College of Engineering & Computational Sciences

Senior Design Trade Fair

MINES™

April 24, 2014

Engineering Design Program
College of Engineering and Computational Sciences

COLORADO SCHOOL OF MINES
GOLDEN, COLORADO 80401-1887

A Special Word of Thanks to Our Judges

It is my pleasure to offer a personal welcome to the judges of the Spring 2014 Colorado School of Mines College of Engineering and Computational Sciences Trade Fair. We appreciate your willingness to take time from your normal activities to evaluate our senior's capstone design projects. The opportunity for our students to get feedback from experienced engineers is invaluable.

Senior design allows our students to demonstrate the engineering knowledge that they have spent four 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, senior 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 processes and 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

Colorado School of Mines thanks the individuals listed below who have provided valuable support for Senior Design students

J. Don Thorson

Al Cohen

Ginger M. Gilfillan

Youn M. Gu

John R. Henderson

Glenn J. Hertzler

David Monarchi

Desiree A. Parrott-Alcorn

James E. Pope

Tyler Schilling

John C. Steuben

Colorado School of Mines thanks the companies and organizations listed below who have provided valuable support for Senior Design students.

Aircell
Applied Control
ArcelorMittal USA
ASCE Region 7
Aspen Seating
Baker Hughes Foundation
Brazz Specialties, Inc.
Checker Industrial Products
Chevron
City of Golden
ConstruKs
Current Pumps
EMJ Company
Epilog Laser
Exxon Mobil Corporation
FCI Constructors, Inc.
Holcim Inc.
Inquiring Systems, Inc.
IEEE
Kiewit Corporation
Lockheed Martin Corporation
M.A. Industries, Inc.
Miller Technology Group, Inc.
MillerCoors Brewing Company
Newmont Mining Corporation
Parker Hannifin Foundation
Phillips 66
PITSCO
Ready Mixed Concrete Company
Red Rocks Community College
R&S Steel
Schlumberger Technology Corporation
Schilling Robotics
Shell Oil Company
Sport Dimensions, Inc.
Stevinson Toyota West & Scion
Stolle Machinery
S2M Consulting
The Home Depot
Toyota Engineering
Toyota Motor Corporation
Tranquility Ranch, LLC
Tribologix Inc.
US Bureau of Reclamation
White Cap Construction Supply
Wolf Robotics LLC
Zimkor

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General Information Regarding Trade Fair

JUDGE'S AGENDA

Time	Description	Location
7:00 - 7:30	Registration and Breakfast Served	Student Center Main Ballrooms
7:30 – 8:45	Breakfast Program • 492 Essay Winners Announced • 491 Elevator Pitch Presentations	Student Center Main Ballrooms
8:45 – 9:00	Transition to Trade Fair	Lockridge Arena
9:00 – 11:00	Trade Fair	Lockridge Arena

FINDING YOUR WAY AROUND

A floor plan and map 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.

GRADING

We seek to achieve consistency in grading between the teams. With that in mind, the senior design faculty has developed the scoring rubric found on the next page. Each row includes several prompting descriptions that are intended to guide the evaluation process. Each description has an associated point value with it.

To completely grade a team, please select a single number from each row of the grading matrix. 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.

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Team Number		Judge Number

TRADE FAIR BALLOT

Judge Name _____

[ ] Client [ ] Alumni [ ] Faculty [ ] 491 Student

INSTRUCTIONS: Circle the most appropriate number from each row in the matrix below. "Exemplary" scores should be reserved for truly outstanding teams only (top 5%). Sum the five numbers and enter the total team score at the bottom of the ballot. Return the form to the registration table when complete. Thank you for participating in Trade Fair.

	Exemplary	Well Done	Satisfactory	Needs Improvement	Unsatisfactory
PROJECT CONTEXT	15 succinctly communicates the project context and goals as related to client needs; fully addresses safety and broader impacts	14 communicates the project context, goals, and client needs; addresses safety and/or broader impacts	12 communicates the project context and goals, mentions safety and/or broader impacts	10 somewhat defines the project context but lacks clarity; does not emphasize project goals, constraints, or safety	0 fails to adequately address the project context
DESIGN CONTENT	15 rigorous engineering analysis; understands the complexity of the design tradeoffs made	14 appropriate engineering analysis; communicates the design tradeoffs made	12 some engineering analysis; mentions the design tradeoffs made	10 does not provide sufficient analysis; neglects complexity of design tradeoffs	0 fails to adequately convey engineering design content
POSTER AND DISPLAY	20 executes an extremely well-organized, creative and professional display; graphics present a clear picture of the project	18 executes a well-organized and creative display; creative presentation; graphics present a picture of the project	16 executes a mostly organized display; somewhat creative presentation; graphics generally present an adequate picture of the project	14 struggles with the display organization or professionalism; some creativity shown in layout; graphics partially present a picture of the project	0 fails to present meaningful information with display
DIALOGUE	25 fluid discussion; team interacts comfortably; confident and thorough during Q&A	23 professional discussion; team interacts; professional Q&A responses	21 rehearsed discussion; minor issues with team interaction; minor concerns with Q&A responses	18 difficult discussion; obvious issues with team interaction; defensive during Q&A	0 fails to adequately discuss the project or meaningfully answer questions
OVERALL IMPRESSION	25 presents a compelling and creative solution	23 presents a good solution	21 presents a feasible solution	18 presents flawed solution	0 does not present a solution

TOTAL
(sum the five circled numbers) _____

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Spring 2014 Design Projects

Each year senior students in the civil, electrical, environmental, and mechanical engineering programs in the College of Engineering and Computational Sciences take a two-semester course sequence in engineering design targeted at enhancing their problem-solving skills. Corporations, government agencies and other professional organizations, as well as individual clients, provide projects for the student teams of five to eight students to work on. Students spend the academic year developing solutions for the projects to which they have been assigned, using tools they have learned throughout their careers at Mines.

This semester, we are proud to present the work of our 42 design teams. Their collaborative design work culminates in today's Senior Design Trade Fair. A list of the teams is provided below. In addition, each team has provided a one page synopsis of their design challenge which is included in the following pages.

TABLE OF PROJECTS

Team Number	Team Name	Project
F13-01	Solar Solutions	Solar Distillation for Rural and Tribal Communities
F13-02	G-Turn Ski Cores	Snow Ski Design and Testing
F13-03	The Green Machine	Self-Sustaining Farm System
F13-04	Structurally Sound Solutions	Sustainable Bridge Design
F13-05	Dynamic Ceramic	Ceramic Microchannel Reactors
F13-06	Colorado AdvantEdge	Wheelchair Sensor System
F13-07	Golden Malting Systems	Pilot Malting, Brewing, and Fermenting System
F13-08	Innova Solutions	JEM-EUSO Global Light System
F13-09	AquaTonic Design Group	Clear Creek Wildfire Sediment Control
F13-10	SocioBot	Social Robot
F13-11	CSM FourCross	FourCross Bike Update
F13-12	TW Designs	Ulysses Skateboard Park
F13-13	Bars and Beams	Roof Deck Addition to Historic Building
F13-14	Black Mesa	Automated Cover Mechanism
F13-15	ElectroMech	Energy Savings in Operation of Large AC Motors
F13-16	Golden Solutions	Energy Savings in Operation of Large AC Motors
F13-17	Victory Lap	Stairs to Dinosaur Tracks
F13-18	Positive Solutions	Looma, A/V Computer for Rural Schools: Electronics
F13-19	Hail Shield	Autonomous Car Hail Damage Protection System
F13-20	EcoAlliance	SafaPani: Arsenic-free Water
F13-21	Blaster Brakes	Single Axle Wheel Lock Static Braking System
F13-22	RPCTKS	Crosshatch Machine Redesign
F13-23	80401 Engineering	XC Sitski Project
F13-24	Looma Mechatronics	Looma, A/V Computer for Rural Schools: Mechatronics

F13-25	Playground Heroes	Mines Park Playground for Family Housing
F13-26	Minion Brigade	Mines Park Playground for Family Housing
F13-27	STSD	Sustainable Design and Construction of High-Efficiency Single Family Homes in Colorado
F13-28	Design United	Design of Variable Friction Continuous ECAP Device
F13-29	Tubular Dynamics	MEL II Lab
F13-30	Stormwater	ERC Stormwater Capture and Treatment
F13-31	OmniPumps	Stream Powered Irrigation Pump
F13-32	Kreative ConstruKtions	ConstruKs
F13-33	Team Luna	Instrumentation Array for Quality Assurance Testing of Jet-Grouted Columns
F13-34	Formula Telemetrix	Formula SAE Telemetry System
F13-35	Wingin It	Formula SAE Front and Rear Aerodynamic System
F13-36	Table Mountain Racing	SAE Baja
F13-37	Blasterbotica Mobility	NASA Lunabotics
F13-38	Blasterbotica Autonomy	NASA Lunabotics
F13-39	Mines Steel Standing	ASCE Steel Bridge Competition
F13-40	Oardiggers	ASCE Concrete Canoe Competition
F13-41	Miner Fuel Consumption	Shell Eco-Marathon
F13-42	Zephyrus	Collegiate Wind Competition

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Solar Distillation Unit

01

Client(s):	Dr. Katie Guerra
Faculty Advisor:	Dr. Tzahi Cath
Technical/Social Context Consultants:	Bryan Coday, Rose Pass
Team Name:	Solar Solutions
Team Members:	Arnold Borysiewicz, Rochelle Collier, Travis Gowler, Jennifer Peter, Joseph Porrello, Lauren Sepp

Solar Solutions has been hired by the Bureau of Reclamation to design and construct a solar distillation unit that will be used in a Navajo community in Leupp, AZ. The unit will be used to desalinate brackish water, and provide drinking water to the members of the community. On location, the pump from the well will provide water to this unit. The current water quality at the well meets general water standards but fails to meet secondary EPA regulated standards as outlined by the Safe Drinking Water Act.

The unit that is being designed will be used for research at the BOR alongside a high-technology design from another university. The unit is to be fully self-sufficient as well as durable. The requirements for the design is that it must be smaller than 4'x4' as well as run off nothing but solar power. Since the unit will be used for testing and research there is only a requirement of distilling one liter of water per day. The design is to be scaled up in order to provide water to the community.

Solar Solutions has come up with a design in which several components will be used in order to distill the water and bring it up to standard that is safe for drinking. The design has been broken down into five system components, energy collector center, pre-treatment center, water recovery center, brine management center, and a clean water center.

Once the system design was completed, calculations and designs for each component were completed. The main areas of focus were the energy collector and the evaporator, as they are the two most important components in the system. After completing the initial calculations, there was some concern with the design so the orientation of the components was changed in order to maximize the capability and efficiency of each component. After the re-design, Solar Solutions is confident that the design is more than capable of producing the required amount of water, as well as the unit being easy to use and maintain.

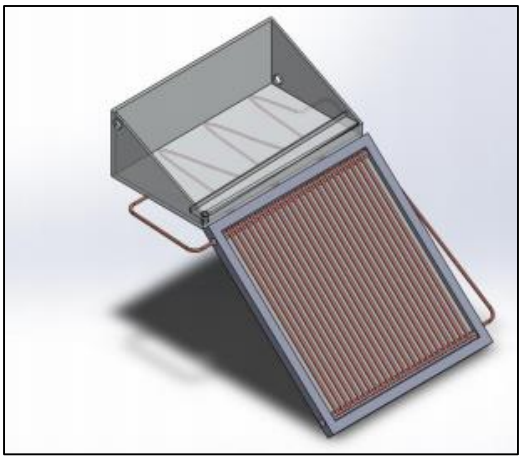

Figure 1: Energy Collector and Evaporator Design

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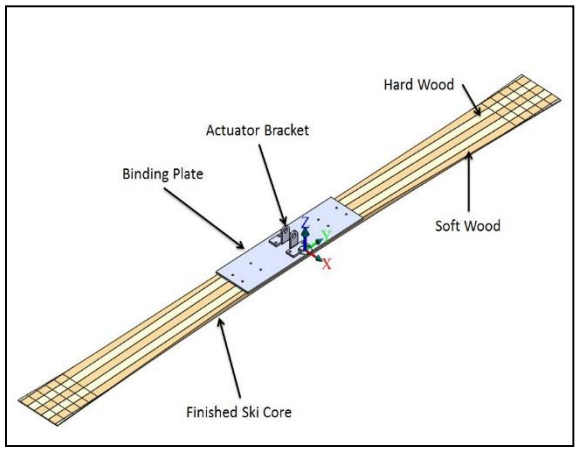
Ski Core Design and Testing

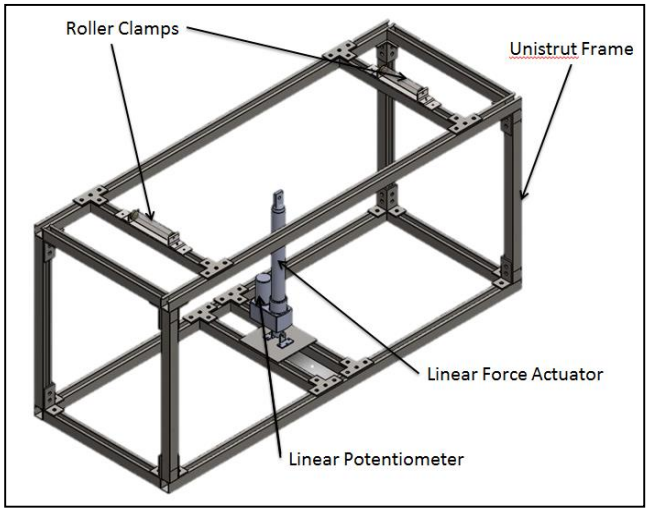
02

Client:	Ben Bramer, Green Light Skis
Faculty Advisor:	Dr. Ray Zhang
Technical Consultant:	Dr. Graham Mustoe
Team Name:	G-Turn Ski Cores
Team Members:	Brandon Aho, Faisal Almazyad, Reuben Brown, Nate Charbonneau, Benjamin Paley, Nico Redfern, Shane Rumley

G-Turn Ski Cores has been hired by Green Light Skis to analyze different ski core configurations. To do this, the team fabricated three different types of ski cores and constructed a testing rig that would test the ski cores. Green Light Skis provided assistance with the specifications and fabrication for the ski cores of the core. The ski cores and the testing rig must be designed inexpensively and the testing rig must be able to support up to 1000 lbf of application. The team will supply test results of the skis and the testing rig as well as all code necessary to run the testing rig to Green Light Skis at the conclusion of this project.

The project has been broken into two design projects: design of the ski cores and design of the testing rig. The design of the skis included material selection, core configuration, and core fabrication. The ski cores must be fabricated using at most two different wood types and be designed for three different skiing conditions: all mountain, powder, and terrain park. The design of the testing rig included controls and electronics, rig structure fabrication, force application, ski core constraints, and data acquisition. The testing rig should test the skis in bending and torsion, take strain gage measurements during testing, and constrain the skis in such a manner that the tests simulate real world skiing conditions. Control of the test and acquisition of the data must be automated. This was done using an Arduino microcontroller, unidirectional strain gages, and a laptop computer. Force was applied to the ski by an electronically powered telescoping cylinder that was fitted with a linear potentiometer. The force applicator was attached to the ski by a plate that was connected to the ski, as a ski binding would normally be attached to a ski. The ski was constrained to the rig using roller clamps as to reduce stress concentrations. Testing the ski cores consisted of bending and torsion tests to failure using strain gages to acquire data.





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The Green Machine

03

Client(s):	JD Sawyer
Faculty Advisor:	Mirna Mattjik
Technical/Social Context Consultants:	Josh Sharp and Liz Cox
Team Name:	The Green Machine
Team Members:	Bree Archuleta, Robert Davis, Matt Hahn, Nathan Kohl, Tyler Vodopich, Brian Zook

Team Green Machine has been approached by client JD Sawyer from Colorado Aquaponics to design an 800 square foot self-sustaining greenhouse structure. The structure must support an aquaponics system, as well as handle Colorado weather extremes. In addition to the greenhouse structure, the team has been asked to provide an attached storage area. Construction of the design will be based on meeting temperature, humidity, transmissivity, and air quality requirements. In order to meet these constraints, the team will be responsible for choosing heating, cooling, and ventilation systems that will provide the necessary means. HVAC calculations will follow ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) codes, and the construction and material choices will follow standard civil engineering practices. The goal of this project is to optimize the sustainability of the greenhouse structure by minimizing the amount of power draw necessary to run the mechanical systems. Additional goals of the design are to meet a budget of $50 per square foot and a structure lifespan of 20 years.

The materials being utilized in the design will be as follows: polycarbonate panels on the north side supported with square steel tubing, main support and greenhouse frame made from rectangular steel tube, pressure treated lumber as the framing for the storage area, and vinyl windows with dual pane insulated glass. The foundation will consist of a concrete strip footing, aided by a two inch foam insulation barrier. The south wall will utilize 60° and 30° slope window angles that maximize direct winter sunlight and minimize direct summer sunlight. The heating systems will require in-ground hot water piping, geothermal piping for air flow, and a furnace. Cooling systems will require a swamp cooler and shade cloth. The ventilation system will require fans and air vents. Each of these components will work to optimize the efficiency of the greenhouse and aid the team in meeting each of the project goals. A model of the design will be constructed, along with a report containing all of the design information.

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Sustainable Bridge

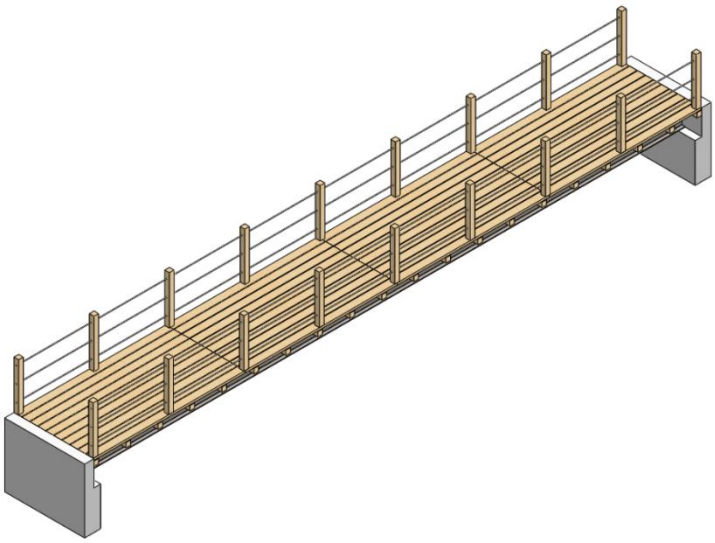
04

Client(s):	Mike Kmita
Faculty Advisor:	Dr. Hongyan Liu
Technical/Social Context Consultants:	Dr. Joseph Crocker, Dr. David Frossard
Team Name:	Structurally Sound Solutions
Team Members:	Michael Hanaoka, Darren Kirk, Eliza Porterfield, Tyler Thoutt, Jacob Zilliox

Structurally Sound Solutions has been hired by The Invictus Initiative, a non-profit organization that supports sustainable humanitarian causes and organizations around the globe, to design a bridge that will be used to transport pedestrian and motorcycle traffic over a river in the Hawagaya community in Southwest Kenya. The current bridge considerably reduces travel time between the village, school, and market but is no longer safe for continued use due primarily to damage caused by biannual flooding. The new bridge was designed to be as cost efficient as possible while being durable enough to withstand the biannual floods and last for five to ten years.

In accordance with the goals of The Invictus Initiative, local materials and a simple design will be utilized to maintain technological sustainability. Small financial contributions and the majority of the construction will be provided by the community members to ensure social sustainability and community investment in the project. The team used codes from the United States and international sources to perform calculations to confirm that the design was created conservatively and to ensure its longevity. At the conclusion of the design process, Structurally Sound Solutions will deliver design and construction drawings together with a digital 3D model.

The completed design features a similar structure to the current bridge. The majority of the load is supported by two steel wide-flange beams running the length of the bridge. They are anchored to identical concrete foundations with footings buried beneath ground. Timber cross beams are located perpendicular to the steel beams at two foot intervals to support the walking surface, which is made of timber planks. Hand rails are located on the walking surface to ensure the safety of the community members.



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Ceramic Microchannel Reactor

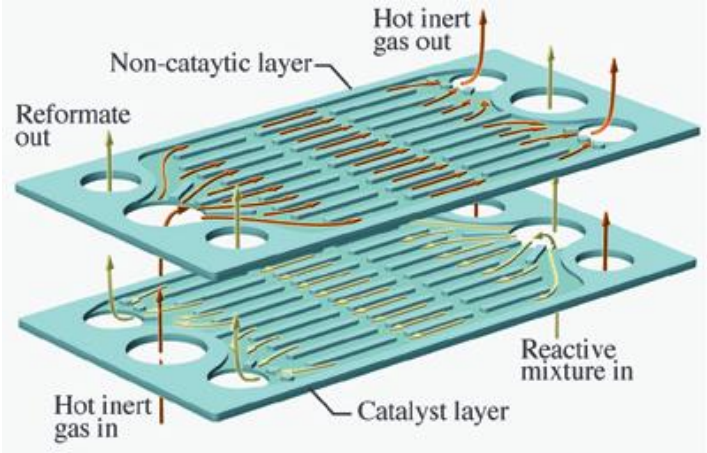
05

Client:	Dr. Neal Sullivan
Faculty Advisor:	Paul Panozzo
Technical Consultant:	Dr. Greg Jackson
Team Name:	Dynamic Ceramic
Team Members:	Michael Miller, Colin Wein, Paul McVay, Julie Thao, Fletcher Hunt, Alex Satre

Dr. Neal Sullivan and the Colorado Fuel Cell Center have created and tested a ceramic microchannel reactor that converts natural gas into hydrogen. Team Dynamic Ceramic has been tasked to analyze the current reactor and find a compatible molten salt that will exert the same amount of heat transfer as the current inert gas. Molten salts are solid at room temperature and liquid when heated to their specified operating temperature. Though often corrosive, molten salts are known for their ability to store thermal energy and are often used as a heat transfer fluid. To find a molten salt compatible with the reactor, the team has: tested the effects of different salts to the current reactor material, compared the properties and effects of air to molten salts, and used a computer modeling tool to graph changes in the temperature profile of the reactor's channels.

