horizontal application creating a more profitable well.

Team members:
Karson Bell
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Werner Hagemann
Gage Jones
Aidan Sklenka
Kelly Snyder

Advisor & consultants:
Yosef Allam
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Dr. Bruce Craig
Dr. Ventzi Karaivanov
Dr. Jennifer Miskimons

Sponsor:
Will Fleckenstein

F17-06 | Transmission Line Design Challenge

High voltage transmission lines are used to transmit energy across great distances and supply reliable power to the public. Extensive protective systems must be employed to ensure reliability of the system as well as the safety of the general public and the power grid. Protective relays detect faults on the system, operate breakers to isolate affected equipment, and provide valuable diagnostic information. NEI Electric Power Engineering contracted the team to reconductor an existing transmission line outside of Las Vegas, update the protective relays at both remote substations, and provide a Supervisory Control and Data Acquisition (SCADA) scheme.

As part of the design, the team was required to utilize the existing transmission structures. The existing Aluminum Conductor Steel-Reinforced Cable (ACSR) Cardinal Conductor was replaced with Aluminum Conductor Composite Core (ACCC) Cardinal, a lighter conductor with a higher line capacity. The dual-primary protective relay scheme utilizes Schweitzer 311L and GE L90 protective line relays with communication over fiber optic via an overhead protective ground wire (OPGW). For Trade Fair, the team created a hardware setup of the updated system to demonstrate the relay's ability to open and close depending on simulated faults and send this information to a human machine interface (HMI) screen.

Team members:
Kristopher Lide
Ethan Ruby
Sam Fynes
Chandler Keyes
Emily Talbott
Kristin Beutel

Advisor & consultants:
Dr. Abd A. Arkadan
Dr. P.K. Sen

Sponsor:
Clifton Oertli, NEI Electric Power Engineering

F17-07 | QL+ Manual Beach Wheelchair

Team members:
Alexandre Blangy
Benjamin Clare
Abigail Eustace
Amy Kleynhans
Katie Kuhn
Mohamad Obeid
Madison Scott
Bryce Townsend

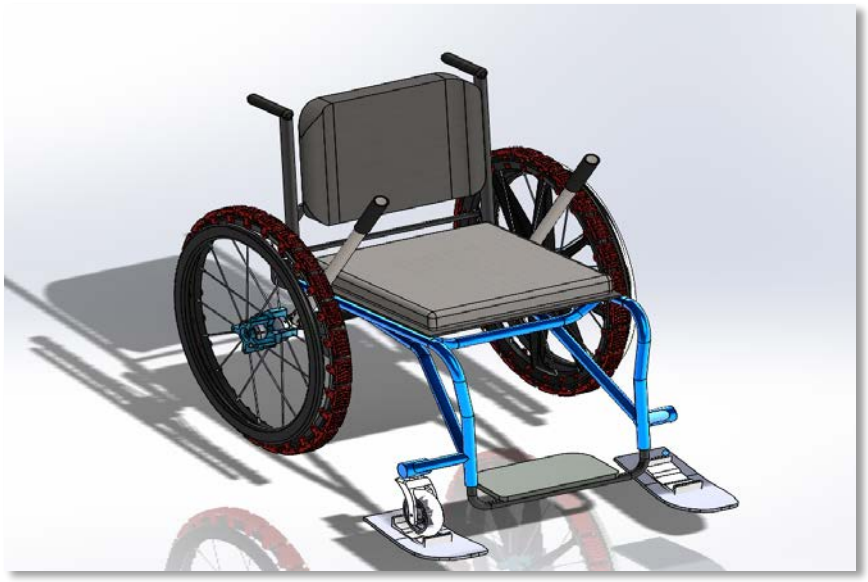
Advisor & consultants:
Donna Bodeau

Sponsor:
Quality of Life Plus

QL+ presented the Manual Beach Wheelchair design challenge for Navy Veteran Nathan DeWalt. Nate was injured while riding his motorcycle back to base after a training exercise. He is an avid athlete who wants to enjoy long walks on the beach with his family. The challenge requires a waterproof design that modifies an existing wheelchair to transition from normal terrain to the beach. This design is required to be balanced, human powered, and unnoticeable to the public. The other requirements of this project are that it is universal for any wheelchair configuration, and all systems are independent.

The intended solution addresses three areas. A front wheel attachment lifts and reduces forces causing the wheels to dig into the sand. The ratchet design helps create more torque to propel the user through the sand. The system is integrated into the axle and the hand levers will be used to apply force to the wheels. A 3D printed tread design is used to create a larger surface area for the rear wheels. All three designs can be used in conjunction with each other, or individually. These innovative designs make it possible for Nate to easily access the beach without further assistance.

We would like to give special thanks to the Mines Outdoor Recreation Center (ORC), the Oasis Beach Volleyball Courts, and Quality of Life + for their generous contributions to our innovative design challenge.



F17-08 | Curb Traversing Wheelchair

Team members:
Brandon Weihl
Hagan Bjerga
Saad Alharbi
Peter Kurz
Tauqeer Khan
Chris Laney
Randy Urso

Advisor & consultants:
Donna Bodeau

Sponsor:
Quality of Life Plus

Velette is an Air Force Veteran, who maintains an active lifestyle despite recently becoming a paraplegic. StepUp Mechanics is focused on traversing curbs as they inherently pose a challenge to Velette. The solution encompasses a system of levers and anti-roll bars to achieve the desired stability. A lightweight design was accomplished primarily using materials such as aluminum and fiberglass. Placed toward the front of the wheelchair are the levers which grab the curb and raise the user to the top of the curb. At the back of the wheelchair, the anti-roll bars create additional stability when the front wheels are off the ground. These anti-roll bars attach to manufacturer-installed nodes on the wheelchair. For increased user customization, a pin system was added to the anti-roll bars so that the user can change the angle of tilt before the bars activate. Additional customization is achieved because fiberglass acts as a spring. The fiberglass rods can be layered allowing the user to adjust the resistance they feel while tilting back. While the design meets the needs of Velette, others can utilize it due to its universal capabilities. The attachments will fit many different wheelchairs and are adjustable in length and spring force. Thus, QL+ can replicate our affordable solution for other challengers.

F17-10 | Passive Cooling Project

Many underdeveloped communities need sustainable methods for cooling buildings that low energy and low cost. The systems we focused on utilize local water resources, either aquifers or seawater, and circulate it through the piping in buildings. These systems can provide greater thermal comfort and improved standards of living for people around the world. Our team was asked to provide engineering data and calculations to support building these kinds of systems in Haiti, Northern California and the Philippines; climates ranging from arid to tropical. Our team, along with the University of San Francisco (USF) architecture team supervised by our client Prof. Seth Wachtel, designed and built physical prototypes of a room to demonstrate the effectiveness of these kinds of systems. Our design placed the water flow tubing through the flooring (one concrete, the other stabilized earth). We tested varying inlet temperatures to simulate the conditions that could be available at different geographic locations to see the overall effects on the floor and room temperature. Temperature control was achieved by cooling and/or heating of tap water with associated instrumentation. We also performed heat transfer analyses to determine the cooling/heating capabilities of this system. Our goal was to prove that passive systems can be effective and efficient in response to factors of climate, available materials, access to electricity, and community constraints.

Team members:
Morgan Gillespie
Taylor Heeg
Bryan Morgan
Carl Schmidt
Nate Todtenhagen
David Wahlstrom

Advisor & consultants:
Dr. Bahman Rejai
Dr. Jason Porter
Dr. Paulo Tabares-Velasco

Sponsor:
Dr. Seth Wachtel,
University of San Francisco

ATES Systems for People

F17-11 | Black Canyon of the Gunnison South Rim Water Supply

One of America's most recent National Parks, the Black Canyon of the Gunnison National Park (BLCA) was established in 1999 to preserve a deep, steep-walled gorge carved through Precambrian rock by the Gunnison River. Hosting a variety of different ecosystems the National Park, the exposed strata of the gorge preserves fossilized evidence of ancient species. As one the newest National Parks, the infrastructure of the park is still in development.

The National Park Service (NPS) has tasked our multidiscipline Capstone Design@Mines team, H2Operatives, to conduct the Front End Engineering Design (FEED) for a renewable energy powered water treatment and distribution system to serve the administrative and maintenance buildings, the visitor's center, and the campgrounds on the South Rim of the Canyon. This system will re-purpose an existing agricultural well at the park to meet future water demand for regular park use, fire suppression and drinking water standards. We designed a new water treatment system for disinfection and corrosion mitigation, as well as a conveyance system, finished water storage, water distribution, and the associated electrical and control system. The system incorporates an off-grid photovoltaic system to power the facility. The control system allows the NPS to monitor the system. Our design is unique in its ability to deliver a reliable supply of water despite high pressures, relative inaccessibility to the site during winter months coupled with low demand and the lack of energy or communication infrastructure.