The ceramic microchannel reactor is categorized as a counter-flow heat exchanger. This ceramic material has a high temperature operation limit, an ability to withstand severe chemical environments, and has a lower cost of materials and manufacturing. The reactor is made of five layers, each with ten microchannels on each layer. The layers are rotated 180 degrees relative to the layer below it.

In order to convert natural gas into hydrogen, catalysts are added which turns the heat exchanger into a reactor. Currently, the inert gas travels at a magnitude faster than the reactive gas so that it can provide thermal energy for heating and reaction of the reactive gases. The large amount of heat transfer inside the reactor drives the chemical reaction and creates raw hydrogen.



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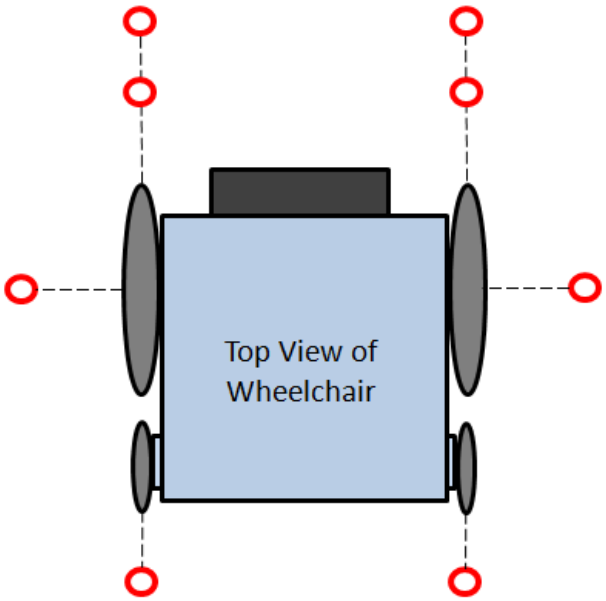
Wheelchair Sensor System

06

Client:	Jered Dean
Faculty Advisor:	Yitz Finch
Technical/Social Context Consultants:	Atef Elsherbeni, Louisa Duley
Team Name:	Colorado AdvantEdge
Team Members:	Erika Blair, Michaela Hammer, Justin Loeffler, Julia Morin, Katie Poffenbarger, Kendrick Stalnaker, and Kevin Tornes

Colorado AdvantEdge has been hired by Jered Dean to design and implement a wheelchair sensor system to help his niece, Kate Dean, safely and independently navigate the world around her using a large electric wheelchair. Her current chair weighs 286 pounds, and can cause significant bodily harm should it tip over on its occupant. An edge greater than 2.5 inches, a forward slope greater than 12 degrees, and a transverse slope greater than 6 degrees could all cause the chair to tip. The purpose of the wheelchair sensor system is to detect dangerous conditions near the wheelchair before the user can drive over them.

After testing several types of sensor technologies and performing edge-case analysis on wheelchair models, Colorado AdvantEdge designed a prototype system comprised of eight distance sensors. In the front of the prototype, two long-range sensors act as the first defense against possible unsafe conditions. Two shorter-range sensors are also mounted in front to pick up additional conditions that may go undetected by the long-range sensors. One shorter-range sensor is mounted on each side of the prototype to detect conditions such as curbs. A pair of shorter-range sensors is also mounted on the back.



Circles indicate sensor measurement areas

The data collected by the sensors is interpreted by an Arduino Due processor, which implements an edge-detection algorithm. If an unsafe condition is detected by the front or back sensors, a primary alert is signaled. For a user with a delayed reaction time, the primary alert may be replaced by a hard-stop of the wheelchair. If an unsafe condition is detected by a side sensor, a secondary, less severe, alert, employing vibration or lighting, is signaled. Accurate sensor readings, paired with effective alerts, allow for the system to provide increased safety and independence to the user.

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Pilot Malting and Brewing System

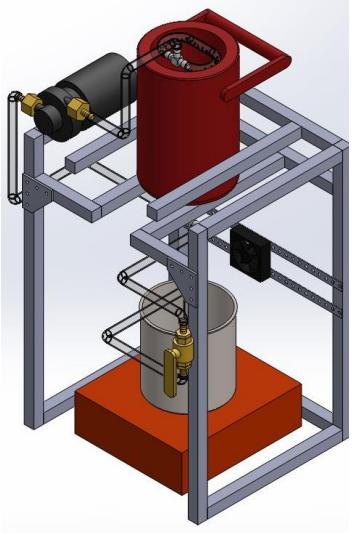
07

Client(s): Dr. Paul Ogg
Faculty Advisor: Dr. Ron Slovikoski
Technical Consultant: Dr. Vincent Tyrone
Team Name: Golden Malting Systems
Team Members: Levi Gerber, Emma Gray, Andrew Legg , Peter Morgenthaler, Matt Snyder, Ryan Weimer, Zac Zillmann

Small breweries have been expanding over the last several years. Unfortunately, the malted barley available for purchase is limited by large brewing companies that set the standard of taste and quality. The small selection of barley results in varieties that are widely accepted but often lack in character and specialty. A small malting, brewing and fermentation system will allow micro-breweries and home brewers the opportunity to present unique beer from barley varieties that large breweries reject as outside the norm.

Germination Agitation Prototype

Golden Malting Systems (GMS) has created Solidworks drawings, a materials list, assembly instructions, and several prototypes for a complete malting and brewing system that will simultaneously process eight individual samples of barley. Each sample will contain approximately one pound of barley and will result in a half gallon of beer. The system will allow for high throughput of several hundred samples of barley per year. The following phases will occur in the malting process: Soaking, where the grains are soaked to 40% moisture content, Germination, where the grain is agitated and grown to a desired maturity, and Drying, where the grain is baked to 10% moisture content. After malting, the grains are transferred to the brewing system where beer is made following the congress brewing procedure. Each step in the pilot system is as automated as possible while remaining under the $10,000 budget.



Brewing System Solidworks Model

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JEM-EUSO Global Light System: Laser Beam Steering

08

Client(s): Dr. Lawrence Weinke
Faculty Advisor: Dr. William Finch
Technical Consultant: Dr. Jason Porter
Team Name: Innova Solutions
Team Members: Casey Baron, John Fruit, Ryan Hanley, David Hirsch, Andrew Osciezanek

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The team, Innova Solutions, have been hired by Dr. Lawrence Wienke of the CSM Physics Department to work on improving the steering of the Global Light System. This system allows for an active study of cosmic phenomenon to test the module's operation by directing a laser to create similar conditions to that of a cosmic event. The Global Light System currently has a 2-stage steering system for directing the laser that has a few issues. The previous design was incapable of rotating continuously due to wire wrapping and, in certain positions, was capable of crashing into itself. The team implemented a slip ring into the design, enabling continuous rotation and additional clearance to resolve the issues mentioned. Additionally, the team redesigned the stages of the current design to be less complicated to machine. The new prototype required testing to ensure accuracy and verify backlash error. Lab methods were devised and implemented to ensure the specific requirements were being met with the improvements. Following the completion of the design/manufacturing/verification process, the finished prototype will be integrated with the rest of the JEM-EUSO system for field-testing.

After design work, the project was split into two subsystems. The first subsystem focused on manufacturing the prototype stages. This required extensive programming with MasterCam and part construction with the CNC machine to guarantee proper dimensioning for assembly. In addition, wiring changes were made so that electricity could successfully flow through the slip ring for operation. The second subsystem focused on testing. This process involved checking the backlash by shooting the laser in multiple positions to test its repeatability and deviation from the actual target. The distances and angles of the laser's coordinates were verified using a total station for measurement.

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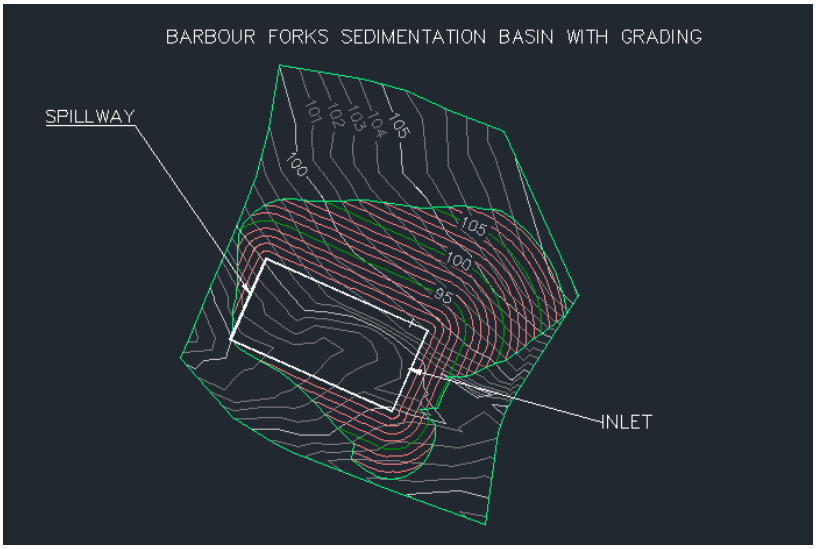
Clear Creek Sedimentation Control Basin(s)

09

Client(s): Anne Beierle & Will Stambaugh, City of Golden
Faculty Advisor: Eryn Ammerman
Technical Consultant: Dr. Terri Hogue
Team Name: AquaTonic Design Group
Team Members: Dustin Dacus, Simone Dennison, Ian Holdeman, Dexter May, Garrett Schirmacher, Carol Skelton

AquaTonic Design Group has been hired by the City of Golden to determine ideal locations and potential designs for sedimentation basins in the Clear Creek watershed to implement in the event of a wildfire. After reviewing preliminary information provided by the City of Golden and contacting over thirty stakeholders, the primary needs and concerns of those who rely on Clear Creek for water have been identified. In an emergency situation such as a wildfire or flood, protecting water supply is the top priority. Accessibility to the site and speed of construction of a mitigating basin, will take precedence over permitting procedures and standard regulations. Pre-disaster design plans for basins will allow the City of Golden and other agencies to mobilize quickly and take a proactive approach to treating large, sediment-heavy flows in the event of a wildfire.

Two potential locations for sedimentation basins have been determined at the Barbour Forks and Little Bear Creek tributaries of Clear Creek. Research into design regulations, two different hydrologic models (Log-Pearson and HydroCAD), and surveying have been completed for both sites, resulting in several AutoCAD surface renderings of the topography and basin designs. These renderings were used to generate a deliverable plan set, including site, grading, and demolitions, as well as removals sheets for each basin. The plan sets incorporate volume and flow rate information from the hydrologic models, as well as spillway, weir, and underdrain recommendations. Excavation and materials information from this plan set has been used for project cost analysis. The potential mitigation that can be achieved by pre planning and designing for sediment control basins is an important component of protecting water quality for regulatory agencies and one that is certain to be looked into more in the future.



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Social Robot

10

Client(s):	Michael Melonis
Faculty Advisor:	Yitz Finch
Technical/Social Context Consultants:	Gongguo Tang
Team Name:	SocioBot
Team Members:	Chris Sanford, Ryan Moos, Josh Wretlind, Josh Duffy, Kelton Manzanares

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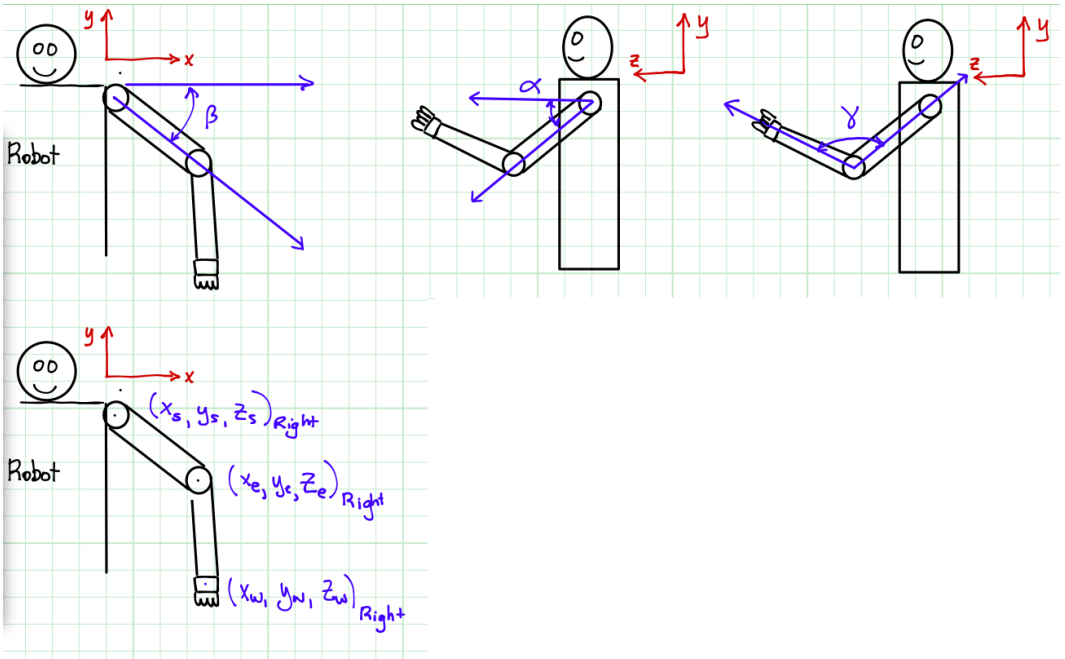
Team SocioBot has been hired by Michael Melonis at the Department of Rehabilitation Medicine at the University of Colorado at Denver to design and build a robot to assist patients with Cerebral Palsy. In order to do so, the Social Robot will utilize a Microsoft Kinect sensor to visualize movement of the patient's arms while sitting in front of the robot. The robot will make calculated movements to mirror the actions of the patient in order to encourage the patient to make more movements. Due to the fun atmosphere of the patients' interaction with the robot, the patient will enjoy playing with the robot which will ultimately help develop their muscular structure. Since patients require several times more repetitions of movements compared to able-bodied patients, the robot can help encourage movement when typical parent and child interaction would require time consuming and repetitive movements.

The robot has six servo motors that are wired to an Arduino which correspond to the shoulder, elbow and wrist of each arm. The Arduino also consists of a Bluetooth module so that it can communicate with a PC, which sends the robot angle data corresponding to the skeleton of the patient picked up by the Kinect. The wiring between the robot and the Arduino is done on a small protoboard, which wires together a 7V battery, and the power and signal buses for the Arduino and servos. In order to get the necessary power supplied to the servos, a linear voltage regulator bolted to a small aluminum heat sink was used. Team SocioBot developed all the code to accomplish the robot's mirroring action, both on the Arduino end and on the PC end.



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CSM FourCross Bike Update

11

Client(s): Chris Read and Dr. Joel Bach
Faculty Advisor: Paul Panozzo
Technical/Social Context Consultants: Dr. Anne Silverman and Dr. Juan Lucena
Team Name: CSM FourCross
Team Members: Clayton Boatwright, Emily Hixon, Abigail Krycho, Hannah Margheim, William Pietra, Jacqueline Stabell, Brian Stack

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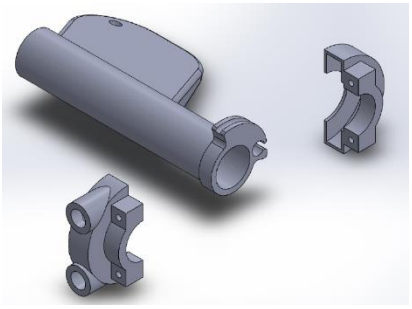
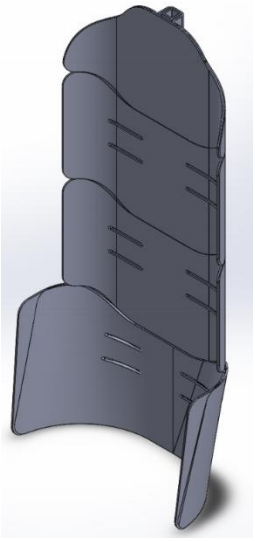
CSM FourCross has been tasked with improving the braking system as well as the seat on the FourCross style mountain bikes. The design for the braking system needs to facilitate riders with limited muscle functionality that involves injuries up to and including a C5 spinal injury. The new design must be fully reversible so that it can be easily exchanged with the current braking system. The new brake design must also reduce brake pad wear from excessive riding of the brakes. In addition, the team has been tasked with improving the seat used on the bike to make it safer and more comfortable for the riders. The riders with limited core strength cannot keep their trunk stable, so the seat must provide proper posture and stability for the rider, while also preventing back hyperextension should a crash occur. The new seat design must be: adjustable to fit all riders, provide protection, and result in a comfortable ride.

Initial prototypes for the braking system and seat back system were designed using SolidWorks FEA. These prototypes were tested by an incomplete quadriplegic who has raced FourCross mountain bikes competitively. This user input was used to create the final designs.



The final braking system consists of the combination of a throttle and pedal. The user engages the brakes by pushing down on or leaning into the pedal. This then turns the throttle and pulls on a cable that is attached to the traditional brake lever. Due to lack of grip strength, the rider's hands are strapped on to the pedal with an adjustable strap that prevents the hands from falling off the pedal.



The final seat back system is a series of panels that allows for height adjustment according to rider preference or need. The higher the spinal cord injury on a rider, the less core strength, therefore more panels can be added for support. The new seating system provides a hinged adjustable seat back so the rider can sit at their desired riding angle. Seat cushions were installed to aid in fitting the rider to the seat, and for protection and comfort.

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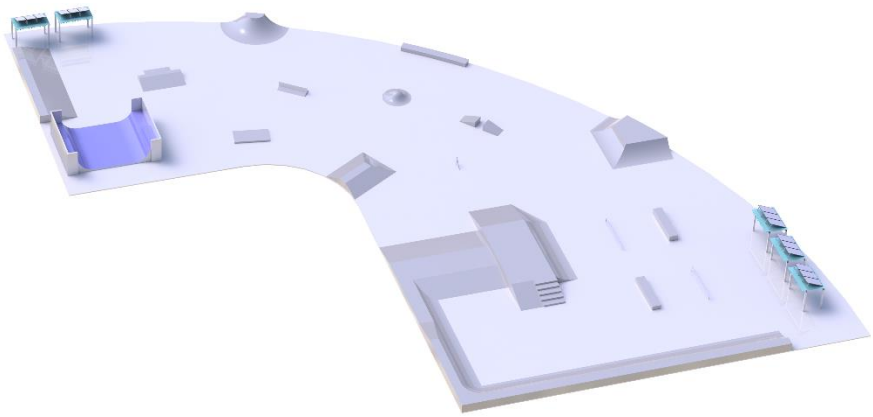
Ulysses Skatepark Redesign

12

Client(s): Rod Tarullo
Faculty Advisor: Chris Dreyer
Technical Consultant: Vaughan Griffiths
Team Name: TW Designs
Team Members: Jaime Diaz, Chris Fleischauer, Kaitlin Hedberg, So Kato, Richard Moore, Catherine Smith

TW Designs reached out to the City of Golden Parks and Recreation Department in order to redesign the city's skateboard park, located at the Ulysses Sports Complex. The existing skateboarding facility is outdated by modern skateboarding standards. Due to the construction of new skateboarding facilities in the Denver Metro area, the current Ulysses skateboard park has become less favored by the skateboarding community. Local skateboarders are choosing to visit new facilities in Arvada, Wheat Ridge, and Broomfield, and the City of Golden would like to provide their citizens with a similar skateboarding experience. The design must provide a functional skateboard park that can accommodate all ability levels, foster progression, take into account the inputs of the local skateboarding community, and be aesthetically pleasing. To address these needs, the team chose to create a complete redesign for the City of Golden.

Based on a recommended budget of $500,000, the team developed a new park design. The new design was based on observations of successful, functional skateparks in the Denver area and incorporated feedback from the local skateboarding community. All park features were designed through the use of relevant skateboard park design guides and meet standards of practice for skateboard park construction. The design incorporates a lighting system, which has been designed through the use of Visual Lighting Software. Solar panels have been incorporated to offset 20% of the park's energy use. Custom shelter features have been designed through the use of *ASCE 7* and the SolidWorks Simulation FEA package. Educational concrete stains and murals have been incorporated that focus on a math and science theme.



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Rooftop Bar Addition

13

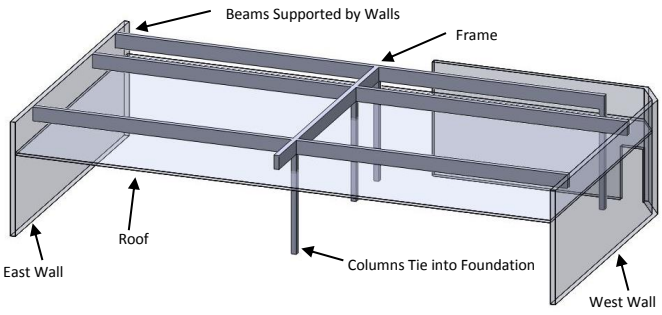
Client(s): Dean and Aimee Valdez
Faculty Advisor: Hongyan Liu
Technical Consultant: Susan Reynolds
Team Name: Bars and Beams
Team Members: Brandon Keller, Nic Martin, Connor Maxon, Jake Montgomery, Eric Pogue, Leslie Sackett

1111 Miner's Alley

Team Bars and Beams was hired by property owners in downtown Golden to design the structural reinforcement to accommodate the addition of a rooftop bar to 1111 Miner's Alley. In addition, the team provided staircase layout to provide access from the roof to ground level of the one story building. The team will provide a design solution that complies with all applicable codes, is cost-effective, and causes minimal disturbance to surrounding commercial and residential areas. A construction plan, cost estimate, and detailed drawing package have been provided as well.