Team members:
Andrew Rademacher-Howe
Carder Ullom
Allan Nguyen
Emily Bailey
Wenli Dickinson
Paul Kuras
Katharyn Peterman

Advisor & consultants:
Robert Huehmer

Sponsor:
Matthew Hirschbeck,
U.S. National Park Service

F17-12 | Recumbent Trike Loading Device

Team members:
Daniel DeCino
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Tim Kelvin
Harrison LaVenue
Cameron Maxey
Robert Schreibman

Advisor & consultants:
Robin Bullock
Jeff Holley
Dre Guerra
Vibhuti Dave

Sponsor:
Quality of Life Plus (QL+)

Former Navy fighter pilot Captain Danny Knutson is an avid cyclist but was struck on his bicycle by a hit and run driver in 2008, damaging his cervical vertebrae and spinal cord. His injuries have resulted in incomplete quadriplegia, causing poor proprioception, impaired balance, and limited range of motion. He now rides a recumbent tricycle.

Currently, Captain Knutson's wife and cycling partners load his tricycle onto a bike rack when traveling for cycling events. The tricycle is roughly 40 lbs. and awkward to lift, which creates significant risk of injury. Captain Knutson desired a device that would assist with loading the tricycle onto his bike rack.

The solution provided is an intermediate device that mounts between Captain Knutson's vehicle hitch and the existing bike rack. The device is equipped with an actuator that lowers the rack to the ground. This allows for simpler loading and does not require the entire tricycle to be lifted at once, thus greatly reducing required effort and risk of injury.

This device is the only system of its kind. With minimal modification, it also has applications for a multitude of bike rack models as well as nearly all other hitch mounted devices.

F17-13a | Human-Centered Design Studio: Climbing Holds for Athletes with Visual Impairments

Team members:
Victoria Crowder
John Mendoza
Megan Grier
Caroline Fuschino

Advisor:
Dr. Joel M. Bach

Climbing walls present a particular challenge for people who cannot see the arrangement of the holds. This is especially true when climbing a new wall. However, people with visual impairments often develop an excellent sense of echo-location. Our solution takes advantage of this skill to provide climbers with an easy way know where important holds are. Each (or many) of the holds on a wall is equipped with a small wireless device controlled by a single wired controller. There is also a similar remote device attached to the climber's torso. The controller takes information from the remote device to determine the climber's location and alert the next hold on the climber's path. When the device in the next hold receives the alert it triggers audible and visual alarms. This enables the visually impaired climber to more quickly identify their next hold, and also allows the possibility of adapting this technology to develop games or training paths for all climbers. To date, no other solution to this specific problem can be found.

F17-13b | Human-Centered Design Studio: Flat Water Kayaking Course for Visually Impaired Veterans

This project was developed for Team River Runner as a way for Visually Impaired Veterans to experience a flat-water slalom kayaking course with audio queues for guidance. The slalom course will be able to guide the kayakers using a series of speakers embedded in each buoy around the course. Each buoy will have a distinct sound that will indicate whether the rider should pass the buoy on the right or left. After the rider has passed the buoy, it will shut off, and the next one will turn on, giving the kayaker feedback on where the next target is. With a modular design, the course can be reoriented into different configurations, allowing the kayakers to test themselves for different times around different courses. The course can be placed in a lake or pond of any width, with a maximum range of approximately 100+ yards from the controller. Input to the system will be from a manual switch to control the speakers on the buoy and start the system. Outputs will include the sound produced from the selected buoy. The buoys are made of 3" PVC pipe and Plexiglas, and are anchored using marine rope and 8 pound mushroom anchors.

Team members:
Tanner Ackerman
Michael Maher

Advisor & consultants:
Team River Runner
Joe Mornini
Dr. Joel Bach
Court Allen

Sponsor:
Quality of Life Plus (QL+)

F17-13c | Human-Centered Design Studio: TRS JAWS Prosthetic Hand

JAWS, modified for TRS, tasked students to create a device that has the capability to grip to handlebars for sports and other activities. The main challenge of the design is the sliding lock mechanism to enable to device to have different force settings. The variable force settings are important so that the user can decide the amount of grip strength they desire for their activity. For example, someone who is motocross racing would want more grip strength than someone who is casually biking around their neighborhood. The solution provides the user the capability to change the force setting on the device using only one hand. The locking mechanism utilizes a simple screw-like mechanism to lock the bar into different positions. Each different position has a different grip strength so that the user can personalize the device to the activity. The final design also allows the user to have radial-ulnar deviation, which is important for comfort and control in many recreational activities. This project is unique because it empowers people to try new things. This product will help to enhance the experience that individuals have when participating in sports and recreational activities. JAWS is a project where you can see the direct change that it makes in people's lives.

Team members:
Estrella Ross
Barathwaj Murali
George Hnsinger
Michael Maher
Andrew London

Advisor & consultants:
Joel Bach

Sponsor:
TRS Prosthetics

F17-13d | Human-Centered Design Studio: More Comfortable Shorty Sockets

Team members:
George Hunsinger
Josh Glanzer
Abby Reuland
Adam Lain

Advisor & consultants:
Joel M. Bach
Adaptec Prosthetics

Sponsor:
Quality of Life Plus (QL+)

Jeremy Bruns is a United States Army veteran and a double, above the knee amputee. Currently his sockets are hot, heavy, and not comfortable to wear for long durations. He has tried to mitigate this problem by wearing prosthetic socks, since they are more comfortable and breathable. Unfortunately, they would slip off his residual limbs, and have no grip on smooth surfaces, which made it hard to move around. Furthermore, he is unable to swim in his current sockets. Additionally, these sockets can replace the use of a wheelchair is his everyday life.

After considering many possible designs, the team concluded that soft poly-blend cap sockets secured by BOA cables would be the best option for comfort and protection. This design should allow for Jeremy to wear these comfortably for long durations of time, swim and move without the use of a wheelchair, while remaining breathable. The BOA cables ended up not providing enough force to secure the socket, so we moved on to using ratcheting straps. In addition, the adjustable cables allow the socket to be put-on and taken off easily. Overall, this design is a compact and flexible solution that will allow for increased comfort and versatility of use when compared to traditional sockets.

F17-13e | Human-Centered Design Studio: Rear Brake Relocation

The client is a transtibial amputee of the right leg and when he performs in motocross races he wears a prosthetic foot. This poses the problem of using his prosthetic foot to operate the rear brake of his motocross bike, which is located on the right side. In order to solve this issue, the client wanted HCDS to design a thumb- operated lever that incorporates his rear brake so that he can operate it using his left thumb.

HCDS ordered a hydraulic reservoir brake system and rear brake caliper for the client's 2004 KTM 125SX motorbike. After installing the new brake caliper and attaching the hydraulic reservoir to the left handle bar, a brake line was connected between the two. When connecting the brake line, heat from the engine as well as external dangers were taken into consideration. This led to the brake line being wrapped in a heat shield that is rated up to 500 degrees Fahrenheit. The client then specified that he wanted the operation lever to be underneath the handlebar. In order to determine his exact measurements an adjustable mock up of the lever was created and adjusted to his comfort. This mock up was then cleaned up and welded to secure it in its position. This prototype was then tested by the client and returned with recommended adjustments. After the adjustments were made, the prototype was used to cast the lever using aluminum.

Team members:
Kayla Hounshell
Megan Koehler
Rheana Cordero
Lauren Harrison

Advisor & consultants:
Joel M. Bach
Derrick Rodriguez

Sponsor:
Spencer McGinnis

F17-13f | Human-Centered Design Studio: Osseointegrated Implant Activity Monitor

Team members:
Tanner Ackerman
George Hunsinger
Blake Parker

Advisor & consultants:
Dr. Joel Bach

Sponsor:
Human Centered Design Studio

The team was tasked with designing an activity monitor that could attach to any osseointegrated trans-femoral prosthetic. This activity monitor should collect data and wirelessly record this data for processing on a separate computer. The monitor should produce force, stress, and strain data that is being applied to the implant. The activity monitor must be completely operational and safe up to 250 lbf. It must also be "low profile" (<3 in. in height) so as to not affect the gait cycle of the user. This particular iteration of the design is to only be used during the two week rehabilitation period of the patient post-surgery. The final design uses a LoadStar Sensor and Raspberry Pi for data collection and processing. The data will be displayed on a web page run by the Raspberry Pi. The web page allows for the end user to see the data anyway as long as they are on the same network as the Raspberry Pi. The top plate and load cell configuration as to accommodate a plethora of different attachments in place of the load button. The top connecting plate will attach to the circular plate with bolts arranged in a square pattern which is common among this type of prosthesis.