With no plans available for the existing structure, the team performed site investigation and analysis of the current conditions. In the existing structural system, joists transfer the vertical loads of the roof deck to steel beams, interior columns, and concrete masonry walls.

The proposed design solution uses a steel frame that is supported partially by the existing concrete masonry walls to support a rooftop deck on the southern half of the roof. Beams will span horizontally in the east and west direction supported by the walls and interior columns. The columns must be put through the existing roof and will tie into the existing concrete foundation. Steel joists will span horizontally across the beams and directly support the deck. With this modular type design, there is potential to extend it to the remaining roof and nearby historical structures to increase the size of the rooftop structure.



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Automated Cover Mechanism

14

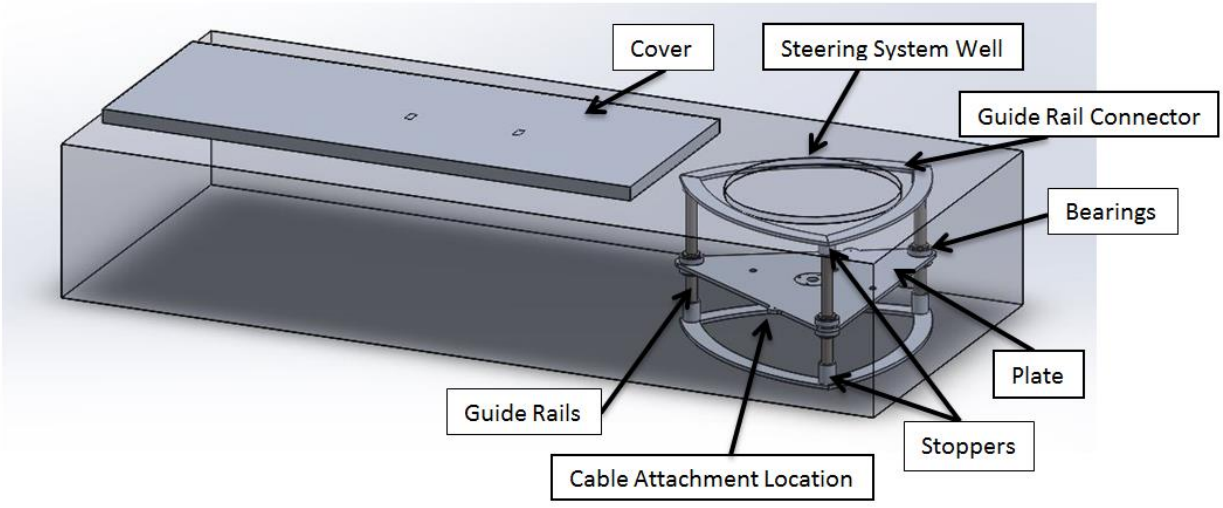
Client:	Dr. Lawrence Wiencke
Faculty Advisor:	Darek Bruzgo
Technical Consultant:	Stephanie Claussen
Team Name:	Black Mesa
Team Members:	Austin Cain, Anna Evans, Tina Gallmeyer, Jon Gossman, Iain Smith, Tom Wills

Team Black Mesa won an engineering design bid for an Automated Cover Mechanism (ACM) for Dr. Lawrence Wiencke of the CSM physics department.

The ACM will, first, be implemented in Argentina and used to further develop the Global Light System for the Japanese Experiment Module (JEM-EUSO) cosmic ray project. If successful, the system will be replicated and used on six stations around the world to protect laser steering mechanisms from each location's respective climates. Full operation must be possible in wind, heat, freezing, dirt, water, and snow. The cover must overall be cost effective, simple, robust, and easily operated with a computer interface.

Team Black Mesa designed a system composed of four main components: a triangular plate to support the laser steering system, three vertical guide rails for this plate to travel up and down along, a sliding cover to protect the steering system, and a motor with a ball screw to run the cover system. The ball screw and motor are attached to the cover and move the cover horizontally. Cables connected between the cover and plate will slide over a pulley and pull the plate vertically into the view plane. For normal operation, the motor is back driven, but can also pull itself closed in an emergency power loss situation.

At the conclusion of Spring '14 semester, Team Black Mesa will deliver: (1) a quarter scale prototype built to show proof of concept and functionality and (2) a set of engineering drawings to facilitate the full build of the cover, taking place after this spring semester.



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Motor Efficiency at MillerCoors

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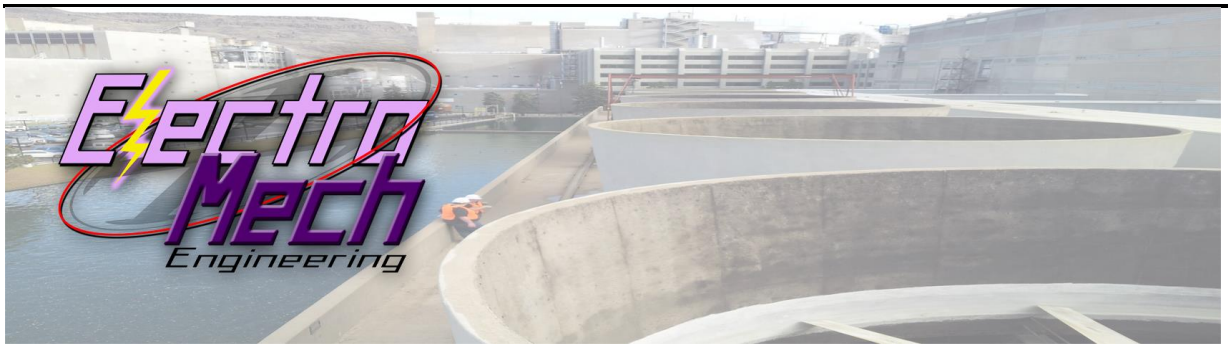
Client(s):	Sean Yates
Faculty Advisor:	Eryn Ammerman
Technical Consultant	Ravel Ammerman, Derrick Rodriguez
Team Name:	ElectroMech Engineering
Team Members:	Bob Francis, Erica French, Riley Geistmann, Erik Johnson, Grant Johnson, Kelsey Neal



ElectroMech Engineering was tasked by MillerCoors to investigate several large AC motor and pump systems of differing applications to determine their operational efficiencies, and recommend design solutions for the improvement of these efficiencies. Electrical data was collected from the AC motors to determine the operational power output that is made available to the pumps and fans studied, and these results were used to analyze the electrical efficiencies of the systems. The physical designs of the flow systems were examined and mechanical calculations were performed to determine the head necessary for optimal flow. The centrifugal pumps currently in use were then analyzed to ascertain the efficiencies of the mechanical systems.

A spreadsheet was created documenting the data and analyses performed. The results were used to identify solutions that will increase the system efficiencies. The primary recommendation from the team is for MillerCoors to replace those motors that were found operating at less than 85% efficiency with NEMA® Premium motors. Furthermore, the design solutions were evaluated to determine if they were eligible for Xcel Energy rebates. For those that were eligible, ElectroMech Engineering delivered the rebate forms containing the pertinent information MillerCoors would need for submittal. It is expected that these solutions will reduce the energy costs of MillerCoors; and in time, transform the Golden plant into one of the most efficient breweries within with the MillerCoors family.

CO2 Booster Compressors at MillerCoors in Golden

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Energy Savings in Operation of Large AC Motors

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Client(s):	Sean Yates
Faculty Advisor:	Eryn Ammerman
Technical Consultant:	Ravel Ammerman
Team Name:	Golden Solutions
Team Members:	Ryan Asensio, Baski Baker, Charlie Basil, Katy Beseda, Jacob Best, Cody Sickler, Trevor Sullivan

Team Golden Solutions has been hired by MillerCoors to analyze motors and pumps in their Fermentation and Maturation facilities for potential energy savings opportunities. The motors and pumps to be investigated are part of clean-in-place (CIP) systems that clean various tanks and lines used in the brewing process. Information regarding the CIP systems has been either provided by contacts at MillerCoors, or collected manually by Golden Solutions. Manually collected data includes electrical motor data, pump flow rates, pressures and pipe diameters.

With this information, Golden Solutions will analyze whether or not the current pump and motor setup is oversized for its intended application and the potential energy savings that could be realized by altering existing components or adding new components to the system. Potential alterations and additions include using variable frequency drives (VFDs), installing corrective capacitor banks, installing new, high-efficiency motors, and improving the pump design. These money saving methods will be investigated based on a return on investment (ROI) analysis, taking into account energy savings, capital costs, and rebates from Xcel Energy. The final deliverable for this project will be an Excel spreadsheet that shows all the data collected, calculated parameters necessary for the analysis, and a sheet that shows the ROI calculations for each money saving method. From this ROI analysis, Golden Solutions will make recommendations regarding which changes MillerCoors should make to their CIP systems.

http://www.alibaba.com/product-gs/356181529/direct_coupled_motor_pump.html

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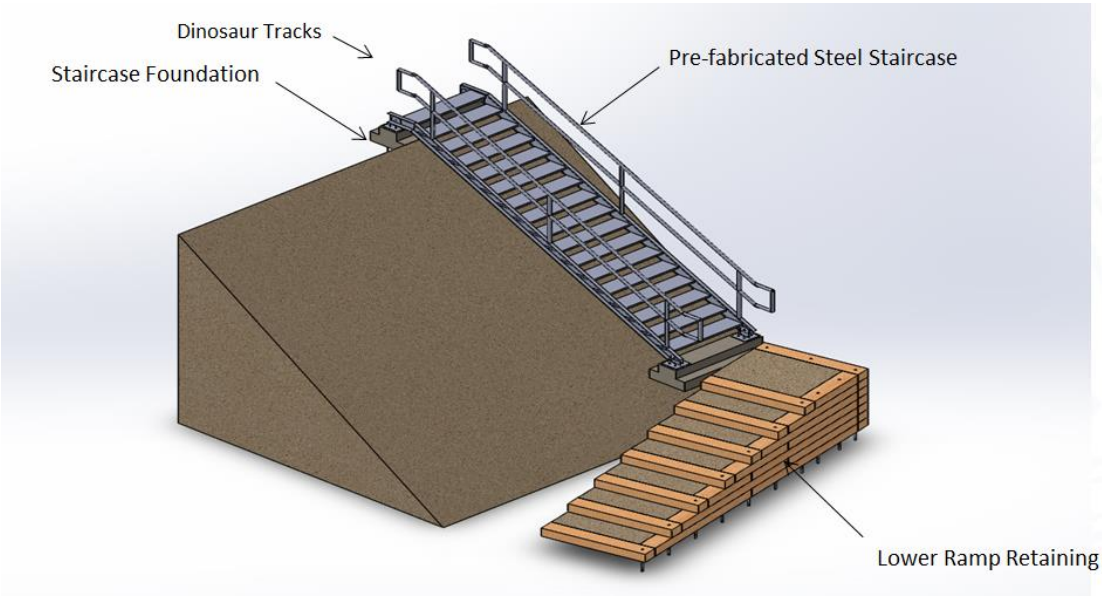
Stairs to Dinosaur Tracks

17

Client(s):	Joe Temple
Faculty Advisor:	Hongyan Liu
Technical Consultant:	Ning Lu
Team Name:	Victory Lap
Team Members:	Dustin Anderson, Curtis Burback, Stevie Davidson, Rebecca Keller, Sean Miller, Greg Proulx

Team Victory Lap has been hired by Friends of Dinosaur Ridge to design a safe and stable staircase entrance to view dinosaur tracks. To do this, the team must overcome a steep slope and a historically sensitive site in order to allow access to the dinosaur tracks. The staircase must meet International Building Codes (IBC) as well as the requirements from Jefferson County. Since the staircase will be on the face of the mountain, it was required that the design blends into the mountainside and must not be visually noticeable from C-470. The staircase needs to allow visitors of the site to be able to clearly see the Iguanodon and Crocodile tracks while also providing two-way foot traffic.



The staircase is going to be a prefabricated steel staircase that will be built by FS Industries. This prefabricated staircase will have slotted treads, it can be painted to blend in with the terrain, and is a cost effective solution to the project. The prefabricated dimensions meet all aspects of IBC codes in regards to the tread, the overall staircase, and the handrails. There will be a railroad tie retaining wall located at the bottom of the slope which will base the steel staircase. This design will give a safe way of accessing the dinosaur tracks located at the top and side of the stairs.

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Looma A/V Electronics

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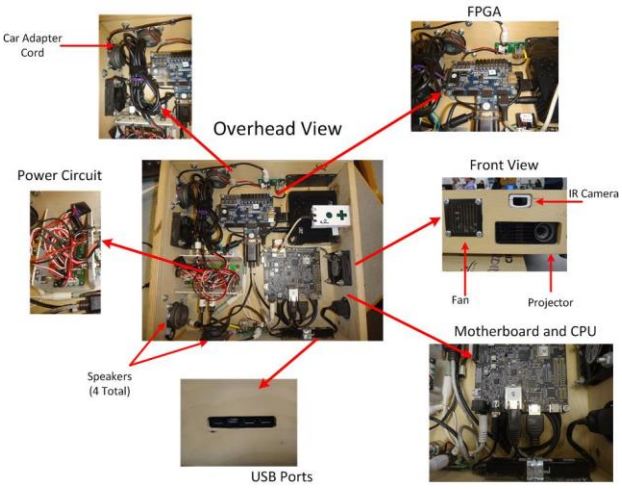
Client(s): David Sowerwine and Skip Stritter
Faculty Advisor: Eryn Ammerman
Technical Consultant: William Hoff
Team Name: Positive Solutions
Team Members: Casey Biemiller, Evan Brown, Matthew Gann, Darren Mans, Brandon Varner, Kamee Vessey

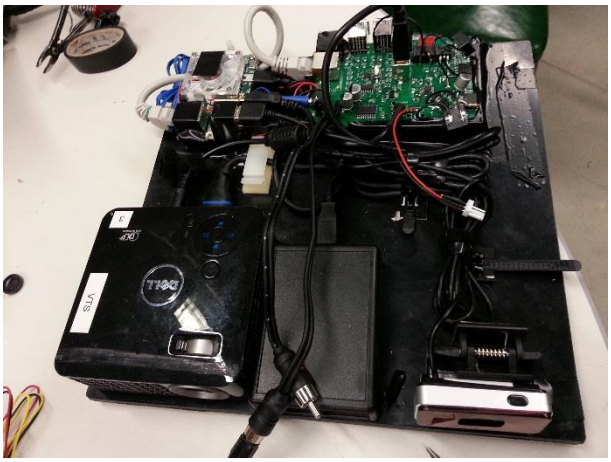
VillageTech Solutions has asked Positive Solutions to assist in the making of the second generation Looma by reassessing its electrical components.



Preexisting Looma

Looma is a prototype of an affordable audiovisual (A/V) center designed as an optical teaching tool for use in developing countries. As shown in the picture to the left, Looma incorporates an embedded computer, high capacity solid-state storage, LED projector, internet connectivity, wand-based user interactivity, and is powered by a solar charged battery. The existing prototype design includes all off-the-shelf subcomponents (projector, single-board computer, PC speakers, Nintendo Wiimote). The subcomponents are assembled into a hand-made wooden box with lots of internal cabling.

The overall goal for the Looma A/V Electronics Project is to create a sustainable next generation Looma design that can be used for high volume manufacturing. Positive Solutions will contribute by creating one mother-board with a pluggable CPU daughter-board. Design ideation and modeling were used to choose the best and most cost efficient products available for the CPU board (Odroid-U3), projector (existing Dell pico projector), web-cam (Odroid USB), and IR pen (Vmarker). To the right, the layout of the next generation Looma can be seen.



Next Generation Looma (in progress)

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Autonomous Hail Protection System

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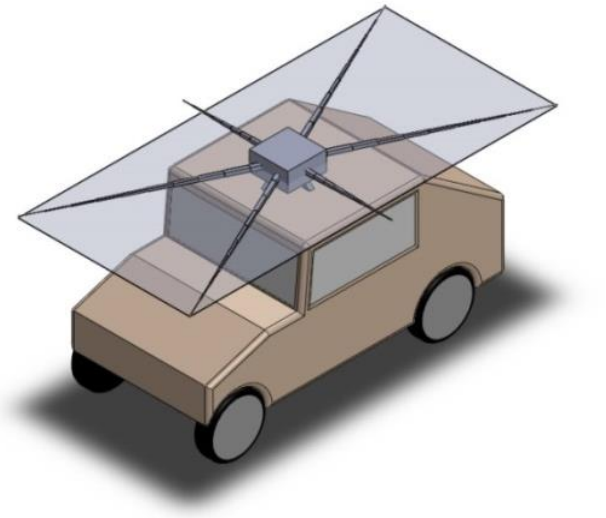
Client(s):	Paul Brayford
Faculty Advisor:	Paul Panozzo
Technical Consultant:	Vibhuti Dave
Team Name:	Hail Shield
Team Members:	Gilchrist Day, Eric Comstock, Jonathan Pritchard, Dustin Whisman, Stefan Manning, Patrick Pravorne

Team Hail Shield has been hired by Paul Brayford to devise an autonomous system that will protect vehicles against the damages caused by hail. To do this, the team has broken the project down into two parts - the method of detection and the method of protection for the vehicle. The detection method consists of using acoustic and impact detection to distinguish between the precursor hail and various other projectiles. On successful detection, a signal will be sent to take the protective action against the oncoming hail, thus protecting the car from further damage. The specifications given to us by Mr. Brayford are that the detection system must be accurate such that the system would not falsely deploy. Also, the protection system must be user friendly for repackaging after deployment; the battery must not need to be recharged frequently; and the protective system must be reusable and if not, cost justified. Likewise, the detection and protective system must meet all the standards and safety regulations for all vehicles.

The first subsystem detects hail by using a combination of electrical devices controlled by a microcontroller. The electrical subsystem uses a piezeo electric contact microphone which would detect hail acoustically, a suggestion given to us by the client. Also, to prevent false deployment, an accelerometer was used detect the impact of the precursor hail. When both sensors are triggered, a signal will be sent to deploy the protective system. Testing of this subsystem involved dropping various projectiles on a sheet of steel. The data would be analyzed according to their acoustic frequency spectrum, thus, allowing us to identify each projectile. This second subsystem is controlled by the microcontroller that will signal a DC motor to deploy the telescoping rods contained with the central housing unit. Attached to the extended rods is a polyester mesh netting, selected by the team through a decision matrix and strength test, which will protect the vehicle from hail damage.



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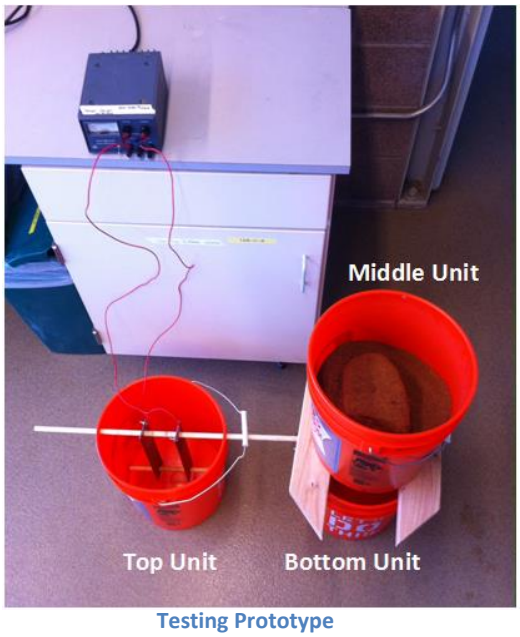
SafaPani: Arsenic-Free Water

20

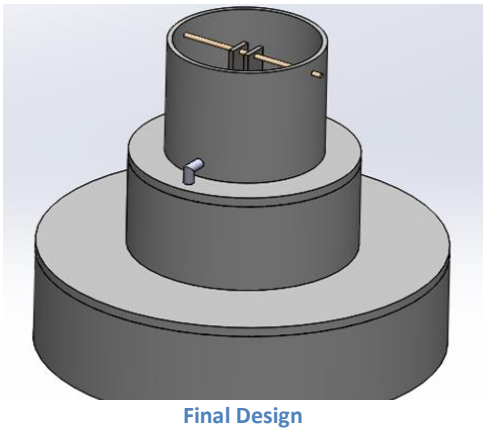
Client(s): David Sowerwine and Skip Stritter
Faculty Advisor: Lauren Cooper
Technical/Social Context Consultants: Linda Figueroa and Mirna Mattjik
Team Name: Team EcoAlliance
Team Members: Krista Albers, Kevin Chan, Melissa Cook, Matthew Cutt, Christine Hrdlicka, and Kristen James

Team EcoAlliance has been asked by Village Tech Solutions to design a manufacturable arsenic water filtration unit to be implemented in rural areas of Nepal and Bangladesh, afflicted with high arsenic concentrations in the groundwater. The filter utilizes the processes of electrocoagulation and physical filtration to treat initial arsenic concentrations of a maximum level of 200 parts per billion (ppb). The product must be designed such that it is cost-efficient at nearly $60 per unit, and effective enough to reduce arsenic-contaminated water to a final concentration of about 10 ppb. A user manual is available for consumers providing step-by-step picture instructions for proper use of the filter. Team EcoAlliance ensured reliability of the design via research, theoretical calculations, and extensive laboratory experimentation.



Testing Prototype

The filtration unit is a three-tiered system that must treat up to 15 liters of water at a time. In the top unit of the filter electrocoagulation occurs, in which influent water is exposed to two iron electrodes charged with a 5 volt source. The electrolysis process is allowed to run for 45 minutes, during which iron released from the electrodes bonds to the arsenic, allowing the contaminant to coagulate out of the water. After this period of time, the valve from the top to middle unit may be opened. The middle unit is a small-scale sand filter that contains 15 centimeters of medium to coarse sand and a diffusion surface. The sand bed captures the iron-arsenic particulate, allowing treated water to pass through to the bottom unit. This last unit stores up to 100 liters of treated water with a final concentration of approximately 10 ppb arsenic.