F17-13g | Human-Centered Design Studio: Snowmobile Seating System

The VA sponsors an event every year called the Winter Sports Clinic that has the goal of introducing disabled veterans to different winter sports. They contacted the Human Center Design Program regarding a project to adapt the snowmobiles in order to make them safer and more user friendly towards passengers with various degrees of postural impairment.

To complete this task, a rigid frame that mounts to the snowmobile was developed. Foam supporting pieces are attached to this frame, which is waterproofed to handle the elements. The passenger is held to the supporting frame and foam by a four point seatbelt harness. This provides adjustability, security, and the ability to quickly release the passenger from the snowmobile in case of an emergency. Additionally, the VA requested four seating systems, so the final product was recreated three more times.

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Sponsor:
Veterans Affairs

F17-14 | Chassis Dynamometer Challenge

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Mines Formula Team is unable to properly test and tune their competition car. Their 100 HP engine only made approximately 35 HP at last year's competition due to limited testing facilities available. The goal of the project is to design and build a small, semi-portable dyno capable of testing vehicles up to 100 HP, with a budget of $4,000 to allow the Mines Formula Team to increase their engine performance.

To address this problem, team Dynosaur has designed a unique dynamometer which weighs and costs approximately half of comparable dynos. The dyno is easily moved with a pallet jack, quickly breaking down for a smaller storage footprint while still absorbing up to 100 HP. The design also accommodates multiple common tire sizes and track widths found on FSAE cars. The data acquisition system is projected to provide accurate and robust power readings while also recording barometric pressure and temperature, converting readings to sea level for easy comparison between tests on different days. Prior to construction, the design was analysed for both static and fatigue failure using hand calculations and simulation software. The final design has been built and is able to provide repeatable test results. This has enabled the Mines Formula Team to improve their engine tunes and get closer to the theoretical maximum of 100 hp.

F17-15 | Clean River Design Challenge (Team Dream Stream)

Litter and trash are a constant nuisance in urban areas, especially in green or recreational areas. Rain or wind can transport this trash to waterways and subsequently to other areas and reduce the aesthetic pleasure and environmental quality of cities. The Clean River Design Challenge is a competition to design and test a device to remove trash and other undesirable material from Cherry Creek in Denver, CO. We have designed and built a prototype for a device that is composed of two main components, a trash collection device and trash directing floating flowerbeds. The flowerbeds use the natural flow the stream to push the trash to the mouth of the collection device while being able to handle certain changes in water height. The trash collection device uses water wheel concept to move trash of all sizes into a collection area for removal. Additional aspects include a solar powered energy system to drive the water wheel and plants in the flowerbeds to improve water quality in Cherry Creek. The device is unique because of its sleek and durable aluminum housing, a renewable solar-power energy system, and an environmentally aesthetic design.

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Sponsor:
The Water Connection of
The Greenway Foundation

F17-16 | Clean River Design Challenge (Team Go with the Float)

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The Cherry Creek corridor is part of downtown Denver, including vibrant business, residential and recreational areas. Currently, the city of Denver spends close to 1 million dollars annually to remove trash and debris from the creek corridor, in addition to hundreds of volunteer hours. To help relieve this burden, the Greenway Foundation created the Clean River Design Challenge (CRDC). The challenge involves developing and implementing innovative solutions to garbage pollution with the goal of decreasing pollution and increasing community awareness of issues surrounding garbage pollution. The designs will directly decrease the amount of garbage and indirectly decrease the amount of garbage pollution through community education. Team Go with Float had the opportunity to enter the CRDC as part of CSM senior design. A screened ramp designed to pick up and collect floating garbage was selected. Similar designs effectively remove debris in agricultural irrigation ditches. The proposed device aesthetically harmonizes with surrounding art culture while remaining functional. The full scale design places a strong emphasis on community education regarding garbage pollution via a placard over a mural. The device will spark local trail users interest as to why the design was implemented. Community education is a key component because trash in cities becomes trash in our urban waterways.

F17-17 | Ayaviri Household Heating Project

Averaging at below 40°F year round, home-heating is a major concern for rural Peruvian Highlands. After communicating with the community about their needs, Qhari Enterprises determined that technology alone would not be sufficient and home heating was a small part of larger community health concerns. Bearing this in mind, Qhari set out to address rural home heating for this community in a way that reduces health concerns associated with indoor air pollution and fosters hygienic cooking practices.

Focused on extreme affordability, local materials, and sustainability, we have designed a cook-stove that doubles as a heat exchanger. Keeping costs below $30, the design utilizes a single 55-gallon drum and local adobe, both readily available in the community. In addition to reducing solid fuel requirements and boiling water more quickly than traditional open fire, the simplicity of this design makes local manufacture, installation, and maintenance an attainable goal. In addition to heating homes, we have carefully considered the influence this design will have on the social environment. The impact of this design is improved by health education and home improvement initiatives focused on boosting health literacy and sustainable economic development. Qhari has confidence that this solution is not limited to the Peruvian highlands, but has global potential.

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F17-18 | Replicable Water Reuse System

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Sponsor:
Miriam Dym of Dym Textiles

Miriam Dym, founder of Dym California Textiles, requested a replicable water reuse system for her textile workshop in Berkeley, California. Ms. Dym creates custom block-printed fabrics for clothing and interior spaces, which generates a large volume of contaminated effluent during the rinsing process. The generated effluent contains Azo dyes, soda ash, urea, sodium alginate, and textile detergent.

The solution, which treats the effluent with activated carbon, incorporates a washing machine design that facilitates decolorization. Beyond satisfying the client's requirements, system efficiency is increased by minimizing manual rinsing in the current process. The system maintains a low cost, energy-efficiency, and is easy and safe to operate.

F17-19 | Solar Farm Design for Closed Landfill

Our team was asked to design a closure system for a landfill that was in operation during the 1970s, which could also support a solar farm. The challenge was designing the solar array to be able to produce 2MW of energy as well as design the array's corresponding foundation that would be supported by the landfill cap. Our solution includes three main components: landfill cap design, solar racking system, and solar array layout. We implemented both a water balance and geomembrane landfill cover. The water balance cover is to be used on the steeper, side slopes of the site, while the basic geomembrane cover is proposed on the rest of the landfill site. This geomembrane cover is composed of an intermediate soil layer, just above the waste, followed by a geomembrane with a protective geotextile on top, and capped with 30" of compacted protective soil, topped with a native grass. The solar racking system we chose involves a ballasted system in which each rack is anchored by four pour-in-place concrete buckets. Finally, we found minimum spacing between the racks to allow for maximum sun exposure as well as the optimal tilt angle for the racks. These two factors, in conjunction with the site geometry allowed us to layout the solar arrays in a way that will to maximize energy production.

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Jen Rutter - Adams County

ADAMS COUNTY
COLORADO

F17-20 | Nepal School Renovation Project

Humanitarian engineering projects present a unique set of challenges and constraints that require a very different approach than many technical, engineering-based projects. The Nepal School Renovation project is located in South East Nepal and is centered around the construction and renovation of a school building in the village of Tintale. The organization supporting the team is the Playing for Change Foundation, whose goal is to connect the world through the education and integration of music. Their vison for Tintale included both technical, acoustic challenges and key humanitarian considerations. To accomplish their mission, Playing for Change wants to renovate the current school building to enable community members with both a structurally sound and space efficient learning area, while also maintaining and further promoting the community's cultural values and needs.

To address these aspects, the team has engaged with the community of Tintale, employed acoustic analysis, simulations, and in-depth finite element stress studies to develop multi-phased, modular building designs. These designs include safe and efficient modular-based building elements utilizing locally sourced materials and building expertise, while providing future acoustic recommendations and expansion opportunities beyond the base school renovation.

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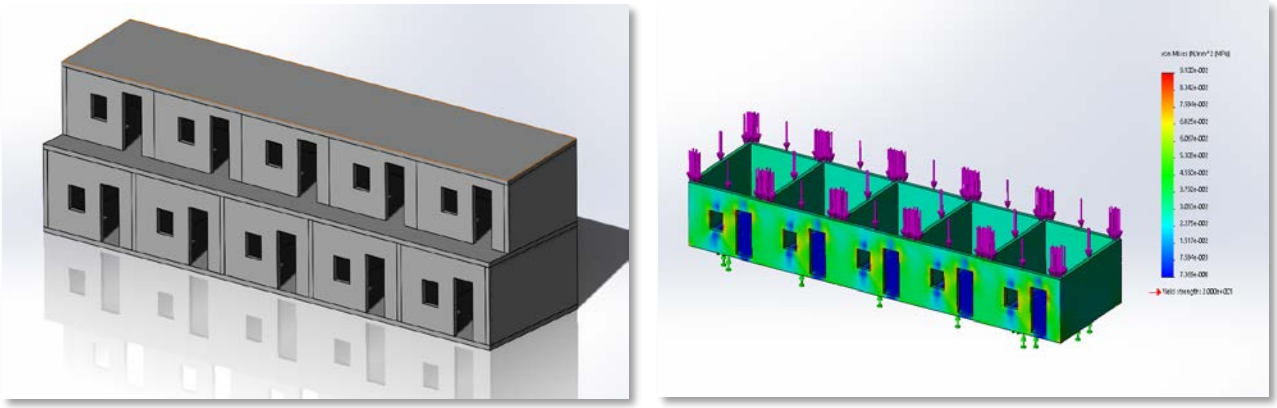

Preliminary Model and Finite Element Analysis of Designs

F17-21 | Net Zero Energy Home Design

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The Fond du Lac Band of Lake Superior Chippewa seeks to develop a Net Zero single-family home in northern Minnesota that costs $120/SF. The unique design challenges presented include designing a home which uses less energy than it produces on an annual basis, while at the same time ensuring the needs of the community are met and all applicable building codes adhered to. The solution we developed includes both two- and three-bedroom single-story floorplans alongside a 7-kilowatt solar array that provides approximately 9,600 kWh annually. The home is 100% electric and was designed using passive house concepts, which include a tight building envelope to minimize infiltration, increased insulation of the roof and walls, and windows and overhangs to allow solar gains in the winter. Heating, cooling, and ventilation are provided via a high-efficiency packaged terminal heat pump, electric baseboard heaters, and energy recovery ventilation. The home is also equipped with ENERGY STAR® appliances and a home energy dashboard that helps the occupants manage electricity use. We used the freely available tools, BEOpt, EnergyPlus and SAM to optimize the home design and model annual energy generation and consumption. Using whole building energy simulations, we estimate that the annual energy consumption will be under 9,000 kWh, resulting in a home that generate more energy than it consumes on an annual basis.

F17-22 | Lightning Suppression with Flange Isolation Monitoring

Solid State Decouplers (SSDs) are devices used in the pipeline industry to protect gaskets at pipe flanges from high voltage events such as lightning strikes and AC induction faults. They commonly work in conjunction with cathodic protection systems, which is a low voltage DC source applied to the pipe to prevent corrosion due to oxidation. These decouplers must accommodate the low voltage applied with cathodic protection while switching during high voltage events to allow current through the decoupler and not the gasket, thus protecting the gaskets at connection points along the pipeline.

There are multiple SSD designs available on the market today, however, there is room for improvement. Our three main challenges were to reduce the form factor, improve the function, and develop one rating for multiple applications.

We modified the existing SSD design and improved it by using modern components and reducing the size and shape of the device to fit compactly on a variety of pipe sizes. Incorporating a faster switching varistor reduces current build up and the modular mounting design allows for easy installation on both the bolted flanges and monolithic joints. These improvements allow for a uniform rated technology to be applied on every pipe size, which lowers the overall cost when manufactured in large increments.

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F17-23 | Seismic Wall Sleeve Challenge

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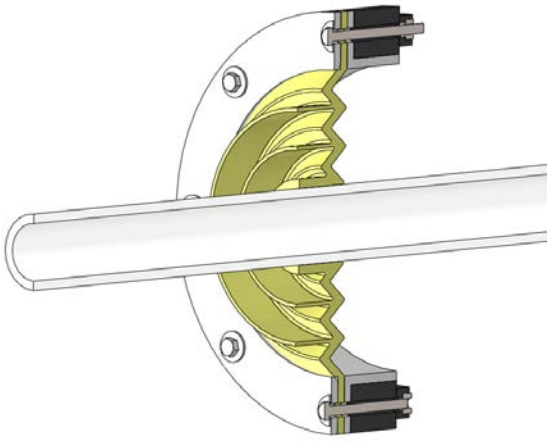
Our team, MEP Solutions, was tasked with designing a pipe sleeve that can help protect wall-penetrating pipes from seismic movement by allowing for up to two inches of pipe movement in all directions. The sleeve should also provide waterproofing around the pipe and be able to withstand one bar of pressure from either side. Additionally, MEP Solutions considered a sleeve design that could be installed after the pipe is already in place as well as making sure our final design is able to accommodate non-concentric pipes.

To address these design requirements, MEP Solutions came up with an innovative design that resembles an accordion. The accordion surrounds the pipe and allows for movement in any radial direction. A hose clamp secures the accordion to the pipe, and the assembly on the outer edge of the penetration creates waterproofing with the wall. MEP Solutions has also integrated GPT's pressure plates into the design to ensure that the assembly will be able to withstand one bar of pressure and create an adequate seal of the penetration. To make the design feasible, MEP Solutions has selected materials that GPT already uses or could easily manufacture. The final product is highly cost-effective, meets all requirements set by GPT Industries, and serves as an innovative solution to the problems created by seismic activity on wall-penetrating pipes.



F17-24 | Lena Gulch Floodplain

Ozark Engineering was tasked with evaluating engineering design options for a floodplain improvement project. The goal of the project was to lessen or mitigate flood danger for commercial properties affected by Lena Gulch in the area between Heritage Road and C-470 roughly parallel to West Colfax Avenue.

Ozark's design maintains the environmental integrity and stability of the channel while actively reducing the floodplain and protecting residences and businesses. Our design is innovative since it maintains a natural channel without overly infringing on adjacent properties and reduces the predicted floodplain. Additionally, the implementation of the design will increase property values through increased safety and attractiveness. The unique design combines engineering technique with environmental consciousness, by means of addressing potential water quality concerns within the channel and meeting the social and economic goals for the project.

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Sponsor:
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F17-25 | Pulse Oximetry Test Device

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The Pulse Oximeter is a widely used device in hospitals and medical facilities used to measure a person's blood oxygen saturation. While this is widely used, there are still numerous areas for improvement including accounting for ambient light and different levels of skin darkness. The Pulse Oximetry lacks the ability to account for all unusual conditions, thus team F17-25 was tasked with building a device to test for the shortcomings in a Pulse Oximetry monitor. The goals include detecting LED firing patterns from the Pulse Oximetry sensors, simulating waveforms produced from a patient, modeling ambient light inputs, creating varied waveforms and a user interface to model results of unusual conditions. We first accomplished detection of LED firing patterns and used the data to simulate Pulse Oximetry results for a human under regular conditions through control of LEDs in a binary multiplex. Then we designed a sensor circuit to detect light and a circuit to simulate ambient light inputs. Lastly, we created a user interface to control the test device, allowing conditions to be easily varied in testing. This overall design allows the Test Device to modulate to different blood oxygen saturation as well as input simulated ambient light into the system, thus allowing a sensor to be continuously tested in order to account for extraneous or varied factors.

F17-26 | Modular Theater Set Design

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Sponsor:
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The Upstagers

The Mines Little Theatre club performs several productions each year that involve the setup and tear down of custom sets. Our team's project is to design a theater set that is modular, reusable, customizable, and easily assembled for a variety of theater productions.

Our solution is a two-story assembly that includes both a front-stage area and a backstage area. The second level is accessible via a staircase from the front stage area and a ladder in the backstage area. Each level is comprised of a platform and a structural wall with doorways for passage between the front and back stage. All elements can be assembled into several different configurations using reusable hardware and connections. Once fully assembled, the set will be able to withstand a myriad of stresses induced by lively theater productions.

Included in our deliverable is an instructional document that includes assembly, construction, and safety directions. The assembly and construction instructions allow the MLT technical crew to put up the set properly, construction documents allow MLT to build their own replacements and expansions without the need of outside consultation. The safety documents ensure that MLT will be aware of the structure's limits in practical usage. All of these elements combine to form a design that is simple, robust, and designed to last well into the future.