Final Design

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Single Axle Wheel Lock Static Braking System

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Clients: Checkers Industrial Safety Products: Danny Coffman, Greg Lundeen, Greg Widgery

Faculty Advisor: Ron Slovikoski

Technical Consultant: Doug Van Bossuyt

Team Name: Blaster Brakes

Team Members: Mitchel Brown, Alexandra Leroux, Brian Lindsadt, Benjamin Palmer, Brandon Sawada, Shannon Spokas, Dylan Witte

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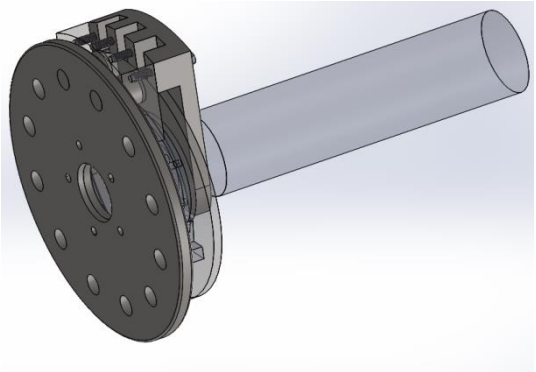
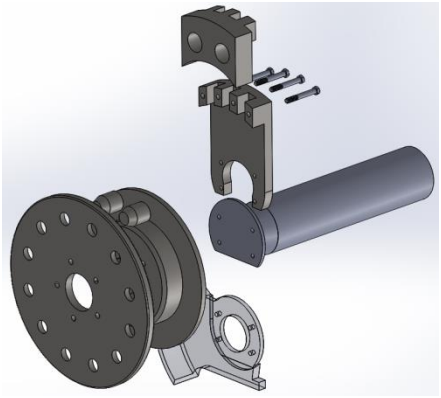
Blaster Brakes was tasked by Checkers Industrial Safety Products to design and prototype a single axle wheel lock static braking system. Vehicles ranging from postal trucks to mining equipment already require the use of manual wheel chocks for securing the vehicle. Therefore, these vehicles are suitable for an automated chocking system; a system that will not only provide a failsafe for the existing braking systems, but also increase safety and efficiency for the user. The proposed single axle wheel lock static braking system is intended to be an automated chocking system.

Although the braking system is designed specifically for a standard Grumman LLV Postal Truck, it must be a scalable system to suit larger vehicles. The design must be economically efficient and maintain adequate automotive design safety standards. The team must design the brake to be an aftermarket product that prospective clients can purchase for their specific equipment. The overall goal of this product is to provide an additional safety feature to replace the currently used wheel chocks that keep the vehicle stationary.

The braking system developed by Blaster Brakes can be broken down into two basic parts: the brake plate and the braking pins. The brake plate is intended to be mounted next to the current disc brake rotor, where it will be secured by elongated wheel studs. This plate will have a series of holes into which the braking pins will insert. These pins will be tapered to be self-guiding and will secure the vehicle in place. The housing for the brake pins must reach over and clear the current brake rotor. A braking system of this design will be placed on each of the rear wheels of the vehicle to ensure the greatest stability and maintain modularity.





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Crosshatch Machine Redesign

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Client(s):	Stolle Machinery
Faculty Advisor:	Darek Bruzgo
Technical Consultant:	Dr. John Steele
Team Name:	RPCTKS (Redesigning Positive Change Towards Kinetic Solutions) Engineering
Team Members:	Rex Madden, Patrick Ernst, Sarah Kelly, Connor Riley, Toni Welling, Kara Ninke

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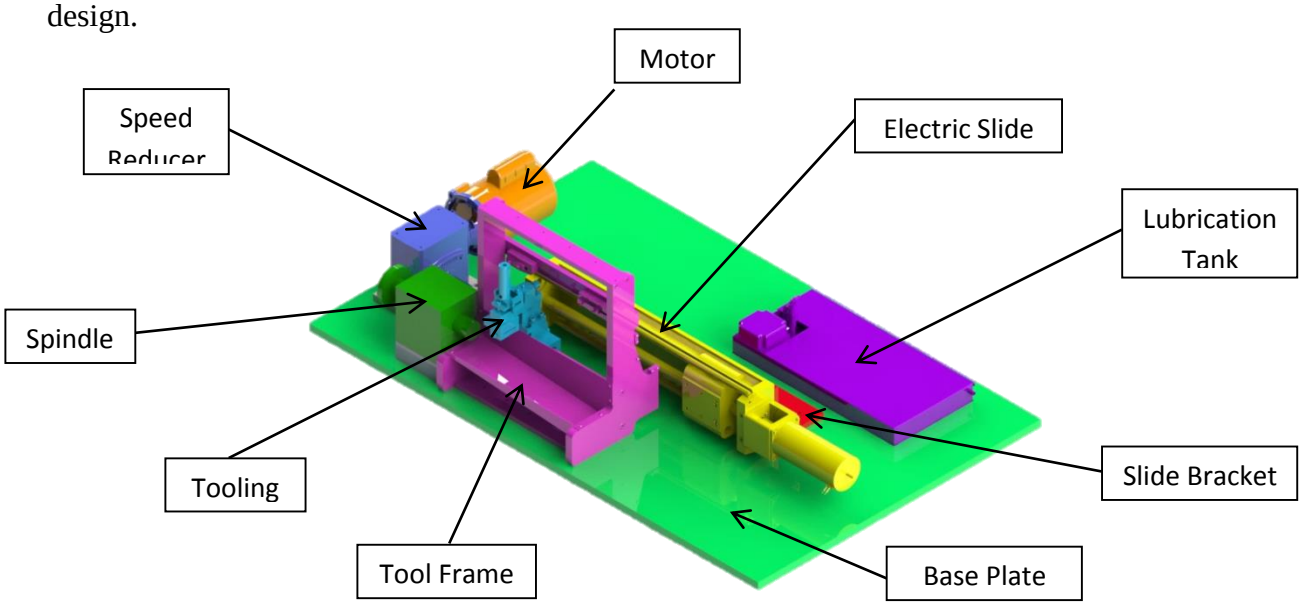
The purpose of this Senior Design project is to redesign Stolle Machinery's crosshatch machine, which resurfaces carbide punch sleeves used in the aluminum can making process. The goal for this project is to redesign the machine to ultimately reduce cost and lead-time. The team's efforts are a continuation from last year's team X-Hatch. Since Stolle Machinery liked many aspects of their design, the team has expanded upon their conceptual design and created a prototype as the final deliverable. It is critical that the new design has the exact same functionality as the original machine, and handles the resurfacing of the punches without sacrificing the tight tolerance.

The scope for this project includes the motor, spindle, baseplate, motor/spindle couplings, and electric slide. The team has focused on selecting and coupling these components while still maintaining the same functionality. During the conceptual design phase, the team faced challenges involving spindle selection, how to connect the speed reducer and motor, and how to implement the existing custom expanding mandrel collet. The team decided to resolve these issues with an off the shelf precision spindle, a C face mounted motor, and belt reduction from the speed reducer to the spindle. The team has selected a motor, gearbox, belt and pulleys, and electric slide for the prototype. Calculations have been performed to ensure that all parts will meet specifications for the design.



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Cross-Country Sitski

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Client(s):	Mark Wellman
Faculty Advisor:	Lauren Cooper
Technical/Social Context Consultants:	Dr. Joel Bach, Dr. Tina Gianquitto
Team Name:	80401 Engineering
Team Members:	Taylor Accardi, Gabriel Block, Geoffery Funk, Melinda Marsh, Krystin Schooley, Mark Shaver

Team 80401 Engineering has been hired by Mark Wellman to provide a new cross-country Sitski design that will allow the user to traverse side slopes. To accomplish this, the team must design an articulating Sitski that can successfully transition from flatland to a slope—where the user will remain sitting parallel with the horizon. A lock-out mechanism must also be in place to keep the Sitski rigid if on flat terrain. The design goal is to provide an articulating design that will not significantly increase the weight from the current 14lb design and that will provide edging into the slope while traversing. Several field tests, including impact testing and normal use tests will be performed to insure durability. A new articulating design will provide Mark Wellman with a similar experience to his current cross-country Sitski, but will make the once difficult back country side slopes easier and more enjoyable.

The Sitski design has been broken into two main subsystems. The rigid upper frame is based off of Mark Wellmans' current design. This includes his seating position, distance from the ground, and general dimensions of the Sitski. Included in the upper frame is a seat with seatbelt and leg strap. The second subsystem or the lower articulating frame is the major focus of the new design. This subsystem includes the ability to articulate for up to 20˚ cross-slopes and includes a lock-out mechanism. The skis are attached to the lower frame and the mounting location is based off the original Sitski.

Mark on his current Sitski

New Sitski with Articulating Lower Frame

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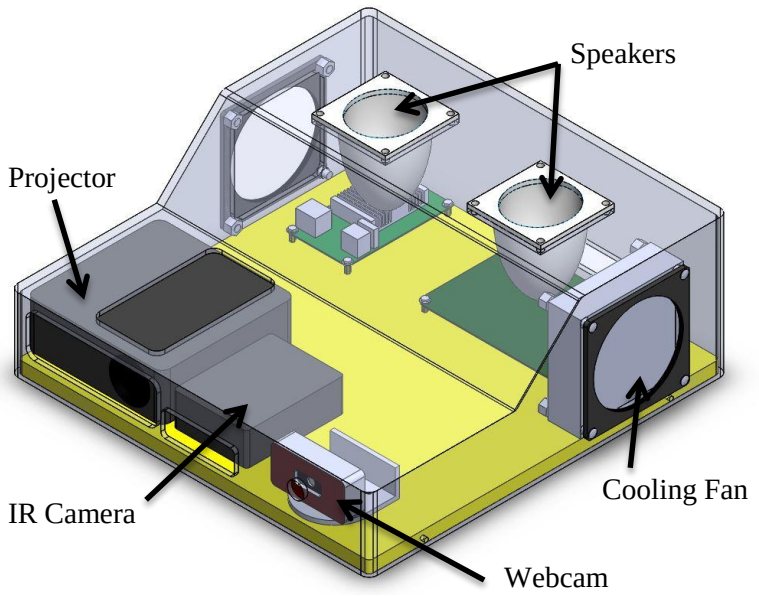
Looma AV System: Mechatronics

24

Client(s):	VillageTech Solutions
Faculty Advisor:	Dr. Vibhuti Dave
Technical Consultant:	Dr. Xiaoli Zhang
Team Name:	Looma Mechatronics
Team Members:	Chris Cowdin, Andrew Grossnickle, Jared Loving, Hope Morton, Matthew Runas, and Matthew Whitney

Looma Mechatronics has been working with VillageTech Solutions (VTS) to design a durable, easy-to-manufacture housing for Looma, as well as to address several design shortcomings. Looma is an audio/visual electronic teaching device designed to create an interactive learning experience for students in the classrooms of developing countries. Some aspects inside Looma include a small projector, webcam, IR camera for a wireless control wand, and custom software that stores multiple digital textbooks and interactive activities. After developing and manufacturing six Generation 1 Loomas, VTS shipped them to Nepal and tested them for several months. The feedback from this testing has been provided to the team and requirements for the next generation of Looma where generated. For the new version, our team was tasked with designing a durable and manufacturable case, improved speaker performance, quieter fans, thermal verification of the design, and adequate power to the projector. VTS requested that our team deliver a prototype of the design and proper documentation for manufacturers to mass produce the design.

Our redesign of Looma fulfilled our client's requirements by creating an easily manufacturable housing made from ABS plastic, using a quiet 80mm fan to provide cooling for the components, more powerful speakers with better acoustics, a new built-in power supply with increased capability, and compatibility with commercially available mounting systems. A Solidworks model was created for all initial dimensions and housing layout as well as initial thermal flow simulations. This file was used to create a full assembly of the whole Looma system. This assembly is shown below in an exploded view format.



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Mines Park Playground

25

Client(s):	Brent Waller, Becca Flintoft, Tana Lane, Tom Garza
Faculty Advisor:	Mirna Mattjik
Technical/Social Context Consultants:	Lauren Cooper (TC), Cortney Holles (SCC)
Team Name:	Playground Heroes
Team Members:	Aaron Gunzner, Erin Keogh, Jared Mapes, Amanda Mascarenas, Taylor Ramos

The Colorado School of Mines Department of Residence Life has selected Team Playground Heroes to design a playground for the on-campus family housing at Mines Park. This site is meant to provide a safe and accessible space to play for the children living in the nearby apartments, reflect themes linked to Science, Technology, Engineering, and Math (STEM), and exhibit elements of the Mines spirit. This is accomplished by incorporating interactive, STEM-based components with the common theme of Engineering Futures, a focus on the work of engineers and scientists in the field. Sustainability is also a significant focus of the playground. This was achieved by utilizing local vendors and recycled materials.

The playground has multiple components, featuring one custom-designed, hardwood jungle gym that will be the focal point of the site. Engineering calculations for this structure have been completed, including, but not limited to, column buckling, wind and snow load analysis, and elements subjected to moment and shear. Secondary components of the playground are pre-fabricated in order to maintain cost effectiveness and to insure adherence with Consumer Product Safety Council Public Playground standards and regulations for specific playground equipment. These components include: swing set (with both toddler and school-age swings), teeter totter, monkey bars, and a Blaster the Burro spring rider to reflect the Mines spirit. A recycled wood mulch ground surfacing will keep the playground accessible while staying low on cost. The site also requires additional seating (benches and picnic tables), trash cans, and lighting, as well as a reconfiguration of the underground irrigation system. A soil analysis was completed to ensure proper ground conditions and an erosion control plan was developed to maintain proper drainage during construction.

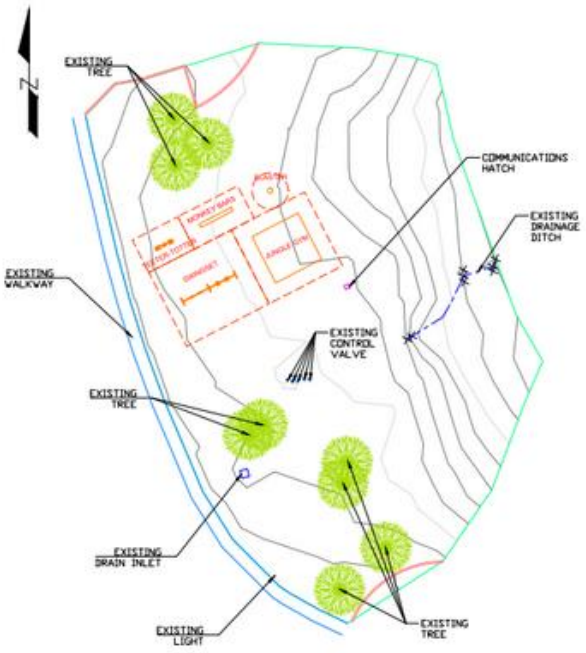

Figure 1: Surveyed site with equipment layout (including use zones) for Mines Park Playground

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Mines Park Playground for Family Housing

26

Clients: Residence Life, Brent Waller, Tana Lane, Capital Planning and Construction

Faculty Advisor: Hongyan Liu

Technical/Social Context Consultants: Alexandra Wayllace, Cortney Holles

Team Name: Minion Brigade

Team Members: Eric Marzari, David Micnhimer, Kris Smith, Carlos Tasayco, Ben Laro, Alex Finke

Team Minion Brigade has been hired by Residence Life to design and analyze a playground for the family housing community at Mines Park. In order to provide the clients with a suitable end-product, the team must perform a site analysis to determine site conditions. From this, the team will propose a site location. After the site has been determined, the team will develop a thorough design of all playground members, materials, connections, and foundations. In addition, the team will also design the playground in order to minimize the construction impact on the environment and topography. The majority of the final design should be comprised of sustainable, reusable, and recyclable materials.

The deliverables that Minion Brigade will be providing include a final drawing package, a calculation package, and a digital 3D model of the design. The final drawing package consists of detailed dimensions of all components design by the team. The components are the: playground, site, lighting, and foundations. The lighting and erosion will be design to the code of the city of Golden, Jefferson County, the State of Colorado, and the International Building Code (IBC). The calculation package contains finite element analysis of all playground equipment as well as supporting feature equipment. Playground equipment design by the team includes: an axe slide, teeter totter, canopy, picnic tables, merry-go-round, swing set, tire swing, climbing wall pyramid, and jungle gym. The digital 3D model as well as the calculation package was generated in Solidworks and Solidworks Simulation. The final 3D model is shown below and shows the site layout.

Figure 1: Final 3D model

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Sustainable House Design

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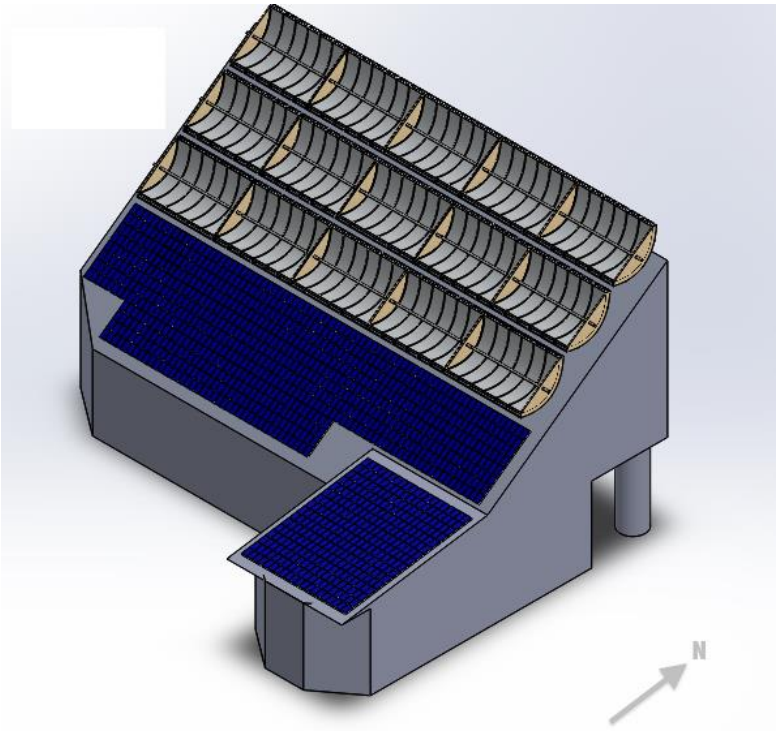
Client(s): Dr. Jason Ganley, Ms. Brooke Smartz
Faculty Advisor: Professor Darek Bruzgo
Technical Consultant: Professor Susan Reynolds
Team Name: Split Table Sustainable Designs (STSD)
Team Members: Chris Asmussen, Colton Becker, Amy Mapes, Ed Mulhern, Casie Ratzlaff, Mallory Wick, Ethan Zimbra

STSD has been tasked with designing an innovative, sustainable, single-family house to be entered into the 2014 International Holcim Awards for Sustainable Construction competition. The house is also to be optimized for the local community in Golden, Colorado and incorporate solar principles, such as those used in the U.S. Department of Energy Solar Decathlon. STSD's house design has been subdivided into four components: geometry, solar photovoltaic (PV) systems, solar thermal systems, and sustainability.

Overall, the house is a single-level house that has been optimized with respect to general shape, orientation, and floor plan to keep the interior at a comfortable temperature for occupants and to best accommodate the design's solar PV and thermal systems.

The solar PV system will be grid-tied (for back-up) and has been optimized with respect to items such as embodied energy, payback time, and ideal angle. Additionally, for the solar thermal system, the team has designed custom parabolic trough collectors and subfloor heating system with tank storage, sized for placement and output.



STSD Sustainable House Design Exterior

Sustainability is the most important component of STSD's design and has been guided by Holcim's Target Issues of sustainability: progress, people, planet, prosperity, and proficiency. Each separate system of the design has sustainability considerations related to these Target Issues. These sustainability considerations were mainly focused on energy savings in the house by decreasing energy losses, self-producing energy, and choosing state-of-the-art, durable, and readily accessible materials where possible.

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ECAP

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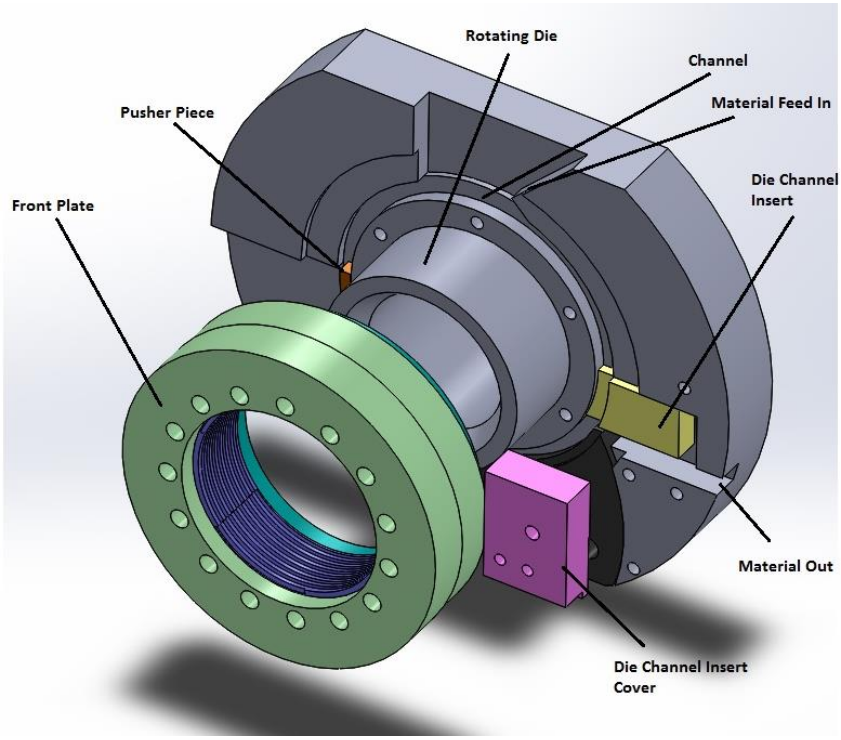
Client(s):	Dr. Terry Lowe
Faculty Advisor:	Paul Panozzo
Technical Consultant:	Dr. John Berger
Team Name:	Design United
Team Members:	Justin Bergman, Amelia Engelmann, Peter Kneusel, Paul Lowry, Matthew Lunsford, John McMullen, Nicholas Romano

Team Design United was hired by Dr. Terry Lowe to redesign the Equal Channel Angular Pressing (ECAP) machine he developed to process a wider range of metals. The ECAP process involves plastically straining metal to decrease the grain size on a microscopic level increasing the strength and conductivity of the material. The ECAP machine performs this process by ramming the material against an insert that forces the material to shear using a die to move the material. The metal rods are fed into the machine using high friction as the feeding force. The machine was designed to process Titanium so the frictional forces are very high, which causes weaker metals to soften due to intense heat and slip. Therefore the team was tasked to redesign the machine so any metal can be processed. A design package with solid modeling and calculations was desired by the client.