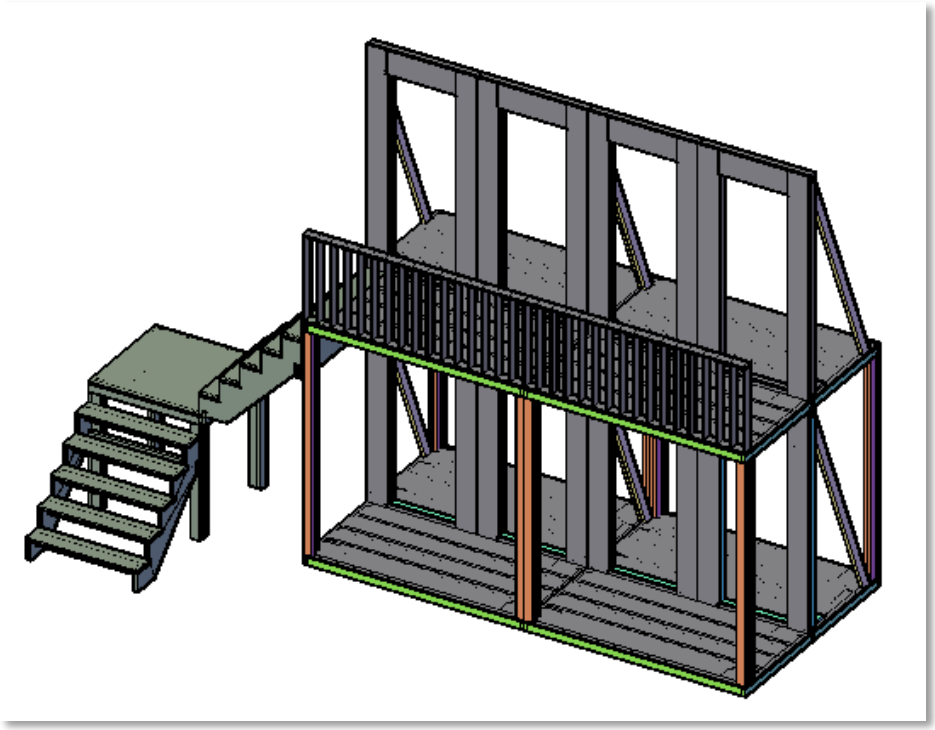

Figure 1: Full Theatre Set

F17-27 | Water Turbine Test Kit

Our team was asked to design a small-scale modular underwater current turbine. This turbine had to be adaptable and promote water power education and research. Our team had the opportunity to work with NREL to build this educational demonstration of hydroelectric power generation. The turbine test kit is designed for use in a water flume. We built a small-scale turbine prototype and electrical system, which displays the amount of power generated and demonstrates generation with LEDs. The turbine prototype includes a modular horizontal axis turbine and a vertical axis turbine based on the Darrius-H machine design. The prototype blades were each fabricated by using a 3D printer.

Our system is unique because it allows for adjustment and redesign of the blades, due to the ability to swap them into a universal mounting hub. This means that students can design their own blade configuration, or adjust the parameters of our blade designs, and test them to determine power output in varying water conditions.

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NATIONAL RENEWABLE ENERGY LABORATORY

F17-28 | High-Volume, Portable Water Filtration System

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Sponsor:
Primo Filters
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It is estimated that 1 in 9 people around the world lack access to safe drinking water. This results in over 3.4 million deaths annually, most of which are children aged 5 and under. In an effort to reduce these numbers, our client, Primo Filters, is developing a portable, high-volume water filter for use in developing areas. Our goal as the Senior Design Team was to improve the current design of the filter system while maintaining the standards set forth by the Humanitarian Engineering Department.

A 0.1-micron membrane hollow fiber filter, which removes all bacteria from source water, is fitted into the patent-pending portable water bucket. Through community engagement conducted by team members in rural areas of Peru, improvements to the design were analyzed for effectiveness. Our team has designed a pre-filter to keep the micron filter performing effectively for a longer period. The bucket's rigidity was improved using specifically designed wooden stakes. This design was chosen was shown to be the most effective in increasing the rigidity of the bucket while also using locally sourced materials and providing jobs to the people who will be using this system. Instructions on how to properly use the system were produced to make the system easier to use. Additional future design changes will also be implemented.

F17-29 | Service Rover Vehicle

Lack of access to adequate equipment limits farmer's ability to utilize half of the world's potential farmland. Team Matumaini accepted the task of designing and demonstrating a concept vehicle to help ease the ongoing agricultural crisis occurring in sub-Saharan Africa due to existing technological and environmental restrictions such as difficult terrain, absence of infrastructure, and sparse applicable resources.

The team has developed a rugged compact chassis multipurpose vehicle with auto leveling suspension. Beyond operation, the designs intent of the vehicle is to also allow for construction on site using available tools. Given its modular design, a completed SRV will be able to take on various agricultural tasks such as carrying people and goods, attaching tools for farming applications, and navigating low infrastructure areas. The design is unique compared to other market alternatives due to its superior off-road and multifunctional design capabilities. Deploying this new design in different sub-Saharan African farming communities will help farmers utilize previously underutilized farmland, leading to greater economic opportunity for the affected farmers.

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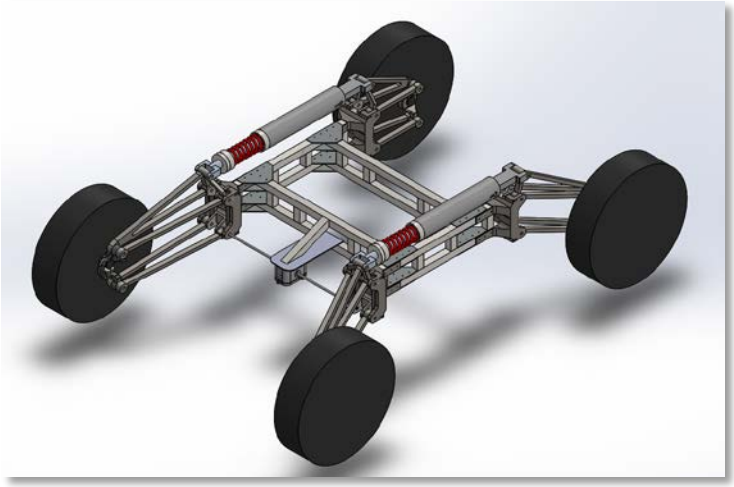

F17-30 | Winglet for PC-12 Aircraft

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Sierra Nevada Corporation

Engineering

On smaller aircraft, it can be a challenge to fit all necessary antennas on the fuselage without significant signal interference. Due to this constraint, the goal of this project is to design a new winglet for the PC-12 aircraft that has specific radio frequency (RF) properties, allowing for antennas to be installed within it. Our team accomplished this challenge by designing an RF permissive window on the underside of the winglet to allow RF communications to pass through it without substantial attenuation. Our system also contains a universal mount to secure the antenna in place and a load-bearing bracket to retain structural integrity of the winglet.

Source: https://blog.wepushtin.com/blog/comparing-costs-pilatus-pc-12ng- beechcrafts-king-air-250/

F17-31 | Smart Home Monitoring System

Many times, home monitoring systems are invasive, expensive, and damaging to install. They typically involve cameras, audio recordings, and hundreds of megabytes of stored data usually stored in an off-site server not available to the end user. Team Smart Wire has created an elegant solution to this problem with a cost effective, non-invasive home monitoring device. This product utilizes a whole suite of sensors to monitor the state of a room. The sensor suite includes an infrared motion sensor, light sensor, and temperature sensor. These sensors relay information about the room to an app installed on your phone or tablet allowing you to observe the data provided by each of the sensors as well as a graph of the data from each sensor over the timespan of a day. Along with monitoring a room and getting a notification if a certain room is active, you can also control the lights in the room without the need for installation of smart lights. The design is simple and safe to install and will not cause permanent damage to your wall. This sophisticated solution is the future of your new smart home.

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F17-32 | Energy Efficiency Retrofit for Guggenheim Hall

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Guggenheim Hall on the CSM campus is one of the most recognizable buildings in Jefferson County. Its golden dome memorializes the civic pride and financial success the area enjoyed at the turn of the century. Unfortunately, it was also constructed using turn of the century technologies that have not proven to be particularly energy efficient. Our project was to meld the present and the past: to maintain the historical integrity of an iconic landmark while bringing its energy use to "greener" 21st-century standards.

The goals of this project were to create, first, a whole-building energy model in OpenStudio that reflects the building's current energy usage. The model is then used to explore retrofit options that reduce overall energy usage by 15%, reduce peak electric demand by 20%, and meet a 10-year, simple payback. Some of the proposed retrofit options include replacing current light bulbs with LED bulbs, updating the current HVAC system, reducing personal desk appliances, and using controls to lower energy usage during non-working hours.

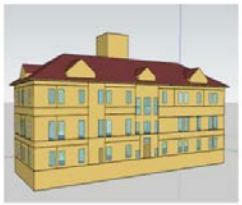
Figure 1: Retrofit Team Model


Figure 2: Guggenheim Building

F17-33 | Second Generation Comfort-Sensing Robot

Nearly all heating, ventilating, and air-conditioning (HVAC) equipment is controlled by wall-mounted thermostats that only sense dry-bulb temperature. However, more factors than just dry-bulb temperature, such as humidity levels and air velocity, are required to determine total thermal comfort. In a given room, these environmental factors also have significant local variance. The lack of thermal comfort information results in an ineffective feedback system.

To address the disconnect between fixed dry-bulb thermostats and whole-room comfort, our team (Beta-Max) developed a second-generation comfort sensing robot. The improved design of the robot is capable of moving autonomously and collecting environmental data of dry-bulb temperature, relative humidity, radiant temperature, and air velocity at predefined intervals. Additionally, our team added luminance and decibel meters to the robot to aid in identifying non-thermal comfort (e.g. direct sun through windows and excessively noisy areas). The robot then calculates an overall comfort rating In accordance with ANSI/ASHRAE Standard 55-2013 based on the thermal data it collects.

The comfort-sensing robot provides the capability to measure comfort dynamically. Our hope is that this product's analysis of thermal data will enable users to identify and address the shortcomings of common HVAC systems.

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F17-34 | Energy Efficiency Retrofit for Chauvenet Hall

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"Earth. Energy. Environment." These key words blazon across the Colorado School of Mines website and serve to provide insight into what our school values the most. Built in 1904, Chauvenet Hall is one of the oldest buildings on campus and past due for an energy overhaul. Our team's challenge is to create multiple retrofit packages for Chauvenet Hall that reduce annual energy consumption by 20% and peak electrical demand by 15%, all while meeting a 10-year simple payback.

Our team has developed multiple packages that incorporate many individual retrofit measures to increase the energy efficiency of Chauvenet Hall as well as improve the comfort of the building. The retrofit measures explored in this project include replacing fluorescent bulbs with LEDs, installing wall insulation, upgrading single-pane windows, upgrading the HVAC system, and managing plug loads via modern sensor technology. The team has also explored coupling alternative energy production and energy storage with the building. A whole-building energy model has been created in OpenStudio that accurately represents the operation of Chauvenet Hall, verified with comparisons to historical energy data. This model was then used to verify energy savings from three different retrofit packages: the lowest capital cost package, the maximum energy savings package, and the greatest peak reduction package.

F17-35 | RF Antenna Project Part 2

Ball Aerospace sponsored our team to create a 3D printed pair of glasses with an embedded antenna operating at Wi-Fi / Bluetooth frequency. This project is significant for two different reasons. The first is the printing process. Being able to 3D print, in one go, a plastic component and a metal component is a novel technique. Instead of using traditional applications, 3D printing will streamline the manufacturing process. The second reason is its Wi-Fi / Bluetooth applications. Essentially, this technology would allow someone to have the same capabilities of a working computer within their glasses. Our design incorporates a dipole antenna with notches for tunability. The University of Texas, El Paso 3D printed the glasses using an nScrypt 3Dn Tabletop printer, using an nFD tool to lay the plastic frame and a Smartpump tool to lay the conductive ink.

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Atef Elsherbeni

Sponsor:
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University of Texas, El Paso

F17-36 | Field Networked Inclinometer

Team members:
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Joel Ebers
Sarah Lansey
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Advisor & consultants:
Dr. Abd A. Arkadan, Mines
Bob Ortiz, CDOT

Sponsor:
Randy Cox
CEO, Co-founder

The Colorado Department of Transportation monitors landslide movement through the use of manually operated inclinometer systems to detect movement in below ground pipes. Due to the manual nature, data is infrequently collected, sometimes after landslides have occurred.

Our updated model is a fully automated inclinometer, condensed for cost, and designed for minimal human interaction over the lifetime of the product. This system is capable of monitoring landslide movement beneath the earth's surface providing daily, more reliable data collection. The device measures the direction, magnitude, and elevation of motion then transmits the data over a cellular network.

F17-37 | Vibration Reduction Vehicle

Ball Aerospace currently transports sensitive equipment across their campus using plastic Rubbermaid carts. This transportation method has no way of preventing objects from falling off or means of reducing vibrations that can damage the equipment in transit. Team Good Vibrations was tasked with creating a transportation vehicle capable of reducing the risk of objects falling off the cart and the intensity of vibrations observed by the equipment being transported. The vehicle needed to fit through doorways and be operated by one person. To reduce the risk of objects falling off the cart, the team created an auto-leveling system that maintains a level surface to avoid rolling. The auto-leveling system uses four linear actuators as cart legs which travel up or down based on an accelerometer measuring the tilt of the top shelf. To reduce the vibrations experienced during transportation, the cart is mounted on four 10-inch foam filled wheels. These large wheels make the cart easier to push compared to smaller wheels and the foam absorbs vibrations from bumps and cracks in the roadway surface. The top shelf of the cart is also covered with sorbothane pads, which absorb high frequency vibrations and provide an additional tacky surface to prevent objects from sliding. Team Good Vibrations has delivered a working prototype cart that secures and protects equipment during transportation.

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Maddie Hack
Conor Staples

Sponsor:
Ball Aerospace

F17-38 | Zoo Lights Panel Design and Light Structure

Team members:
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Sponsor:
Denver Zoological Foundation

Each year, the Denver Zoological Foundation hosts its “Zoolights” experience for guests. The Zoo is challenged with power distribution to the light structures and creating new displays each year. The Zoo Pals team was tasked with developing a new power distribution panel, and a modular light structure to create a more interactive experience for Zoo guests.

The team developed a waterproof panel with digital timers, power distribution, and a light control system. A configurable mounting option for the panel was implemented for ease of installation. The panel complies with NEC 2017 and Denver City Code. Three different models of light structures were developed. For marketing purposes, the Denver Zoo requested a small, 64 LED light structure to demonstrate a configurable light show. A third-scale sized model, comprised of 108 LED lights, was developed to demonstrate the modularity and light control of the full-scale structure. For a full-scale implementation, lighted nodes and connecting members were fully manufactured and assembled. The manufacturing processes included 3D printing and casting.

F17-39 | Earthquake Resilient Classrooms in Nepal

Summit for Seven's project goal was to evaluate earthquake resilient classrooms that are currently being implemented in rural Nepal by Edge of Seven and to create an alternative design that is feasible, safe, and less costly. The existing design is expensive to construct, which is preventing Edge of Seven from building more schools around the Solukhumbu region of Nepal. A less costly design will help Edge of Seven achieve their mission to improve access to education in rural Nepal, especially for girls whose educational opportunities are not as valued in society.

Summit for Seven focused primarily on two aspects of the project. The first aspect was to create the design for an earthquake resilient school structure. The new design was created by incorporating "Gabion Bands" within the body of the structure as a replacement for the reinforced concrete currently being used. This design provides an innovative solution that is both less costly and more feasible to implement in rural areas. The second aspect of the project was to evaluate current practices being performed by Edge of Seven and to identify improvements to the existing design and humanitarian model. This evaluation and recommendation process offers key and relevant insight that future teams will be able to use if the project continues in order to address the concerns of the client and further reduce cost.

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Lindsay Hoylman

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Greg Rulifson
Shiling Pei

Sponsor:
Edge of Seven
Peter Mason

F17-40 | Military Vehicle Testing Platform

Team members:
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Ian Coberly
Troy Hart
Gary Hutton
Tim Lyle
Josh Schrieber

Advisor & consultants:
Yosef Allam

Sponsor:
Paul Brayford

The assigned task was to design and analyze a military vehicle testing platform modeled for the size and performance parameters of a Ford F-150 Raptor. The testing platform will focus on suspension travel, life of the system, and the g force in the x, y, and z directions. The end deliverable of this project is a proof of concept consisting of research in design and materials, a SolidWorks model, and Finite Element Analysis to prove the capability and strength of the platform as well as assist in the adjustable development of the next generation of testing. The design is based on an industry proven, researched idea involving hydraulic actuators and a universal joint to ensure a high range of motion in all directions. The assembly will be replicated four times - one for each wheel connection, and connected using a plate directly to the axle hub. This concept provides a balance between high adjustability and factor of safety with the ability to outperform given constraints. The design includes easy maintenance and prefabricated parts, minimizing risks and expenses to users. Points tested includes high Von Mises stress, factor of safety, and displacement due to different force configurations. The advantages of this design result in a quality solution that values safety, reliability, and performance.