The design chosen to be implemented by the team involves a solenoid actuated pusher piece that will come in contact with the metal rod and push the piece through the machine from the back. Enough pressure from the front plate will be applied to the channel so that rods can be fed into the machine but slip at the die channel insert until the pusher piece comes in contact with the material. This design will make the machine no longer continuous, but after detailed calculations and FEA models, was found to be the most viable solution. With the pusher piece design the machine is only limited by the power of the motor, so materials such as titanium can still be processed. The design also includes a solenoid that can retract the pusher piece into the front plate when it is not needed and when it passes the die channel insert so that there is no interference between the two. The solenoid will be manually controlled by the operator and will need to actuate the pusher piece into the channel once the metal rod has been fed into the machine. There will be a failsafe located right before the die channel insert that will retract the pusher piece so that it can safely pass the insert.



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MEL II Wind Tunnel Redesign

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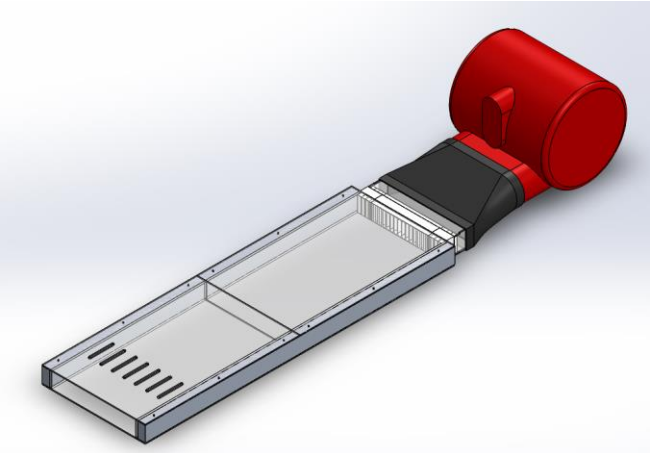
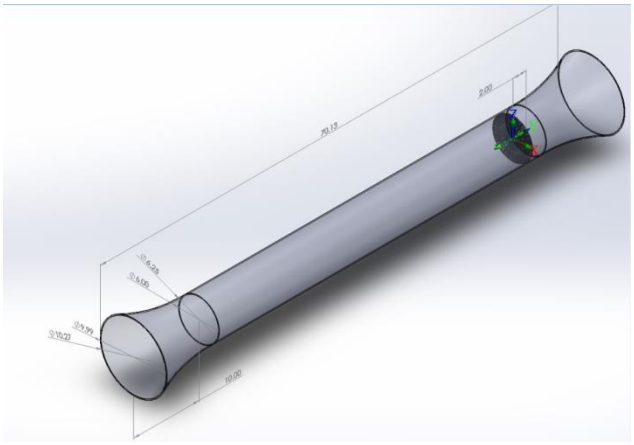
Client(s):	Dr. Ventzi Karaivanov and Prof. Jeffery Holley
Faculty Advisor:	Dr. Christopher Dreyer
Technical Consultant:	Dr. Neal Sullivan
Team Name:	Tubular Dynamics
Team Members:	Logan Gee, Alex Nussell, Kjirsten Olson, Rachel Reinke, Zach Towner, Peter Weddle

Dr. Ventzi Karaivanov and Prof. Jeffery Holley of the Colorado School of Mines approached Tubular Dynamics with the challenge to design a wind tunnel to replace the existing wind tunnel used by undergraduate students in the Multidisciplinary Engineering Lab. The requirements for the new design were as follows: 1) the wind tunnel must have a small foot print for storage and use in the lab, 2) data collected about airflow within the system must be consistent with theoretical predictions, 3) the data collected must be repeatable, 4) the new equipment must be simple to set up, and 5) the new equipment must be safe and simple to use. The final deliverables for this project were thus a physical prototype, assembly instructions for recreating the wind tunnel, a new lab procedure utilizing the new system, and sample lab reports proving the repeatability of the data.

To address these requirements, the team utilized CAD and CFD software, SolidWorks and SolidWorks Flow Simulation, respectively, to create possible design solutions. Through discussions with the client about the results from the simulations, two wind tunnel designs emerged: a circular-pipe wind tunnel and a rectangular-duct wind tunnel. Both of the duct profiles for these tunnels are shown below. These two systems allow for different airflow velocity profiles to be observed due to the different cross-sectional area profiles of the ducts. Additionally, the wind tunnel designs allow for multiple principles from fluid mechanics to be observed and measured.





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ERC Stormwater Capture

30

Client(s):	Dr. John McCray and Skuyler Herzog
Faculty Advisor:	Mengistu Geza
Technical Consultant:	Jeffery Holley
Team Name:	Stormwater Innovations
Team Members:	Alaudeen Lazkani, Ryan Logan, Taylor Miller, Jared Riemer, Derek Skrdlant, Megan Stokes.

The ReNUWIt Engineering team and the ERC at the Colorado School of Mines are seeking to rethink the process of water usage and treatment by developing more environmentally responsible water usage. In order to do this, Dr. John McCray and PhD Student Skuyler Herzog have asked our team to develop a storm-water capture system at Mines Park which will capture water to be held and studied for future research. The future research will delve into how a community could introduce water treatment into their neighborhoods or apartment complexes by the use of a small stream that will clean their water for re-use in irrigation.

Our team initially was going to design a stand-alone pond structure at Mines Park. Upon further research and site visits, an existing stormwater capture pond just south of the AQWATEC MBR was determined to be adequate for our needs. The client indicated that he would need flows of 1 L/hr for 8 hours coming in to the test stream in order to conduct his research. This volume of water would be approximately 1,000 cubic feet. The overall volume of the existing pond structure is 66,211 cubic feet, meaning that only 1.5% of the existing pond volume will be utilized to capture enough water to run the tests. This new pond will be dug into the existing pond, with a volume of around 1500 ft^3. A liner will be installed to prevent seepage and reduce organic contamination. A diversion structure at the pond inlet will be constructed so the client can control water flow to suit the needs of the test. This structure will be a simple concrete box with two separate grates: one that directs flow towards our structure, and one that directs flow along the natural storm water path within the existing pond. Because our pond is to be dug in to the existing pond, there is no need for an outlet structure. A sump in the center of our structure will collect water for easy access. From there, a pump will draw the water out and transport the water through a flexible hose into the test stream.

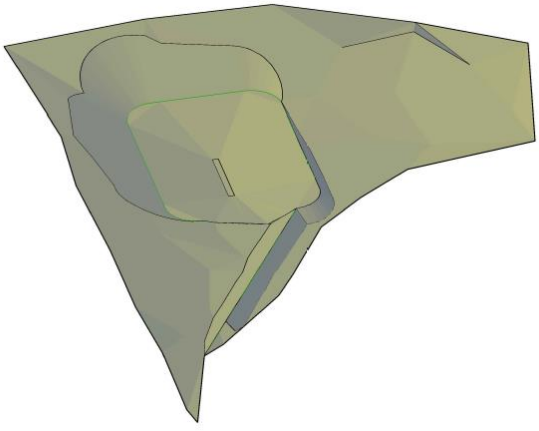

Figure 2: A drawing of our designed pond.

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Updating Archimedes

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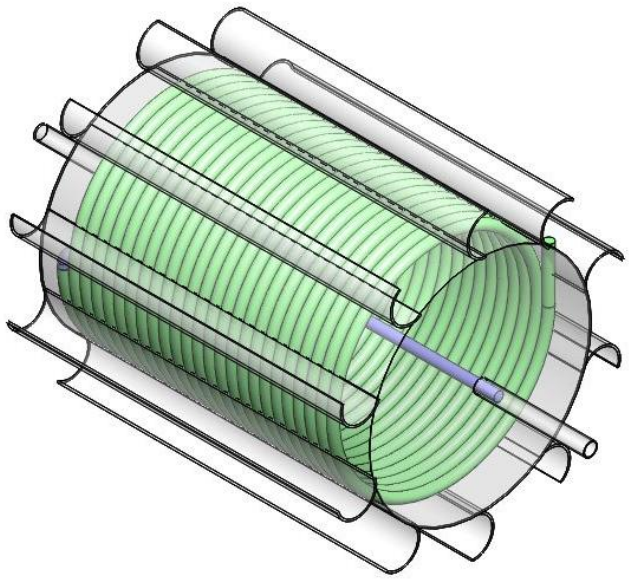
Client(s): Mr. Dirk Long
Faculty Advisor: Dr. Ron Slovikoski
Technical/Social Context Consultants: Dr. Robert Braun / Dr. Juan Lucena
Team Name: OmniPumps
Team Members: Eric Chapa, Aaron Faulkner, Nicole Davis, Adam Mowery, Logan Ramseier

OmniPumps has been hired by Current Pumps to analyze and optimize the design of a stream-powered water pump. The team is responsible for generating test data that will determine whether the pump represents a viable design for the needs of farmers in Niger. Pressure head and flow rate are the primary technical design requirements. The final design must be manufacturable with materials and labor available in Niger at low cost. In addition, the team must consider the social context surrounding the project and present solutions that can be scaled and altered to meet a range of individual user needs for the Niger culture and economy.

Upon completion of the project, OmniPumps has provided successful analytic and experimental foundations for the study of the stream-powered pump. The team developed a prototype with three inlets that would theoretically triple the flow rate of the original design while maintaining the same pressure head. Testing in both controlled and field environments demonstrated that the increased flow rate could be achieved but the pressure head could not be maintained. The team completed the project by providing the client with a framework that clearly outlines the limits and capabilities of potential pump designs. Test data were used to create pump output curves which characterize the performance of those designs under various operating conditions. Particular attention was paid to offering Current Pumps a clear path for stream-powered water pump design moving forward and conveying the team's optimism for future prospects of the technology.



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ConstruKs®

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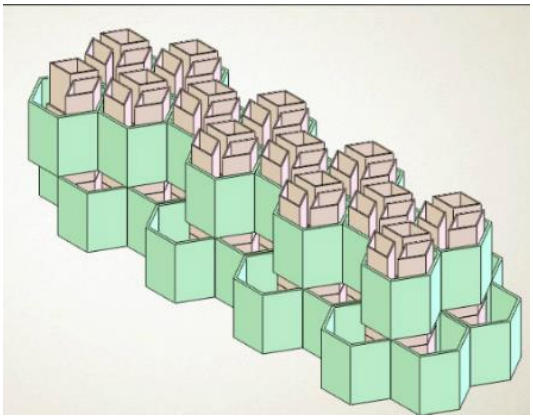
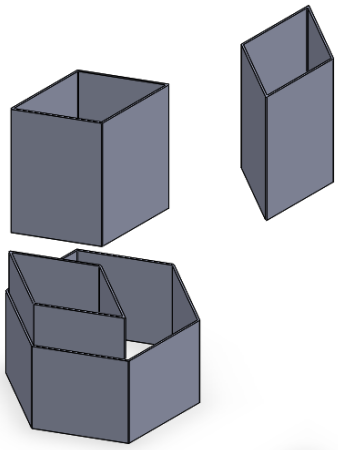
Client:	George Bigger
Faculty Advisor:	Lauren Cooper
Technical Consultant:	Dr. Andres Guerra
Team Name:	Kreative ConstruKtions
Team Members:	Kyle Grassel, Kevin Hart, Katharine Howe, Jordan Schreiner, Brenna Svoboda, Kelsey Waage, Kacie Wolverton

Kreative ConstruKtions has been working with ConstruKs® to create a mathematical model for retaining/gravity wall structures as an erosion control mechanism along roadways and to develop an in situ water treatment system for mining sites' runoff. Through finite element analyses and testing, the team determined how ConstruKs® perform under conditions simulating real life loading scenarios. ConstruKs® are designed with a hexagon and diamond lattice structure resembling that of a honeycomb and each unit may be filled with a temporary or permanent ballast material. The material used for ConstruKs® must be durable enough to withstand various environments and portable for transportation and easy installation.



One project goal is to use ConstruKs® systems as a replacement or upgrade for erosion control and green infrastructure applications. In addition to the structural performance of the units, the use of permeable versions of ConstruKs® allows them to be used for in situ water treatment. This provides an easily constructed treatment system for non-point source contamination of surface waters. The ConstruKs® materials can be varied to provide a wide range of structural support and customize filtration rate. The ballast can be varied to provide physical benefits and chemical treatment. Materials tested include corrugated plastic, cardboard and cloth units, coconut fiber, and geotextile samples. Potential ballast materials include sand, gravel, soil, or similar resources that can be readily found in the local environment. "ConstruKs® have a sustainable answer for managing nature using natural resources as a natural defense against natural disasters from mountain to seashore" (George Bigger).



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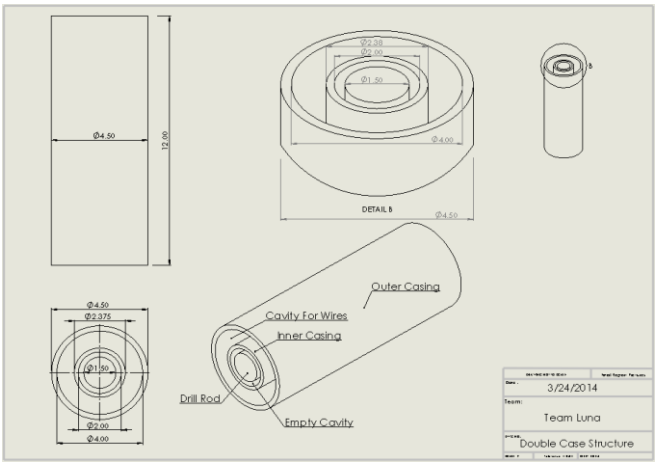
Jet-Grouted Columns Testing and Quality Assurance Instrumentation

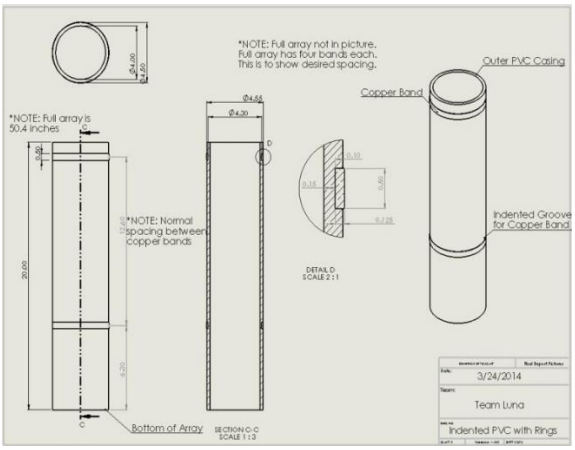
33

Client(s): Michael Mooney
Faculty Advisor: William Finch
Technical Consultant: Randy Haupt
Team Name: Team Luna
Team Members: Alfredo Jurado, Jonon Gantumur, Marcus Nelson, Thalia Haro, Tucker Danell

Team Luna has been hired by the Underground Tunneling and Construction Department at the Colorado School of Mines to design a prototype instrument for testing the quality characteristics of jet grouted columns. In order to satisfy the customer needs, the design team has investigated various known and well-proven testing methods and chosen the most ideal type for the given project. To do this a prototype that has the ability to transmit and receive signals underground inside a freshly poured jet-grouted column. The prototype must be designed to be inexpensive and durable enough to withstand field deployment.



The Prototype design consists of two main ideas, an electrical array, and an acoustic array. Team Luna is required to focus on the electrical aspect of the prototype design because the client is more interested with the advancement of this side of the project. The electrical array has several cylindrical components as well as conductive bands around the outside cylinder, which are wired internally. The outer case will be a robust PVC case with copper electrode rings attached to it. The inner case prevents contact between the internal drill rod support and the wiring. The electrical array provides enough data to evaluate the quality of the jet-grouted columns without the support of the acoustic array. However, the acoustic tests do provide valuable information and if necessary an acoustic prototype could be implemented alongside the current prototype using the electrical method.



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Formula SAE Telemetry System

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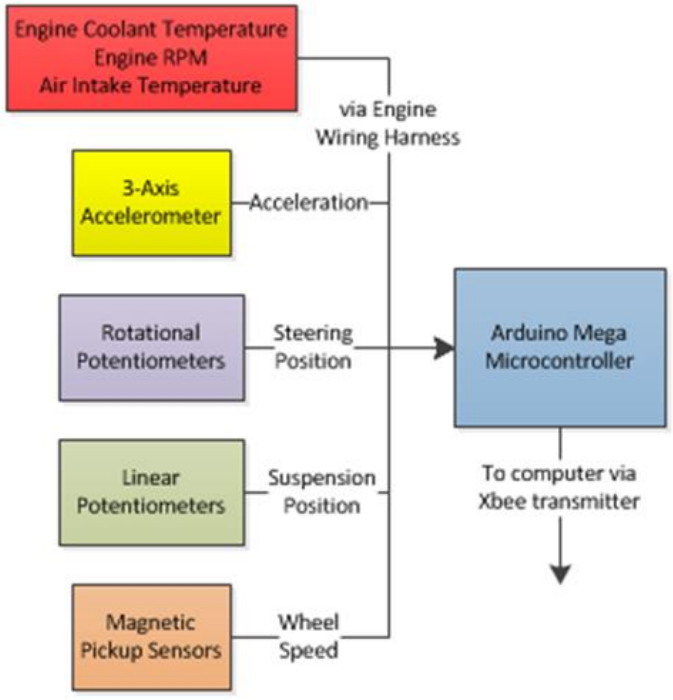
Client(s): Dr. Gregory Bogin
Faculty Advisor: Dr. Jeff Schowalter
Technical Consultant: Dr. Randy Haupt
Team Name: Formula Telemetrix
Team Members: Eric Evans, Alex Lampe, Matuesz Pena, Daniel Peter, Raymond Puckett, Matthew Smith, Max Trainoff, Caleb Whitehead

The problem that Formula Telemetrix was tasked with solving was implementing a functional, low-cost telemetry system to integrate with the Formula SAE car. The system will be used for tuning engine, car, and driver performance during SAE events. The system is required to gather the following information: wheel speed, suspension position, steering wheel position, 3-axis acceleration, engine coolant temperature, engine RPM, and air intake temperature.

The system must be modular, easy to use, and low-cost so that the team can continue to use and improve the system for years to come. This system will be a starting point for more advanced systems in the future, such as active aerodynamics and traction control.

To address the project problem, stakeholder surveys were performed to determine client needs. After that, the team performed several engineering analyses including: stress analyses, black box modeling, and analysis of existing telemetry systems. The ideas were then cut down to the best solution using design matrices and design analysis of the SAE car.

For the final design, Formula Telemetrix selected a number of low cost sensors, including accelerometers, potentiometers, and magnetic pickup sensors. Additionally, the engine wiring harness was used to gather engine-specific data. All of this information is aggregated by an Arduino Mega microcontroller where the data is then sent via an XBee wireless radio transmitter to a receiver connected to a computer, which then collects, processes, and displays the information from the car. The final deliverable for this project is a complete system integrated with the car.



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Formula SAE Aerodynamics

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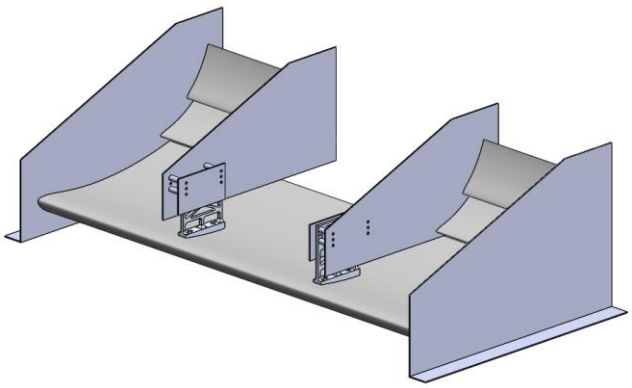
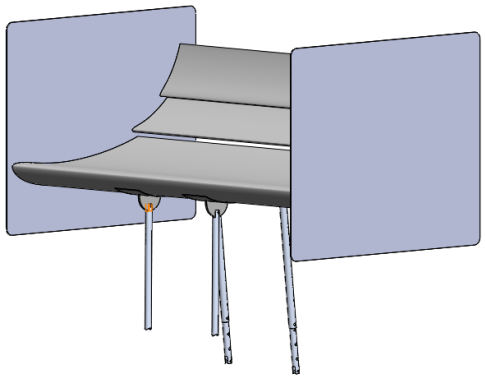
Client(s): CSM Society of Automotive Engineers
Faculty Advisor: Dr. Ron Slovikoski
Technical Consultant: Dr. Gregory Bogin
Team Name: Wingin' It
Team Members: Gabe Alvarado, Andrew Boissiere, Matt Brady, Ashley Hertzler, Mathew Jirele, Kit Lewis, Richard Nguyen, James Wilkerson

Team Wingin' It was selected to design and manufacture the aerodynamics system for the Colorado School of Mines (CSM) Formula Society of Automotive Engineers (FSAE) competition car. The purpose of the aerodynamics system is to generate downforce. By increasing the normal force between the tires and the track, downforce increases grip and allows for faster cornering. Downforce is generated through the use of inverted airfoils. Under competition operating conditions, where expected speeds are low and drag is negligible, assemblies of multiple airfoils can be utilized to generate substantial downforce. The responsibility of the team is to manufacture a lightweight aerodynamics system that conforms to the FSAE regulations and will generate maximum downforce without incurring excessive drag or otherwise harming the performance of the car. The wings also need to allow for angle of attack adjustment and removal for vehicle transportation.

Extensive aerodynamics research and computational fluid dynamics (CFD) analysis was conducted to optimize the airfoil assemblies. After real world validation of the CFD model, airfoil comparison, and parameter optimization was performed, the team selected an airfoil and determined that front and rear triple-element airfoil configurations were the optimal solution. To ensure that the wings are lightweight and durable the team elected to fabricate the wings from carbon fiber, using iterative mold construction and a vacuum resin-infusion process. The final step was to design and manufacture adjustable attachment mechanisms. The performance of the aerodynamics system will be validated via suspension potentiometers prior to competition in June.



Front Wing Assembly



Rear Wing Assembly

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2014 CSM Mini Baja

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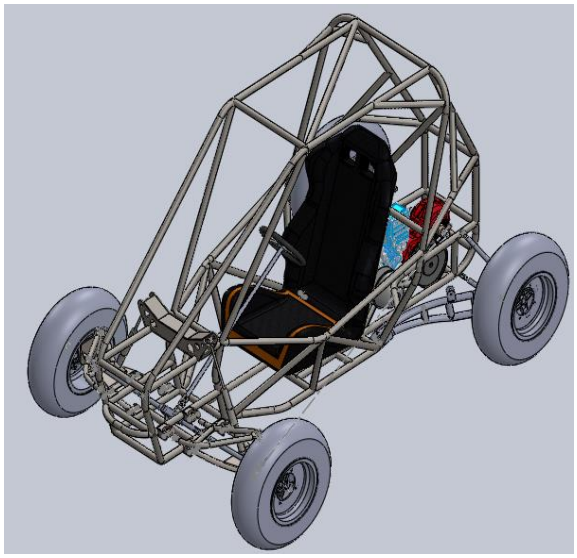
Client(s):	Frank Peterson
Faculty Advisor:	Jered Dean
Technical Consultant:	Jenifer Blacklock
Team Name:	Table Mountain Racing
Team Members:	Leanne Thompson, Cole Parrott, Jake Lockhart, Kyle Dickson, Laura Brigham, Tyler Zimmerman, Zack Powell, Jackie Lewis

The 2014 CSM Mini Baja Team will represent the Colorado School of Mines in the 2014 Baja SAE competition. This competition simulates a real-world engineering design project in which engineering teams are challenged with designing, manufacturing, testing, marketing, and racing a single-operator, off-road vehicle. The competition consists of several static and dynamic events in which design teams compete to have their baja selected for manufacture by a fictitious firm. Teams are scored on design, cost, and performance in the dynamic racing events.

The team was provided with the vehicle from the 2013 Mini Baja Team and was given the option of completely designing a new vehicle or making modifications to the previous vehicle. The decision to design a new vehicle was based on a reverse engineering analysis of the previous vehicle. Before and during the redesign of the vehicle, research was conducted by all team members. The most important sources for this research were the competition rule book, previous team members, a test drive of the previous vehicle, and disassembly of the previous vehicle. With the advice of various stakeholders and previous team members in mind, the team chose to redesign the vehicle from a wheels-in approach. In this approach, the placement of the wheels relative to the frame was the first design parameter to be set. The rest of the vehicle was then designed within the set vehicle foot print. Within this foot print, the vehicle was broken down into the following subsystems: suspension, drivetrain, steering, braking, ergonomics, and chassis.



The final design features double a-arm front suspension, three-link rear suspension using trailing arms, rack and pinion steering, constant velocity driveshafts, a CVTech Continuously Variable Transmission, and a locking differential with a mechanical selectable locker. The team made heavy use of SolidWorks and Finite Element Analysis (FEA) to test designs. Additionally, tools such as decision matrices, were used to find the best solutions to the design challenges. The team's goal is to place in the top ten at competition.

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NASA Lunabotics – Mobility

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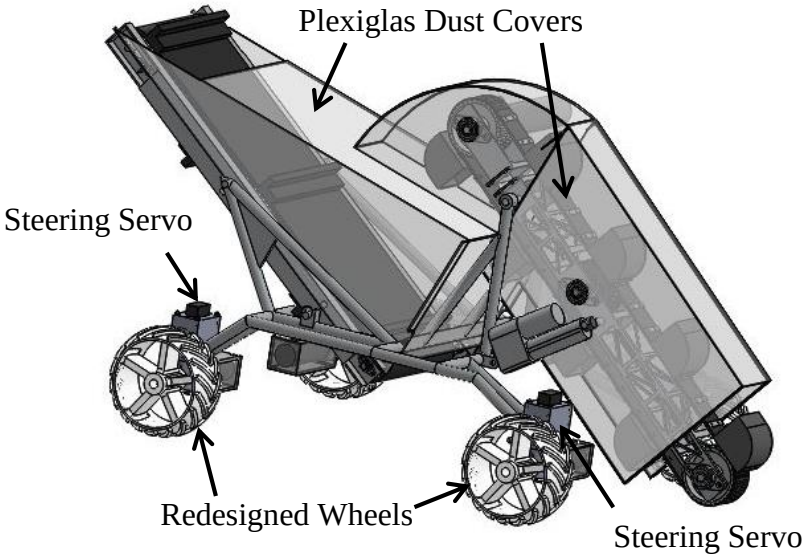
Client(s): Dr. Angel Abbud-Madrid
Faculty Advisor: Dr. Christopher Dreyer
Technical Consultant: Dr. Ozkan Celik
Team Name: Blasterbotica-Mobility
Team Members: John Aspinwall, Kevin Dirscherl, Joanne Haas, Peter Jaron, Caitlin McMahan, Mike Riechers, Susan Tran, Dillon Voss

Formed in the interest of participating in NASA's Fifth Annual Robotic Mining Competition, the Blasterbotica-Mobility Team was tasked with redesigning the mobility system of the previous year's rover. The competition, formerly named the NASA Lunabotics Competition, is an annual competition in which university students design, build, and operate rovers to collect, transport, and dump as much simulation regolith as possible within a 10 minute time limit while crossing a course with several obstacles.

In order to transport a payload of at least 10 kg on a bed of simulation regolith, the mobility system of the rover was required to provide high amounts of torque at a reasonable speed while minimizing wheel slip. This led to redesigns of the following subsystems: wheels, velocity control, steering, and dust mitigation. The wheels were designed with a specifically-chosen tread pattern to maximize traction and decrease the chance of the robot digging itself into a hole. The velocity control utilizes encoders on each of the drive motors to measure the speed of the rover as well as the distance travelled, which are then used to keep the velocity of the rover within an acceptable range. The steering system uses four servo motors which rotate each of the four wheels, allowing for reliable zero-point turning and translation in both the forward and sideways directions. The dust mitigation consists of Plexiglas coverings around the sensitive components of the rover. Each system was designed based on engineering calculations and tested experimentally using small-scale models and the full rover.



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NASA Lunabotics - Autonomy

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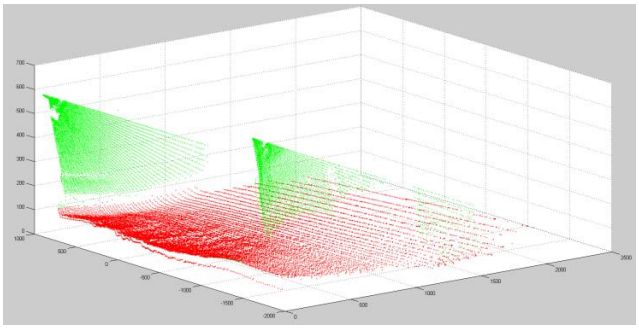
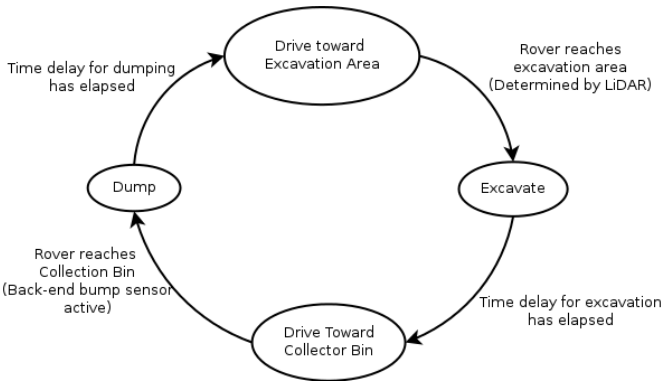
Client: Dr. Angel Abbud-Madrid
Faculty Advisor: Dr. Christopher Dreyer
Technical Consultant: Dr. Andrzej Szymczak
Team Name: Blasterbotica-Autonomy
Team Members: Marc Allen, Mykala Miller, Andrew Nelson, Ryan Stauffer, Quoc Tran, Vladimir Yaremenko, Kevyn Young

Team Blasterbotica-Autonomy has been commissioned by Dr. Angel Abbud-Madrid of the Center for Space Resources to expand upon the capabilities of the rover built for last year's NASA Lunabotics competition, now renamed the NASA Robotic Mining Competition. Specifically, the team is tasked with enhancing the autonomous operation of the rover during competition, as completing the competition run autonomously could potentially determine the victor of the competition. To do this, the team must select sensors that complement one another and provide sufficient positional information to allow software to successfully execute a fully autonomous competition run. These sensors must be chosen through empirical testing to determine their effectiveness and error. Additionally, the team must collaborate with the Blasterbotica-Mobility team to develop and test on the rover prior to competition. The team is expected to produce a fully functioning rover that can operate without human intervention during competition in May 2014.



The overall design can be divided into five major components: LiDAR (left), vision, proximity detection, self-contained sensors, and software. The previously-used LiDAR has been enhanced to tilt in order to generate a three-dimensional map of the arena, which provides additional detection capability. The vision system relies on an onboard camera to detect the rover's distance from an external beacon system for use in orientation and path planning. Proximity detection involves the placement of multiple bump sensors across the body of the rover to detect when the rover has collided with an obstacle or wall; this is necessary to protect the rover's sensitive components from harm and provide feedback during normal operation. The rover also uses a self-contained inertial measurement unit in order to detect changes in orientation, enabling for course corrections during movement. Software handles the gathering of data from the different sensors, the derivation of a path to the target location, the transmission of commands to and from the rover, and the verification of each step in the rover's state machine design, as shown on the right.



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Steel Bridge

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Client(s): Ian McQuade, TSH
Faculty Advisor: Lauren Cooper
Technical Consultant: Dr. Shilling Pei
Team Name: Mines Steel Standing
Team Members: Brien Coffey, Caitlin Greagor, Conor Lenon, Luis Mauricio-Perez, Moises Mendez, Mitchell Murphy, Logan Shade, Nate Thompson

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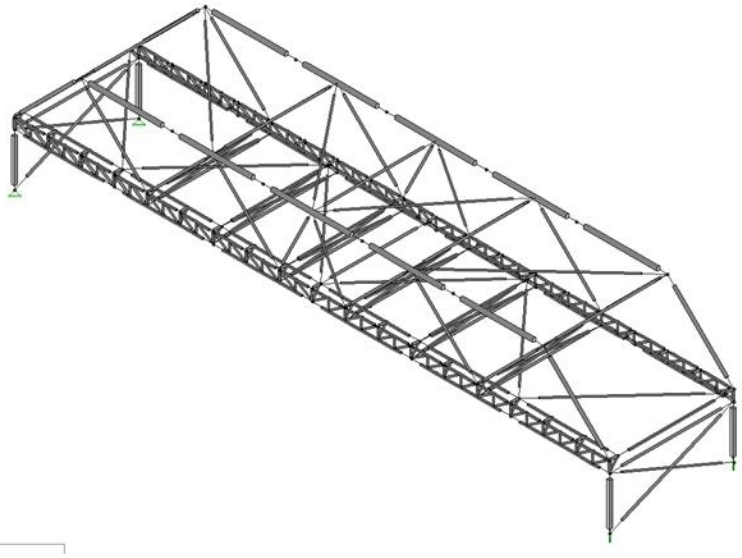
The 2014 Colorado School of Mines Steel Bridge competition team, Mines Steel Standing, is proud to present our award winning bridge design. This annual event is hosted by the American Society of Civil Engineers (ASCE) and the American Institute of Steel Construction (AISC) for the purpose of "supplementing the education of civil engineering students with a comprehensive, student-driven project experience from conception and design through fabrication, erection, and testing, culminating in a steel structure that meets client specifications and optimizes performance and economy." Competition took place at the regional level in Fort Collins at Colorado State University, in which a total of thirteen teams from various schools participated. Representing Mines' academic excellence, Mines Steel Standing achieved first place in both bridge lightness and overall performance.

The client for this year's Student Steel Bridge Competition (SSBC), NE&SW, requested bridge designs to replace an outdated wood timber trestle spanning the Spodumene River. The bridge is vital for transporting lithium ore from a local mine, and therefore, the client has required the use of Accelerated Bridge Construction (ABC). A 1:10 scaled model has been developed to demonstrate the design concept. The scaled bridge is subjected to a total design vertical load of 2500 lb and a total lateral load of 50 lb. Mines Steel Standing successfully designed and fabricated a bridge that safely supports both the vertical and lateral loading within the respective deflection standards.

Based on geometric requirements and constraints, various alternative bridge designs were considered and evaluated. Using Risa 3D, an overhead arch bridge design was developed and optimized for adequate member design using LRFD for six different loading conditions. Following the superstructure/substructure design, connections were developed and modeled in AutoCad. Six weeks of fabrication followed, taking place at Zimkor Steel Fabricators, with the bridgework being performed entirely by Mines Steel Standing.



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Concrete Canoe

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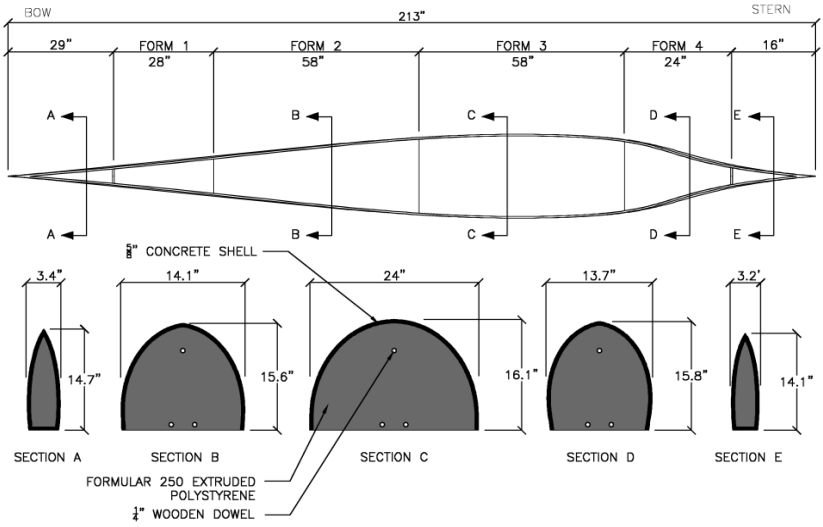
Client: Ben Seling
Faculty Advisor: Susan Reynolds
Technical Consultant: Dr. Panos Kiousis
Team Name: Oardiggers
Team Members: Dustin Burner, Nathan Carbajal, Katharine Courtright, Edward Huss, Haley Jewell, Kate Lyssy, Edgar Robles, Je Young Yoo

Under the guidance of Susan Reynolds, the Oardiggers sought to compete in the American Society of Civil Engineers' Concrete Canoe Competition. Our mission was to design, construct, and race a canoe comprised of concrete that is lighter than water, yet strong enough to support four paddlers during an energetic race. The competition score is based on four equally weighted components: a design paper, an oral presentation, an aesthetic display, and a series of five races. Subsequently, the team had to focus on engineering design, aesthetic design, and paddling and placed 4th at the Rocky Mountain Student Conference (regional competition).

The vessel—named Humboldt after the deadly, giant squid—is cast from a concrete mix that is comprised of Type I Portland cement, Class C fly ash, Class F fly ash, Forta Ultra-Lite (a homopolymer polypropylene monofilament fiber), CenoStar Cenospheres (lightweight, hollow ceramic microspheres), and three sizes of Poraver expanded glass beads ranging from 0.25 mm. to 2 mm. in diameter. This mix has a compressive strength of 1440 psi, a plastic (wet) unit weight of 60.0 pcf, a dry unit weight of 54.2 pcf, an air content of 7.6%, and a slump of 2 in.

In designing the hull geometry, the team aimed to prevent cracking, reduce drag, and improve maneuverability. Subsequently, the team opted for a shallow-arch cross section, a narrow angle of attack, an asymmetric weight distribution, and a gradient keel which is exaggerated at both ends and diminishes to lay flat in between. As a result, Humboldt weighs 186 lbs. and is 17 ft. long, 24 in. wide, and 16 in. deep with a wall thickness of 5/8 in.



The concrete is primarily reinforced by a carbon fiber reinforced polymer mesh, Chomarat C-Grid. This mesh proved to be too brittle to conform to the sharp keel near the bow and stern. Subsequently, the keel was reinforced with a more malleable fiberglass reinforced polymer esh, Tensar International GlasGrid.

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Shell Eco-marathon Competition

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Client: Matthew Sands
Faculty Advisor: Darek Bruzgo
Technical Consultant: Dr. Jeffrey Schowalter
Team Name: Team Miner Fuel Consumption
Team Members: Jessica Ho, Adam Longoria, Steven Nichols, Gabriel Rios, Dylan Stiles, Roy Stillwell, Nikolaus Thorell, Seth Wilson

Team Miner Fuel Consumption has been chosen to represent the Colorado School of Mines in the 2014 Shell Eco-marathon Americas Competition. Participating teams must design and build a hyper fuel-efficient, one-person vehicle. The vehicle will compete against several other vehicles in its fuel category to achieve the highest mileage per gallon. This year, Team Miner Fuel Consumption is participating in the prototype diesel competition with a goal of achieving over 1000 miles per gallon.

Through brainstorming, engineering calculations, and trial-and-error, the final design for the competition vehicle was created. The diesel engine is a Hatz 1B20 and is mechanically tuned by inserting a needle valve into the high pressure fuel line to choke fuel flow. The fuel delivery system is contained inside of the engine, and the glass fuel tank is mounted to the back of the engine using ABS plastic to dampen vibrations. The drivetrain has a centrifugal and manual clutch system with a flywheel. The double-clutch system engages and disengages with the drive shaft and rear wheel to optimize the storing of kinetic energy while driving. The engine, drivetrain, and rear wheel are mounted on 8020 aluminum bars and bolted into the car as a modular system. The front wheels are road bike tires with 700c rims and carbon fiber wheel covers. The rear wheel utilizes a Chris King ISO rear hub, which is durable and allows for minimal rolling resistance. Disk brakes are installed on all wheels for their braking power and ease of installation. The steering mechanism is a butterfly wheel mounted to a mini rack and pinion. The main engine control unit is a BeagleBone Black, which also controls the automatic throttle and provides data to the driver on an LCD screen. Various safety features are incorporated into the design to comply with the Shell requirements including a 5-point safety harness, a bulkhead made of carbon fiber, and side view bicycle mirrors.

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Collegiate Wind Competition

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Client(s):	National Collegiate Wind Competition
Faculty Advisor:	Dr. Atef Elsherbeni
Technical Consultant:	Dr. Salman Mohagheghi
Team Name:	Zephyrus
Team Members:	Cabe Bonner, Alex Dell, Jyoti Gandhi, Kate Rooney, Kevin Tan, Aaron Troyer, Jeremy Webb, Quinn Weber, Kelsey Wokasch

Team Zephyrus was chosen to compete in the first Collegiate Wind Competition sponsored by the Department of Energy. This competition consists of designing and building a portable wind turbine, developing a business plan, and giving a presentation on current market issues with wind power. At the competition in May, the wind turbine developed by Zephyrus will be tested for various characteristics. The business plan details strategies for the commercial viability of the turbine. The market issues presentation explains how to modify the outward appearance of wind farms in order to make them more culturally accepted.

Zephyrus chose to build a vertical axis wind turbine (VAWT) of the Savonius type to maximize torque at low wind speeds. The turbine is constructer out of aluminum and fabric. This light, fully collapsible turbine is meant to appeal to hikers who need to charge small electronic devices. The blades are made of a nylon 30D Ripstop Nylon and have semi-circular aluminum arms to capture maximum wind and collapse easily. A gearbox is used to increase the RPM of the generator input shaft while decreasing the available torque. The generator converts the rotational mechanical energy to electricity. The support consists of hollow aluminum shafts that allow the angle of the turbine legs to be adjusted and can be staked to the ground. These aluminum poles are designed to collapse like tent poles. The shaft housing holds low–friction bushings and the generator in-line. It also encases the circuitry which converts the AC signal to DC power, in order to charge portable electronics.

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Individual Broader Impacts Essay

This semester all Senior Design students were assigned to write and submit an individual, 1500 word essay about how their engineering choices impact the social, environmental, and/or economic lives of communities and individuals. The top 15 essays from this group of 275 senior engineering students were chosen by the course faculty and are included in the Program in alphabetical order.

The top essays have been judged by a panel of volunteer judges and winners of the best essay contest will be announced at the Judge's Breakfast before Trade Fair begins.