F17-41 | Food Conveyor Clean-In-Place System

The Food Conveyor Clean-In-Place (C.I.P.) System was designed as a solution to the tedious and costly way conveyor belts are currently cleaned. Specifically designed for the Haury Farms citrus packing facility conveyor belts, the C.I.P. system replaces the current conveyor cleaning process which is completed on a weekly basis and shuts down the packing process. The final prototype was designed to be easily maintained, inexpensive, frequently operated, and long lasting with exposure to water, detergent, and peracetic acid. The final system consists of a detergent mixer, detergent and rinse spray bars, brushes, squeegees, an adjustment system, and an overall engagement system to complete the cleaning process. The Food Conveyor Clean-In-Place System, accompanied by the user guide, can be used effectively by anyone without any engineering background. By keeping the prototype inexpensive, the system will break even with labor costs to manually clean the conveyor belt in the next five years. Compared to conveyor cleaning systems on the market, the Food Conveyor Clean-In-Place System is an effective, inexpensive alternative to cleaning conveyor belts without ceasing production.

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Sean Kopel

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Bahman Rejai

Sponsor:
Haury Farms
Greg and Angela Haury

F17-42 | Pump Conversion Challenge

Team members:
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Ben McInnis
Scott Mayer
Eric Wilde

Advisor & consultants:
Dr. Abd A. Arkadan

Sponsor:
The Invictus Initiative

the invictus initiative

This design project involves the retrofitting of a diesel engine to reduce the cost of operating diesel-powered water pumps in southeastern Moroccan villages.

This solution incorporates the filtering and combustion of used vegetable oil from cooking processes to supplement diesel fuel. Through mixing the oil in different ratios, the users will be able substitute pure fuel for the mixture.

Flexibility and modularity are important aspects of this design, allowing end users to source materials locally. This minimizes foreign dependence and empowers the users to take responsibility for the project. The end goal is for the users to be able to run the engines sustainably using the new technique and perform any maintenance to the system independently.

The main technical focus is to provide the framework for the filtration and delivery systems. The design implements a two-stage filtration system in which vegetable oil flows through a nested coarse particle filter within a storage tank, then subsequently through a removable inline filter to remove finer particles.

F17-43 | Motorcycle Front Suspension Redesign

The telescoping fork system that has been used for motorcycle front suspension and steering have been the industry standard for over a century. However, it is not without its flaws. Current motorcycle forks have problems with nose dive while braking and maintaining stability when cornering. Our team went about addressing these flaws with our total redesign of the front suspensions system. Despite needing a radically different suspension design, we also strove to maintain the general feel of a typical motorcycle. Anything too different would not be marketable to traditional motorcycle riders and ultimately we plan to bring this system to the public. Our solution is this hub-centered suspension system. Unlike with a traditional system where the wheel is connected directly to the handlebars via the forks, our wheel and shocks are mounted to the frame with an actuating swing arm beneath the rider. The wheel is allowed to deflect upwards, but as it travels upwards, it maintains a constant angle of steering, which makes the bike more stable than a traditional fork suspension under braking. Our design is steered with push-pull cables and maintains the same steering feel as a traditional fork. Our unique and aesthetic design solves many problems with current motorcycle suspensions and we look forward to seeing it on the open road in the near future.

Team members:
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Advisor & consultants:
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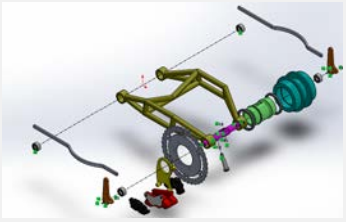

F17-45 | Portable Electronic Generator

Team members:
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Roger Kroog
Morgan Proffitt
Colin Reardon-Black

Advisor & consultants:
Donna Bodeau

Sponsor:
Woodward
Greg Hampson

Woodward tasked PAKBAR Engineering to develop a Portable Electronic Generator (PEG) that would that would have optimal performance utilizing landfill gas. To support field engines a portable diagnostic tool was developed in parallel to optimize the performance of engines running on Bio Gas.

The PEG was equipped with electronic spark and fuel flow control, both of these modules are controlled by Woodward's Small Engine Control Module (SECM). CA50 and Air Fuel Ratio are then able to be controlled to optimize the performance of the engine. With the addition of these modules, preliminary tests were performed to differentiate the combustion metrics of propane and methane.

Due to the variability of Bio Gas composition, the development of our portable diagnostic tool is critical for field engineers. This provides an economical means of properly tuning an engine's performance for every Bio Gas. The portable diagnostic tool is comprised of Woodward's Large Engine Control Module (LECM), a portable power supply, configurable inputs and outputs encased in a rugged industrial case. Critical engine performance sensor inputs include pressure, temperature, exhaust oxygen content, and crankshaft and camshaft angle.

F17-46 | NASA Mars Ice Drilling Challenge

While Mars has been the focus of space exploration for many years, the recent discovery of water ice deposits just beneath the Martian surface has rekindled excitement for exploration of the Red Planet. With NASA's goal to put humans on Mars by the 2030's, it is now more important than ever to design ways to utilize this valuable resource. Our team, Team MINERS, was tasked with designing and prototyping a drilling system in order to extract ice from below the Martian surface. In June of 2018, we will be competing in the NASA Mars Ice Challenge, in which university teams compete to extract as much ice as possible. Our team has designed a unique, two-step method for ice extraction. The first step involves a two-inch auger drill that creates a borehole in the regolith covering the subsurface ice. Descending with the auger is a detachable casing that is left in the borehole to prevent collapse. The second step involves a custom heat probe that is placed in the hole to melt the ice and pump out the subsequent water. This two-step system allows for faster drilling and cleaner water extraction. Using our prototype, Team MINERS hopes to win the Mars Ice Challenge and help pave the way for future Mars exploration.

Team members:
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Robert Ortega
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Dr. Jason Porter

Sponsor:
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F17-47 | AIAA - Design Build Fly

Team members:
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Chris James
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Advisor & consultants:
Robert Huehmer

Sponsor:
BurroWorks Club

Our team was challenged to design and build a small aircraft capable of performing multiple air and ground missions in an international competition. These missions consist of remotely piloting a loaded aircraft through a flight course and replacing random components of the aircraft in a timed challenge. The team's score was heavily dictated by the weight and wingspan of the airplane according to the competition requirements, so the team optimized the design as such. Our aircraft features a multi wing design to increase lift without increasing the wingspan, and, despite being lightweight, the aircraft can carry 8 "passengers" and 2 cargo blocks simultaneously. To fill educational gaps related to aeronautics, our team engaged in self-directed learning of advanced manufacturing techniques and computational fluid dynamics of compressible flow. We have designed, built, and flown many prototypes over the past two semesters and are excited to share with you the results of our hard work. Come to our display to see and experience our competition aircraft.

F17-48 | NASA Robotic Mining Competition

Recent space missions have discovered evidence of water in regolith, rocky deposits found on planets and asteroids. In order to colonize a planet such as Mars, extraction of these water formations is necessary for in-situ resource utilization (i.e. living off the land), mainly for human consumption, agriculture, rocket propellants, or other needs. Thus, for a decade, NASA has offered universities nationwide an opportunity to tackle the challenge by hosting the RMC at the Kennedy Space Center.

The key obstacle stems from retrieving bulk regolith of gravel, about 30 cm below BP-1 simulant, which is finer than sand. Utilizing former Blasterbotica's design, significant modifications have been made to improve structural integrity, simplify electrical components, and optimize dust protection, while leveraging previous autonomy for the new system. To accommodate the new rules, we developed a ladder excavation design that uses buckets with tines to scrape the ground. In addition, a vertical motion system was added to collect and deposit the available regolith gravel at each site. Though complex, it is mostly isolated from the drivetrain system, resulting in less vehicle movement during two competition runs. Simultaneous localization and mapping then help determine the robot's position and optimal path for the simulated environment.

Team members:
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Alexander Dodge
Dylon Patschke
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Garret Van Buskirk

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F17-49 | ASCE Concrete Canoe Competition

Team members:
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Brittany Bender
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Jimmy Zerr
Murphy Gershman
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Sponsors:
Mines ASCE Student Chapter
Kiewit

The ASCE concrete canoe competition currently engages over 5,000 students at over 200 universities in designing, constructing, and racing canoes made of reinforced concrete. Each year, Colorado School of Mines students compete in the Rocky Mountain Regional conference and are judged on their design report, oral presentation, canoe aesthetics, and race results. The regional conference was April 5-7, 2018.