This year's judges were:

Frank Adler
Brenda Chergo
John Ford
Crystal Long
Tony Petrella
Don Thorson

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

The topic for this semester's essay is:

Seemingly minor design decisions made by engineers can significantly influence human behavior. Examples include the placement of energy meters in visible locations to reduce consumption or the use of particular features in street design to reduce accidents. Present an example of engineers changing behavior through design (either purposefully or serendipitously) that is either related to your project or your field of engineering. As applicable, discuss the social, environmental and/or economic impacts on the local community or stakeholders.

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Visualizing Solutions

Erika Blair

Few industries are as integral to the American lifestyle as agriculture and animal husbandry, and the largest sector of that industry is the farming of meat and poultry. Right now there are four farm raised chickens for every one American, and counting. In total, U.S. factory farms have "added nearly 650 cows every day between 1997 and 2007" [1]. These farms make up a significant portion the of the country's food supply, and positively impacting the efficiency of the feedlot industry can appreciably impact the American economy. Fortunately, one remarkable woman was able to do just that.

Temple Grandin, a professor at the Colorado State University, is known for being an animal science doctorate, a cattle behavioral expert, a livestock industry consultant, and an engineer. She was able to completely redesign the standard for cattle and hog handling facilities that are used on feedlots, ranches, or personal properties by optimizing the curvature and angles of fence panels and pen layouts. What makes her a remarkable woman, other than her achievements in the animal husbandry field, is that she is autistic. Temple Grandin's redesign of livestock management facilities, while immediately impacting the way cattle move through meat farms, more broadly impacted the safety of employees in these facilities, the economic output of these farms, the conservation of scarce resources, and the ethical treatment of slaughter-house animals.

Grandin is a high-functioning autistic person that is able to communicate what many severely autistic people feel and cannot communicate. She is an autistic activist that speaks worldwide on the importance of developing autistic minds for science, technology, engineering, and mathematics (STEM) applications. What makes her talks compelling is how she able to describe the primarily visual functions of the typical autistic thought patterns. Grandin compares her own thoughts to watching a slideshow of photo-realistic pictures, or to watching a film. She is able to memorize her surroundings, and replay the "mind-movie" from different angles, or under different conditions [2]. This makes her very suitable for solving open-ended design problems.

Grandin utilized her autistic mind and its ability to think visually to understand problems in cattle management facilities that were previously not even identified. By observing cattle, she was able to distinguish patterns in their movements, especially when acting as a herd. Feedlots are often places that are crowded with nervous animals, whose only human interactions have been branding, castrating, ear tagging, or some other unpleasant scenario for the animal. As a result, separation from the herd or visible human handlers are stress-triggering events. Once cows balk, or refuse to move forward, it can be very difficult and sometimes dangerous to force them to move forward. Electric cattle prods and other devices have been invented for the sole purpose of attempting to push cows forward as safely as possible.

Grandin observed that cows without visual cues of people were more likely to move along chutes. Even more critically, she observed that cattle herds tend to move in circular patterns, and a cow that is separated from its herd will nearly always circle back to where it came from [3]. Another tendency of cows is not to move unless they can see a place to go far enough ahead of themselves. After noting these behaviors, Grandin was able to mentally tour facilities from a cow's point of view to pinpoint which areas in cattle managing facilities were inefficient and problem-instigating. She was able to identify obstructions in the chutes, spots where it would be too hard for cattle to turn around, unlevel ground that caused strange crowding in pens, and other similar issues that were widespread in 1950's meat farms.

Grandin's design is to reshape traditional rectangular pens and chutes into 180-degree semicircles and curves. These curves work with cattle's natural instinct to return to the place they last left the herd; circling cattle feel they are returning to the curve's origin even as they are actually moving away from the feedlot toward holding pens [3]. Properly dimensioned chutes allow cattle to see at least two body lengths in front of themselves, which also promotes more unforced, forward movement. The gates operated by people are always equipped with opaque shields and guards that prevent cattle from seeing people before they fully enter the new holding area. Grandin recommends that all hanging chains, or similar distractions, be removed from cattle handling areas, as they often cause cows to balk; most facilities were surprisingly full of hanging obstructions that people did not notice and that cows took to be rather menacing.

These design changes, while simple to implement, made a staggering difference in the ability of feedlots and meat farms to manage their animals. Grandin's first breakthrough was with cattle, but she went on to observe hogs, sheep, and other farmed animals to create species-specific facilities layouts. Quiet, calm animals that move along planned routes in the chutes make meat farms more efficient, productive, and a safer environment for their employees. Fewer employees were at risk for injury by sticking their arms through fence panels or chute slots to persuade cattle to move forward. All stakeholders in a business benefit from safer employees, fewer onsite accidents, and dollars saved from avoiding incidents. A tour of any modern slaughter plant or livestock farm will reveal that these designs, though first put forth by Grandin in 1965, are still the standard in use today.

Besides saving dollars, these designs actively earn more for the meat farms that implement them. More steadily moving animal traffic means that more animals can be managed or slaughtered in a single day, and revenues for all stakeholders increase. The increase in efficiency is what allowed for the rapid growth of the meat industry into the 894 billion dollar industry that it is today [4]. Billions in wages are paid by the meat industry to producers, importers, wholesalers, packagers, salespersons, warehouse operators, and more; over 5.7 percent of the American GDP is comprised of capital generated by meat farming [4]. However, the

efficiency created by these pen and chute designs acted as even more than an economic boon to the country, they also promoted resource conservation in America.

Cows that are housed in a Grandin system of pens are less stressed and nervous than cows which are not. A stressed cow does produce as much milk as a calm cow, and also cannot digest and utilize its feed as effectively. Therefore, unstressed cows do not need to be fed as much in corn feed as their stressed counterparts in order to maintain the same fitness and body weight. Much of the American corn crop is devoted to feedlots for cows, and less need for cattle feed means that more corn can be devoted to food, and less corn needs to be grown in general. Corn is one of the largest users of North American water resources, and less corn grown allows more water to be conserved, and more waterways to be preserved. Grandin's system for moving unstressed cattle created this domino effect that resulted in conserving resources.

Grandin was also recognized for creating less-stressed cows simply on the grounds that cows deserve to be treated ethically before they are slaughtered. She was given the "Proggy" award in the Visionaries category in 2004 by People for the Ethical Treatment of Animals (PETA) [5]. This award was only added to a long list of honors for creating her facilities designs: three honorary degrees from Carnegie Mellon, McGill University, and the Swedish University of Agricultural Sciences; named a fellow of the American Society of Agricultural and Biological Engineers; a 2010 film *Temple Grandin* after her life; and following that named in Time's top 100 list of influential people. It may seem like a lot of fanfare for changing a few angles and switching from square corners to round ones.

However, the simplicity in Temple Grandin's design is what allowed its effectiveness and ease of implementation, and gave it its ability to affect human behavior. Grandin's design is a perfect example of how sometimes problems can be solved by attempting to understand the problems better rather than creating more technical solutions. Grandin took the time to see the world through a cow's eyes, and helped reform an entire industry in doing so. A seemingly minor design decision, like what angle a chute comes out of a pen at, can have much broader impacts that originally realized. As an engineer, it is part of one's profession to understand the implications of one's design decisions. Grandin illustrates that well-thought out, small design decisions can impact the economy and the environment on a global scale.

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Fun Theory

Dustin Burner

The modification of one's behavior is challenging enough in its own right, but to modify another's through design means alone is truly what separates average engineers from the innovative minds of our time. Maybe the real question shouldn't be how do we modify behavior through design but instead how do we improve behavior through design? How can we influence others so as to improve all of our lives through design? The answer lies with how we teach our children. When teaching a child to brush their teeth or eat their vegetables we don't threaten or punish. We make games out of it and improve the experience. So how does this translate to the design process? Well we must take the base emotion and build on it. We make it fun.

Can we influence behavior through design by making it fun? Currently, in Sweden, Volkswagen is pushing an initiative that does just that. This movement has been dubbed "The Fun Theory" [1]. It all began in early 2010 when Volkswagen thought they could increase seatbelt use by not allowing the entertainment system to function unless the occupants were buckled. Soon after, they began an international competition that invited entries from all over the world to compete for the best design that would not only improve behavior through design but make it fun. There were hundreds of entries, but only a few finalists, and one winner. All of the finalist's designs were built and tested in Sweden. The winner of the competition also took home 2500 Euros which is equivalent to around 3500 USD. Although this movement began with car safety in mind the competition is actually focused on "The thought that something as simple as fun is the easiest way to change people's behavior for the better. Be it for yourself, for the environment, or for something entirely different, the only thing that matters is that it's change for the better." [1]

The first finalist was the "Piano Staircase". This experiment was implemented in a subway station in Sweden. In this area there was an escalator and a staircase directly next to each other and almost no one would use the stairs. After closing the area off to traffic, each individual step was then covered with a pressure plate that would emit a tone when depressed. Each one of these plates was also painted to look like a piano key. When the area was reopened to traffic there was a 66% increase in people that took the stairs instead of the escalator. Also, not only were more people taking the stairs but many of them would jump from note to note so as to play specific tunes. Through audio stimulation physical activity was encouraged by making it fun. If these staircases could be implemented throughout the country we could encourage people to be more physically active and ultimately reduce obesity in America. Of the population in America today nearly two out of every three people are overweight or obese.[2] This epidemic could be the result of many things but lack of activity is thought to be one of the main contributors. If more Americans could be encouraged to simply walk up the stairs rather than taking the elevator or escalator the social and economic impacts on our society could be

staggering. Other broader impacts could include lower health care and insurance costs for consumers due to incentives provided by companies for healthy lifestyle changes. Some corporations are already beginning to start programs like this. Even further, the government may provide incentives to the companies that adopt these kinds of changes in the work place. All together these changes could make a huge impact on the growing obesity epidemic in America.

The next finalist was the "Bottle Bank Arcade Machine". In this experiment, an arcade style recycling machine was crafted. The front of the machine had six holes into which empty bottles could be placed for recycling. Above each hole, a light was placed that would illuminate in a random order during the game. To play, someone would push the start button to begin. Lights would flash above each hole and the user would have a limited amount of time to insert a bottle for recycling. For each bottle inserted in the allotted time, the user would gain 100 points. The score would then be displayed on a screen above the machine. This machine was placed near a standard recycling bin for one evening. During this time nearly 100 people used the arcade machine while only 2 people used the standard machine. By encouraging the fun competitive nature of human beings they were able to increase recycling substantially. In 2009 only about 7% of all plastics made in the US were recycled but nearly 30% of the plastic bottles consumed were recycled. Considering that this arcade machine encouraged nearly 100 more people to recycle than would have normally, imagine what these arcades could do for our country. Almost half a billion dollars was wasted in the US in 2009 due to non-recycled plastic items.[3] Instead, these recyclables are disposed of in landfills, ditches, waterways, and the oceans. The economic benefit from recycling is more than enough to secure a position for this design.

The third finalist was the "World's Deepest Trash Bin". In this experiment a sensor and speaker were place in the top of a trash receptacle so that the sensor could see if anything is was dropped inside. This trash receptacle was then placed in a public high traffic area. Whenever someone would place an item in the trash bin the sensor would see it and initiate a sound that the user would interpret as a long fall with a crash at the bottom. The average trash collected in that area was around 31kg before the experiment but once the "World's Deepest Bin" was installed the daily trash collection was increased to 72kg which is more than double the average. Once again, by introducing audio stimulation people were encouraged to not only throw away their trash but also to pick up trash in the surrounding area so that they could hear the sound again. In America today around 75% of people have littered in the past 5 years and the yearly cost to clean up litter is around $11.5 billion.[3] This nifty little device with its low cost entertainment encouraged people to dispose of double the normal trash amount collected. The implementation would not be significantly expensive and could result in a considerable reduction in littering.

The final and winning entry was the "Speed Camera Lottery". In this experiment, a sign was placed alongside the street that would tell you how fast you were going. If people were speeding by the machine it would take a picture of them and issue a citation. All of the money that was collected from the citations was then placed into a pot. The interesting thing about this machine was not that it would issue citations but that it would also take pictures of the people that were not speeding and place them in a lottery to win the pot of money collected from the speeding citizens. This machine was implemented on a street in Sweden where the speed limit was 25 km/hr. The experiment took place over a three day period and just over 24,800 cars were photographed. Before the machine was installed the average speed for cars traveling along the street was 32 km/hr but after the machine was up and running the average was reduced down to 25km/hr. In America today 13,000 people die each year as a result of speeding. Auto crashes involving excessive speed cost approximately $40 billion annually.[4] By installing this device the average speed was reduced by more than 20%. Now consider what impact that number could have on the 13,000 lives that were lost last year. Simply installing these in important locations such as school zones, neighborhoods, and high accident areas could prevent unnecessary deaths. The numbers speak for themselves in the selection of the winner for the Fun Theory award.

This idea of improving human behavior through fun is simple yet inspiring. Another interpretation of this method could simply be positive reinforcement which is basically the encouragement of a specific behavior through reward. Rewarding someone for good behavior with a positive stimulation is by no means a recent discovery but much of mankind still believes that negative reinforcement is far superior. Although this experiment does not compare "The Fun Theory" to other methods that could include negative reinforcement, it does encourage engineers as a whole to implement their designs in such a way that people have fun doing what is right and, as in the case of the winner, ultimately saving lives.

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Engineering Change: For Better or For Worse

Nicole Davis

For many years, engineers from the Western world have been trying to solve problems in developing countries. The motivations for these projects vary, but a few examples include political gain, mission work, the desire to end poverty, and corporate social responsibility. In addition, the technological advances made in the "developed" world have increased the gap between those who are considered to be in the "developing" world. Coupled with increases in media coverage and international travel, the number of non-profits and social enterprises has been increasing all over the globe. For example, Engineers Without Borders USA has grown from a few members working in Belize to over 13,800 members working in 47 countries in ten years [1]. Engineers are part of a movement to have a positive impact on global health and poverty.

Current Pumps, a social enterprise started by Mines graduate Dirk Long, is hoping to use engineering to change the behaviors of farmers in Niger, Africa. A social enterprise is a business, but instead of maximizing profit for shareholders, the primary purpose of a social enterprise is the common good [2]. The founder of Current Pumps traveled to Niger and saw farmers carrying buckets of water from the river to their nearby farms. After further investigation, he found that the alternative to this method was to buy an expensive Chinese diesel powered pump. As a compassionate engineer, Dirk wanted to invent a product that could cheaply move water a short distance using only the river and locally available materials. When he returned to the US, he built a prototype of a stream-powered water pump. Now, my team and I have spent the past five months researching and redesigning the pump. The design decisions that Current Pumps and our team makes regarding the pump could have both positive and negative social, environmental, and economic implications for the farmers in Niger.

One decision made by Current Pumps was to use the Niger River as the sole power source for the pump. Environmentally, removing the fossil fuel dependence is a positive aspect of this design. Fossil fuel is expensive, dangerous, and the emissions are not beneficial for the environment, but I don't think the analysis can stop there. If too many of these pumps were placed in one area, there could be an impact on the fish population and water levels. Also, anyone else that uses the river for boating, fishing or washing clothes may be upset with the circumstantial change. Economically, it would seem that this project is beneficial because once an individual buys a Current Pump, they do not have the recurring cost of fuel and they can water their crops with much less effort than it takes to carry the water by hand. By reducing the costs and time required, the farmer could save money and spend it on education for his family, a key factor in breaking the cycle of poverty. This is the positive impact that we as a team want to have, but I do not think the technology alone will bring about these changes. There are two key assumptions being made in this cycle; first, that the farmer will

spend his extra money on the right things and second, that infrastructure exists to enable him to save money. Often in developing countries, these assumptions are entirely inaccurate. For instance, in many cultures, the men are more likely to spend money on themselves than on the children or women in the household [3]. Another concern is that this pump has the potential to change a system of distribution that is already in place. The individual or family that typically sells the diesel fuel or distributes the Chinese pumps may not be a supporter of Current Pumps goals and could even sabotage the project because of the fears of losing customers. This has happened before with a water project lead by David Munoz, the previous Director of Humanitarian Engineering at Mines. Social justice is not typically discussed in the engineering curriculum, but for international development projects to succeed, I think engineers need to understand and take some accountability for the social inequalities that could arise by the introduction of their designs into a developing country.

Another major decision in the design of the pump was to continue to use locally available materials and techniques. With the globalization that exists today, I can easily compare prices across borders and often find that parts and manufacturing are less expensive out of the country. Since extreme affordability is a driving factor for design in developing nations, it would seem that finding the least expensive parts and manufacturing would be the engineer's choice. From the perspective of the environment, social enterprise, and community development, this may not be the case. First, by using local materials and manufacturing techniques, the carbon footprint of the pump is greatly reduced due to the transportation decrease. Second, by choosing locally available materials and planning to use local manufacturing, more of the money stays in the community. Local part suppliers see an increase in sales while manufacturers see an increase in business, which could lead to job creation. Economically, the presence of the Current Pump may not only impact the farmer, but a whole system of people in the community could be improved with just one product. Socially, using parts and equipment that the people are familiar with allows the user to have more autonomy in the function of the pump and enables the locals to repair the pump on their own. Design changes can be made quickly and easily by the farmer to make the pump function better in specific situations, instead of using a generic technology that is in a closed system and difficult to understand. A design that is made of a blow-molded frame may have fewer parts and be faster to mass-produce, but it does not enable the locals to make fast repairs. With our design, if one of the PVC fins on the pump cracks, a farmer can quickly replace the part with locally purchased materials. An engineer is not typically taught to make designs that build the capacity and capabilities of the user. Typically, an engineer is told to design something that will accomplish the task as efficiently as possible for the least amount of money. Engineers need to understand that simple decisions about the parts list or the equipment needed to manufacture products for developing nations can have major ramifications for the users. I believe this is particularly difficult when engineers are designing for a culture and a location that they do not understand.

Many similar projects in the past have failed to fulfill their well-meant goals. The Playpump was another method of pumping water in developing country. The idea of the Playpump was to connect a merry-go-round outside of a school to an aquifer, using the energy of the children to pump water to a tank. There was a large amount of excitement and celebrity involvement surrounding the project. Unfortunately, after a few years of the project, only13 out of the 42 installed pumps were still operational. In some cases, the pumps were breaking down without methods for repair and in others, there wasn't sufficient water in the aquifer. In one case, the installation of a non-functional Playpump left a community without water for six months [4]. A group of engineers designing a pump in Washington DC never had the intention of the technology hurting societies, but nonetheless, this has happened. Engineers need to be aware that though they may not technically be held accountable for the social ramifications of a design for the developing world, their approval of the design gives them a part of the responsibility.

Design in the humanitarian engineering field needs to be approached from a human-centered perspective, taking into account the possibility of both positive and negative effects on the user and the user's community. In this case, this means not only considering the technical output of the pump, but also how the pump's design can open opportunities for capacity building and the possibility of causing social injustices within the community. I argue that there are many social assumptions that engineers will make that could cause international development projects to fail, especially in those situations where the engineers are far removed from the location for which they are designing. Though engineers are an essential part of projects that could reduce poverty and increase health in the poorest of nations, I believe a multidisciplinary approach is needed. Thankfully, Current Pumps has already started this process. The two other founders of the enterprise are Luke, who has a MA in International Development and Matt, a businessman and marketer. Current Pumps also has a long-standing relationship with Yacooba, a local in Niger who currently teaches farmers new farming techniques. This integration between the local community, engineers, anthropologists, economists, and marketing experts is a key part of any successful international community development project.

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iPhones: Reinforcing America's Throw Away Culture

Eric Evans

Today in American society, we often find ourselves craving the latest, most advanced technology that producers have to offer. With the market being constantly inundated with new smart phones, laptops, televisions, and many more products, it is difficult to resist the temptation of discarding your "outdated" devices and buying the latest ones, only to discard them again when the next generation is released. This throw away culture that is so deeply seated in American society has been planting its roots for decades. Ever since manufacturers discovered the value of disposability, products have been purposefully engineered to break or become obsolete after a short period of time. The iPhone is a perfect example of such a product. In recent years Apple has been releasing a new model of the iPhone every six to twelve months. The company's tremendous success has made it obvious that Americans do not hesitate to discard their current devices and head to the store to pick up the shiny new model. The design practices implemented by Apple as well as countless other companies clearly reinforce the concept of disposability that has made Americans the world's most insatiable consumers.

One of the earliest disposable products invented was the disposable razor, fabricated by King Camp Gillette in 1901. Gillette realized that a hefty profit could be made by selling a cheap razor with blades that were meant to be thrown away after a short period of time, thus ensuring that a customer would return to buy more razors. It did not take long for this idea of planned obsolescence to gain momentum in several industries, especially in the 1920s and 30s when automobile manufacturers began implementing frequent design changes to car parts, convincing customers to buy annual replacements. Producers of all industries continued to capitalize on this philosophy, purposefully designing parts that are meant to fail, break, or become undesirable after a limited amount of time. In his book *Made to Break,* Giles Slade states the following:

> "Deliberate obsolescence in all its forms — technological, psychological, or planned — is a uniquely American invention. Not only did we invent disposable products, ranging from diapers to cameras to contact lenses, but we invented the very concept of disposability itself." [1]

This deliberate obsolescence has established itself as the backbone of our capitalist society, and can be easily observed today in almost any industry.

In more recent years, the philosophy of planned obsolescence has become quite prevalent in many technological industries. One of the most obvious of these is smart phones. It is nearly impossible to turn on the television or get on the internet without encountering advertisements for the latest smart phone, with promises of better coverage, faster processors, bigger displays, higher definition cameras, the list goes on.

Consider the iPhone, for example. Apple has released three different models of the iPhone 5 in the time span of a year: the 5, the 5C, and the 5S. Production of the iPhone 5 was already discontinued the same day that the 5C and 5S hit the shelves. The 5C is basically a re-released version of the 5 that comes in a variety of colors, while the 5S bolsters improved hardware. So how much of a difference exists between the iPhone 5 and 5S? To the typical consumer, the most notable differences are the flashy gold color that the 5S is available in and the fingerprint ID scanner. When examined more closely, the 5S offers two more main differences. The camera has a slightly higher resolution, and the processor is faster [2]. Are these slight upgrades worth spending another $400? Many would answer yes. In fact, Apple sold over nine million iPhones during the opening weekend of 5C and 5S sales, compared to five million for the iPhone 5 [3].