The theme for the CSM 2018 concrete canoe is Daedalus; named for the skilled craftsman renowned for designing the famous labyrinth and wings in the Greek myth of Icarus. By naming the canoe after the legendary inventor, the team strove to uphold the same values of thoughtful engineering, skilled craftsmanship and innovation.

This year, the team focused on innovation and sustainability. Innovation can be seen through the W-shaped hull, which makes it unique from other canoes. The W-shaped hull is often used in still water kayak construction due to its stability. The boat is able to self-correct when it begins to tip to one side. Sustainability was addressed throughout the project by repurposing the construction materials used to make the form for the canoe.

F17-51 | AISC/ASCE Steel Bridge Competition (Team Steel Standing)

The AISC/ASCE National Steel Bridge Competition (NSSBC) is an intercollegiate event that challenges students to design, fabricate, erect, and test a steel bridge that complies with 2018 rules and regulations. This competition provides an opportunity for Steel Standing to practice technical skills and compete against other colleges and universities. The effectiveness of each team's design is determined by weight, construction time, and aggregate deflection during loading

Over the last seven months, Steel Standing developed RISA 3D models and CAD drawings to capture the design intent and efficiency. These documents were tools used to manufacture and construct the bridge with the aid and insight of Dave Genova at Zimkor, LLC. The project came to fruition with the opportunity to construct and load the bridge in competition.

A triangular truss, deck bridge was designed and reinforced with an under-truss attachment to reduce aggregate deflections. Rotated connections were utilized between members to decrease construction time. This design was selected due to its unique appearance, constructability in a competitive setting, and limited deflections. The final iteration of this structure weighs 200 pounds and has a calculated vertical deflection less than one inch during load testing.

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Sponsor:
Kiewit
Amy Huynh & Ben Seling

Kiewit

F17-52 | AISC/ASCE Steel Bridge Competition (Team Euler)

Team members:
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Sponsor:
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Rachel NiiFahey

Kiewit

The Steel Bridge team is responsible for designing a bridge to compete in the National Student Steel Bridge Competition. The bridge must stay within the rules and regulations set by AISC and ASCE in the Student Steel Bridge Competition Rules Handbook.

Our team designed a bridge using Risa3D that would be able to withstand the load cases provided by the Competition.

Our bridge design, with a focus on construction speed, was designed around the use of rectangular HSS sections with a truss pattern created by using a water jet. With this truss pattern created first, the amount of welding was cut down as well as the weight of the bridge.

F17-53 | SpaceX Hyperloop III Competition

In 2013, Elon Musk released the concept of a high-speed transportation system widely known as Hyperloop. To facilitate its development, SpaceX has sponsored multiple Hyperloop Pod Competitions, allowing student teams across the globe to design, build, and race their own prototype pod. This year, DiggerLoop is one of twenty teams worldwide accepted into SpaceX's competition in July in Hawthorne, CA. There, teams will compete for the title of having the fastest self-propelled pod. The DiggerLoop pod is designed to obtain speeds up to 300 mph within the mile-long test track. This is accomplished through a high-powered battery system, supplying power to an electric motor. This motor propels the pod down the track via a single racing wheel and chain-drive system. A NI controller reads data from various on-board sensors and responds to speed and position along the track for acceleration and braking. Our controller also monitors several system pressures and temperatures for safety and overall health of the pod. All components are efficiently mounted on a lightweight, aluminum chassis and reliable suspension system, allowing the pod to maintain a low profile. DiggerLoop has been invited to the final competition for the second year in a row, and we plan to race our newly designed and upgraded pod from last year's competition.

Team members:
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Rachel Breshears
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Michelle Golden
Niki Grotz
Ashley Haran
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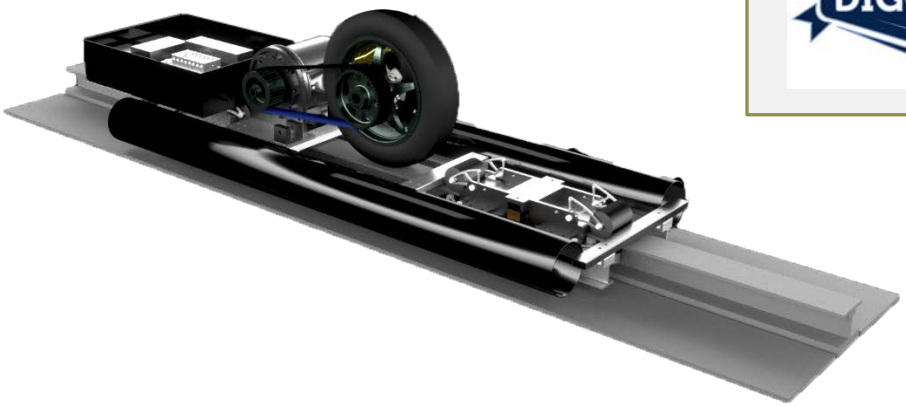
Dillon Simpson
Calvin Swanson
Andrew Wang
Patrick Weaver
Ashton Weyerman

Advisor & consultants:
Dr. Kristine Csavina
Dr. Anthony Petruska
Darren McSweeney
Karl Grueschow

DIGGERLOOP



F17-54 | Bushing Design for Belt Power Transmission

Team members:
Raymond Karam
James Maleski
Junn-Yeu Lock
Josh Covar-Orendain
Matther Dekruif

Advisor & consultants:
Dr. William (Yitz) Finch

Sponsor:
Gates Corporation
Michelle Davis

For this project, the team was tasked with improving the torque capacity of industry standard Taper-Lock bushings. The bushings are used in order to clamp sprockets onto shafts and transmit torque between the two components. As drive belts have improved over the years, the tensile strength of the belts has exceeded the maximum torque capacity afforded by the existing Taper-Lock bushing design, introducing the requirement for a more robust sprocket attachment method. Because of this, the team was tasked with first building a testing device to quantify the torque capacity of existing bushing designs as a reference benchmark for a potential new design. A pneumatically actuated testing device with the ability to log applied torque to LabView was developed for this purpose. The team then designed three alternative bushing designs, with the intention of increasing torque capacity while maintaining the same design criteria of the existing Taper-Lock design, including size, ease of removal, and compatibility with standard size shafts. After benchmarking these three alternative designs against the existing design using the testing device, the team chose the final design based on its improved torque capacity and relative ease of manufacturing.

Individual Broader Impacts Essay

This semester, all Capstone Design@Mines students submitted individual essays about how their engineering choices impact the social, environmental, and/or economic lives of communities and individuals. The topic for this semester's essay was:

> *Designed systems can impact the behaviors of people and environments. Develop a position that argues how an engineered system has either positively or negatively affected the behavior of society, the environment, and/or the economy. The essay should be either related to your project or your field of engineering and use contemporary, concrete examples in the arguments.*

The top 10 essays from this group of 362 senior engineering students were chosen by the course faculty and are included in this packet for your review.

Essay Title	**Author**
The Impact of Developing Cost-Effective Agricultural Vehicles in Sub-Saharan Africa	Ryan Tan
Smartphones and the Human Addiction	Sam DeAngelo
Sticking to Nuclear Power	Trenton Long
Public Transportation: Failing Those That Need It Most	Katharyn Peterman
How Needles Have Gotten Under Our Skin	Haylie Hertz
The Impacts of Glen Canyon Dam	Brittany Bender
What Broader Impacts Impacts	Marc Hauser
Human Datafication and Algorithm-Based Society: An Unprecedented Threat to Democracy	Calvin Swanson
Exoskeletons: Changing Lives or Ending?	Abigail Eustace
Broader Impacts: Individuality in Engineering	Barathwaj Murali

The three best essays will be announced along with the Design Showcase results. The top 10 best essays were judged by a fantastic and experienced panel of volunteer judges:

John Agee
Brenda Chergo
John I. Coats
Richard J. Collins
Steven K. DeWeese
Stephen P. Kutska
Dr. Jennifer E. Labs
John J. McEncroe
Michael Oakley
Dr. Arthur J. Pansze
Eric Phannenstiel
Jeska A. Robinson
Martha L. Sanchez-Hayre
Scott Sanford
Leslie Schluter
Dr. Samuel Spiegel
Emma R. Watson
Dr. Carol Weber
Ken Witherell

We thank you very much for your time and effort involved in choosing the top essays!