So what do people do with their old smart phones after upgrading? If they are environmentally conscious, hopefully they will either sell them or recycle them. However, it is far more likely that the old phones sit in a drawer for some time before eventually being thrown in the trash. According to the Environmental Protection Agency (EPA), less than ten percent of discarded cell phones were recycled in 2010 (the last year the data is available), leaving the rest to be trashed [4]. This means that the opening weekend of iPhone 5C and 5S sales resulted in over eight million phones eventually being thrown in the trash, assuming that a large majority of the customers bought one to replace their current cell phone (which is a fairly safe assumption). While this number may be a little high due to an increased number of trade-in and recycle programs since 2010, it is still astonishing.

It is evident that the throw away culture that America has so readily adopted has had several significant impacts on the environment. The constant stream of new products flooding the market has created a rapid growth in the amount of electronic waste, or e-waste, that America produces. According to the EPA, the U.S. generated 3.41 million tons of e-waste in 2011 [5]. Less than a quarter of this waste was recycled, leaving the rest of it to be trashed in incinerators or landfills. Mobile devices such as smart phones account for a little less than half of the number of disposed electronic devices. The majority of these devices contain toxic chemicals such as mercury or lead that can accumulate in the soil at a landfill and disrupt natural ecosystems. Greenpeace conducted a study on the iPhone in 2006 to test for hazardous materials, and found several in heavy doses including phthalates, polyvinyl chloride, and brominated flame retardants [6]. After the results of the study were published, Apple promised to eliminate the use of these chemicals in production, but unfortunately millions of these devices were already buried in the ground. It is a shame that such a large portion of our discarded smart phones are sent to a landfill, especially because almost all the components can be recycled. However, recycling programs are not yet well enough established to handle the massive influx of electronic waste.

America's throw away culture has clearly had several effects on the way we behave and interact with each other. It has created a much more materialistic society where we value our time and convenience over our money. If a product breaks, it is much faster to toss it in a landfill and replace it rather than taking the time to repair it. It is much more convenient to utilize paper towels, napkins, and tissues to eliminate the need of washing cloth towels or handkerchiefs. We also often find ourselves competing with our neighbors regarding who has the bigger house, the faster car, the latest smart phone, etc. Things such as this tend to define our social status, and in order to climb the social ladder we are constantly trashing old products to replace them with the latest and best technology.

In addition to the many environmental and social affects, the philosophy of planned obsolescence has had a large impact on the economy of the U.S. The entire economy revolves around the idea of making cheap, disposable goods that will soon be tossed aside to make room for the next product. In America, we are surrounded by products that are foreign made, from smart phones and laptops to the clothes on our backs. The manufacturing process is often outsourced to other countries were labor costs are very low. The iPhone, for example, is manufactured in China by a Taiwan based company. The products are then shipped and sold here in the U.S. If they break, they must be repaired here, where labor costs are much higher. So high, in fact, that it is often much cheaper to replace a damaged item rather than repair it. This yields tremendous profits for the American companies, whether the customer repairs or replaces their product. This type of economy is not sustainable, as it requires one key ingredient: oil. Oil is used in everything from the manufacturing process to the transportation of these products. We will eventually run out of it, causing our economy to collapse if significant measures aren't taken. It is our responsibility to build a new economy based on durable products and renewable energy that will allow us to sustain economic progress.

The iPhone is the perfect example of how manufacturers reinforce our desires for the latest, most advanced products. This desire, instilled by the philosophy of planned obsolescence, has led to the throw away culture of America that has had significant environmental, social, and economic impacts on our society. There are ways we can combat this idea of disposability, both as engineers and as consumers. It is important for us to invest in more durable products, whether they are products we are selling or buying. The upfront costs will be higher, but it is worth it in the long run. When these products do eventually wear out, recycling is a far more favorable option than dropping them in a landfill.

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The FEDI Effect

Robert Francis

In the early 1980s, a growing number of scientists began to analyze climate models and discovered a trend in rising global temperatures. These scientists postulated that this rise was due to a greenhouse effect causes by gases such as methane, water, and carbon dioxide (CO_2). It has long been known that the burning of fossil fuels releases CO_2 into the atmosphere, where it aggregates and increases the total concentration of trapped greenhouse gases. This increase of greenhouse produces the phenomenon known as global warming [1]. To try and mitigate the harmful effects of increasing greenhouse gas concentrations, scientists and engineers researched the major contributors releasing CO_2 into the atmosphere. They have concluded that over the last 50 years in the United States, the transportation sector has accounted for more than 33% of the emissions from the combustion of fossil fuels that contributes to global warming [2]. Environmentally conscious organizations such as Greenpeace began massive campaigns to raise public awareness of the threat posed by this consumption of petroleum by the average automobile driver [3]. These campaigns successfully convinced automakers that there was a growing demand for vehicles to have some form of a fuel economy display visible for owners to assess their personal consumption. Thus, pioneering electrical engineers began to develop what is commonly referred to as a fuel economy driver interface (FEDI) to be included in a vehicles' instrumentation panel [4]. This technology evolved with that of the microprocessor, and practically every vehicle currently sold in the US incorporates a FEDI system in its design. Aided with a FEDI, motor vehicle operators are adjusting their driving habits to reduce their fuel consumption through a process social scientists term Feedback Intervention Theory [5].

The road to driver enlightenment was not always as smoothly paved as it is today. The first FEDI technology introduced into vehicles used vacuum type gauges to provide the operator a relative display of average fuel economy based on the engine's manifold vacuum pressure. Using typical strain gauges, the design was relatively simple and extremely cost effective. Importantly for both manufacturers and consumers, it did not appreciably increase the cost of the vehicle. However, these gauges began to serve the important purpose of bringing fuel economy awareness to the drivers of those few models that incorporated this new technology. Unfortunately, FEDI technology advancement was stalled at this point because of the inherent limitations of engines that utilized carburetors as a fuel delivery system. Microprocessor technology was not affordable to integrate any more complex processing than simple strain gage and thermostat measurements. In the early 1990s, auto makers transitioned most models into a fuel injection system controlled by the then newly developed engine control module (ECM). It was this coupling of the fuel delivery system with what was basically a computer that brought a renewed interest into developing FEDI technology by fuel economy enthusiasts [6].

Intrinsic to the design of the ECM was the onboard diagnostic port (OBD II) that would provide a means for technicians to diagnose and service the vehicle based on data stored in the ECM. Given the means to tap into the vehicle's computer, it was only natural that the ever-tinkering electrical engineer would begin to develop the technology to read that stored information for his particular interests. By the late 1990s, aftermarket devices such as momentum-based miles per gallon (mpg) meters began to appear. This technology would calculate the differential strain measurements based on the strength of a driver's acceleration and braking and use simple red and green lights or gauges to indicate excessive or acceptable fuel consumption. It was also during this time period that the global warming movement was foremost on the minds of many environmentally friendly grass-root organizations. Demand for FEDI technology grew such that a subculture of drivers began to emerge—the *hypermilers*. These dedicated fuel economy aficionados began to actively promote driving techniques that would maximize the gas mileage of any vehicle. Though the demand for newer, more accurate and reliable FEDI technology was growing, the US population as a whole was still not too terribly concerned with altering their driving habits to reduce its fuel consumption. Oil in the late 1990s into the early 2000s hovered around $30 a barrel; and the national average for gas prices ranged from $0.95 to $1.10 per gallon. FEDI technology had significantly improved over the past decade, but it was still isolated into a niche market and not applied to many US automobiles. American scrutiny of its driving behavior and its attention would soon change.

In May of 2006, former Vice President of the United States Al Gore released the ground breaking documentary *An Inconvenient Truth*. Man-made global warming was capitulated into the spotlight of American discourse, with CO_2 emissions once more taking the center stage of environmental debate. Fortuitously for the FEDI concept, oil prices began to spike above $100 a barrel, and gasoline prices rose accordingly. A vehicles rated mpg was no longer just a number on an invoice sticker in the dealer lot that only received a cursory glance. The mpg would soon become a defining factor in car purchases. The sale of aftermarket fuel economy meters skyrocketed as more and more everyday citizens grew concerned with both the rising cost of gasoline and their own carbon footprint [7]. Additionally, customers would also begin to demand that auto makers incorporate the latest FEDI technology into new vehicles. By the end of the first decade of the new millennium, FEDIs had become standard in almost every new vehicle sold in the United States.

The FEDIs currently installed in new and late-model vehicles vary greatly in appearance and overall functionality as automakers now use its design as a major selling point. They may provide analog or digital gauges, illuminator lamps, bar charts, numerical outputs and a myriad of other display features. They can also provide information such as instantaneous fuel economy based discrete flow measurements, average fuel economy, distance to empty and even driving styles such as aggressive, moderate or conservative. Hybrid vehicles include FEDIs on LCD screens that also display the measurement of two sources of energy: electricity

and gasoline, as well as the direction of energy flow [8]. Automakers have recognized that fuel economy has become such an important characteristic of the American driving experience that consumer options for measurements are virtually limited only to the imaginative preference of the individual.

Whether a driver wishes to modify her driving behavior because of the cost-savings associated with lower fuel consumption or the ecological benefit of reducing CO_2 pollutants, the impact of having a user-friendly, technologically advanced FEDI system on her driving style has been monumental. Numerous studies over the past few years alone support the notion that introduction of FEDI systems in automobiles have been instrumental in substantially altering a large portion of the American populations' driving habits. Research has shown that drivers with FEDI systems respond to the display by adjusting their driving to a more conservative mode of operation when confronted with data alluding to aggressive driving that increases fuel consumption [9]. Auto drivers may not have completely adopted every tactic and technique of the pioneering hypermilers, but they are incorporating a significant number of their mileage saving techniques. Instead of rapid acceleration and deceleration, the transitions have become much smoother and more slowly controlled. Mindful people are increasing their distances between vehicles to prevent sudden deceleration for stopping, ensuring their FEDI display continues to read maximal mpg. When a rational adult notices that their FEDI indicates their driving may be too aggressive for their current driving conditions, the driver will more likely ease off the accelerator pedal to return to a more controlled and even-keeled state better suited for conserving gasoline consumption. As an added benefit, FEDI users have been observed as safer drivers. Their usually reduced speed allows for greater reaction times to respond to road hazards, whether they are natural or the result of the careless driving of other motorists.

The use of fuel economy driver interfaces has had, and continues to have, a substantial impact on the relationship between man, the automobile, and the Earth. FEDI technology has become almost as ubiquitous as smartphones, and assimilation of the data generated by these devices into a person's decisions about driving behavior is very nearly as flawless as recognizing the need to slow down when highway patrol vehicles are in sight. Man-made global warming caused by the combustion of fossil fuels is an incontrovertible fact supported by thousands of scientists and engineers world-wide. The release of CO_2 into the atmosphere by the American motorist continues to be a major driver for this horrid condition, but the integration of FEDI technology into their driving behaviors offers hope for salvation from the apocalyptic future resulting from global warming.

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Sustainable Restroom Design

Jessica Ho

The emphasis on sustainability in today's world cannot go unnoticed. With the ever-increasing population of the world, people are consuming more energy and generating more waste than ever, which is why it is important to make greener, more environmentally-friendly changes. Restrooms account for 30-60% of water usage in public facilities and residential homes, making them a prime candidate for sustainable design [1]. From water-saving toilets to energy-efficient hand dryers, engineers have designed many ways to reduce the impact of restrooms on the environment while decreasing costs. Sustainable restroom design contributes to the increased awareness of the importance of going green, resulting in more people adopting eco-friendly practices.

Sustainable public restroom design began with an attempt to save water and cut costs because people often forgot to turn off lights and leave the faucet running upon exiting the restroom. Instead of trying to change people's behavior by posting signs near light switches and faucets, technologies were designed and implemented to address the problem directly. Thus, sink faucets and lights equipped with motion sensors can turn the device off automatically when not in use. Sustainable public restroom design was taken further with the introduction of water-saving toilets and energy-efficient hand dryers. When considering sustainable restroom design, engineers consider ways to reduce water consumption and waste, minimize energy use, and keep initial and maintenance costs low [1].

WaterSense, a program in partnership with the U.S. Environmental Protection Agency, seeks to help people save water by labeling products that are at least 20% more efficient than other products in their category. The WaterSense label also guarantees that the product reaches at least the same level of performance their conventional counterparts [2]. Many public restrooms use WaterSense faucets, which use aerators to reduce the faucet flow rate without sacrificing water pressure [3]. WaterSense faucets have a maximum flow rate of 1.5 gallons per minute while conventional faucets can run up to 2.2 gallons per minute, resulting in over 30% savings in water [2]. When combined with electronic motion-detecting faucets, these new high-efficiency faucets achieve a total savings of 70% in water use [1].

The design of energy-efficient light fixtures has also contributed to major cost and energy savings for public restroom facilities. A switch from incandescent light bulbs to fluorescent light bulbs reduces energy usage while providing more than adequate lighting. Many bathroom lights are equipped with timers and motion sensors. These lights turn on when someone enters the room, and they turn off after sensing inactivity for a certain period of time. Some restrooms have also been designed with appropriately placed windows in order to allow natural daylight to illuminate the room, minimizing the need for electric lighting [3].

Low-flow and dual-flush toilets have become popular in public restrooms, especially schools and universities. The Energy Policy Act (EPA) of 1994 mandated that toilets could use no more than 1.6 gallons of water per flush, a significant decrease from conventional designs that use 3.5 gallons per flush [4]. Low-flow toilets use less water but still have enough power to properly remove waste and control odor. Some of these models use compressed air to increase the flush velocity [1]. Dual-flush toilets have two flushing options, using 1.1 gallons to flush liquid waste and 1.6 gallons to flush solid waste [3]. The Alliance for Water Efficiency estimates that the savings from more energy efficient toilets is 18.2 trillion gallons of water over the last 20 years, or 4.6 billion gallons of water per day [4]. Related to toilets, urinals have also had an efficiency makeover. Traditional urinals that use 1 gallon per flush are being replaced with high-efficiency models that use either no water at all or only 0.5 gallons per flush. Waterless units are made practical by designing them with self-draining mechanisms and methods of odor control [1].

Public restrooms typically provide paper towels for users to dry their hands with; however, electric hand dryers are becoming more popular for the increased cost and energy savings. Although disposable paper towels require little to no energy during actual use, the energy and cost of manufacturing, transporting, and disposing the product adds up. From manufacture to disposal, paper towels require 743 kilojoules of energy per towel. Additionally, paper towels need to be restocked on a regular basis, incurring maintenance costs over their lifetime of installation. In contrast, electric hand dryers simply require a one-time installation with the occasional need for service and repair. Conventional hand dryers are greener than paper towels, but even these are being replaced with the next generation of high-speed, energy-efficient (HSEE) hand dryers. An energy analysis shows that HSEE hand dryers use 80% less energy than conventional hand dryers. Compared to paper towels, HSEE boasts a 95% cost savings. HSEE hand dryers also reduce the carbon footprint of hand drying by 70% compared to conventional hand dryers and 100% compared to paper towels [1].

As another type of facility with excessive water usage, hotels have been designing more sustainable restrooms while encouraging patrons to conserve resources. On average, hotel bathrooms use 84 to 173 gallons of water per room per day. This is significantly more than the 69 gallons of water the average U.S. household uses per day. Although the cost of installing new bathroom technology is a large capital investment, the cost savings and environmental impact in the future pays off quickly. For example, an Australian hotel recouped its initial investment of $19,500 on low-flow technology after just 18 months. It also reduced its water consumption by 50%, which will continue contributing to more cost savings in the future [5].

In addition to installing water-saving toilets and aerated faucets, hotels have found several other ways to save water and cut energy costs. Several European hotels have installed electric showers equipped with flow regulators and timers in order to encourage guests to take shorter showers. Although guests are not prevented

from taking longer showers, the timers increase awareness of the importance of conserving water and energy. The use of electric showers also saves water by design. Electric showers heat water up locally right before dispensing it whereas traditional showers draw water from a central water heating system. This prevents the need for guests to let the water run as they wait for it to warm up. Furthermore, it provides the additional benefit of not running out of hot water mid-shower [5]. Gray-water systems have also proved to be beneficial to hotels. These systems harvest wastewater from sinks, showers, and toilets to be reused for kitchen disposal units and other maintenance facilities [6].

Sustainable restroom design is not only a cost and energy savings initiative for public facilities, but it is also applicable to residential homes. Toilets make up nearly 30% of a household's water usage. By switching to a water-saving toilet, an average family of four can conserve over 16,000 gallons of water and save at least $100 in water bills [7]. Replacing old faucets or retrofitting existing fixtures with WaterSense products can save families up to 700 gallons of water per year. This equates to enough water to take approximately 40 showers with. Because saving water also saves energy on heating water, residents can expect their electricity bills to go down if they revert to using water-saving and energy-efficient bathroom fixtures. If all homes committed to using only WaterSense faucets, it would amount to a savings of $1.2 billion in water and energy costs as well as 64 billion gallons of water [2]. Thus, redesigning restrooms in residential homes has proven to be viable as both an economical and sustainable option.

Sustainable restroom design cuts costs and reduces the environmental impact of excessive water and energy use. With constant advances in technology and sustainable design changes, people are becoming more aware of the economic and environmental implications of their choices. People are more likely to follow green trends if they are educated about its benefits for themselves as well as society. For this reason, design in public places is an important aspect of promoting greener lifestyles. Studies have shown that people are more likely to change their behavior and support green living if it becomes the social norm. With the design of sustainable public restrooms, people can choose to flush using the appropriate handle on dual-flush toilets, conserve water while washing their hands, and reduce their carbon footprint by utilizing electric hand dryers. In hotels, people are more open to using their bathroom towels more than once as it becomes more common practice [8].

Technological advances continue to be made in the design of sustainable public restrooms. Commercial facilities, hotels, and residential homes have many options when choosing an eco-friendly and energy-efficient restroom design. As new restroom technologies are adopted, public awareness of the environmental movement will spread, and the world will continue to move towards increased sustainability.

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High-tech Problems, Low-tech Solutions

Jacquelyn Lewis

In a world run by technology, we develop serious, long term, passionate relationships with our devices and our networks. We seek out connectivity to our friends as much as we seek out our friends. As personal technology has become more and more sophisticated and elegant, our dependence on it has become more and more pervasive. The social climate suffers and ever new technology is created to supplement the natural social 6interactions we veer away from with headphones in our ears, our eyes lowered to our screens. But none of these applications provides us with the organic human contact we were designed to crave. Though not (yet) particularly influential, the "offline glass" provides a low-tech solution for a high-tech problem.

The concept of the "offline glass" is simple: the glass will not stand up unless supported underneath by a smart phone. The user is therefore forced to tear their attention away from their emails, texting conversations, Facebook pages, and fantasy football leagues for at least long enough to enjoy a beer the way god and men intended: in the physical company of friends and strangers. Instead of spending an evening out surfing or communicating with people who are not actually present, which has only become a phenomenon and social burden in the last 10 years, bar patrons are coerced into meeting new people and making conversation with those around them as was commonplace in such recent history.

Salve Jorge, a bar in São Paulo, Brazil has implemented these offline glasses as a way to encourage the more healthy social interactions of decades past. They employed the local advertising agency Fischer&Friends to create this glass to change the atmosphere of their establishment. Mauricio Perussi's design, a simple half-bottomed glass, has been a success at Salve Jorge despite its obvious lack of sophistication. It has the obvious effect of forcing many people to trap their phones beneath the glass, but its significance is far greater. There would be little difficulty in outsmarting the glass and ignoring its intended use, as the size and shape of a smart phone is easily replicable using any number of materials in a restaurant or bar. Thus the glass only changes the behaviour of those willing to play along [1].

While technology of the last decade has created instant access and encouraged free expression in online media, it has had the unintended consequence of robbing us of a lot of normal social behaviours. Surveys regarding the effects of smart phone use have brought forth suggestions of higher stress levels when smart phones are used daily [2]. Studies even show the negative impact that the mere presence of smart phones can have on social interactions [3]. While smart phone applications are often design specifically to facilitate communication and add new aspects to social communication, it has been suggested by research that strong relationships develop with the device instead of with the people on the other end. Phone use can be an impediment to trust and intimacy in face-to-face interactions [3].

Every technological development has the potential to do more harm than good. So it was in automobiles before the implementation of safety measures such as seat belts, air bags, and traffic signs, or bicycles before helmets and reflective gear. Society needs protection from devices which can do them bodily harm. It seems that protection is also needed to safeguard us from developing dangerous social habits and adverse behaviour in personal relationships. The offline glass is one protective mechanism that offers relief from our own addictions to electronics.

As stated previously, the glass presents a problem: how to prevent it from falling over. It also suggests a solution: use a smart phone to stabilize the glass, effectively barring any convenient use of the phone. The product can do no more than that: a basic problem, a basic solution, which will hopefully solve the much larger problem inherent in obsessive cell phone use. But the intention of the glass is perhaps more important than its actual physical impact. Most people would submit to the glass and surrender their cell phone, especially since thus far it is a product specific to a single bar – patrons choose to go and they are likely already aware and open to it's beliefs and methods. But the mere existence of a product intended to forcibly limit cell phone use indicates collective awareness of a social problem, and brings the issue to the forefront of the community.

An analogy could be made between healthy social practices and healthy eating practices. The presence of organic food products in the market and an increasing number of restaurants specializing in natural and healthier foods will not force healthy habits upon anyone. But the more available and apparent the product and the concept of healthy eating, the more awareness there is amongst the community of their options and the benefits of healthy choices. The same is likely true for the pitfalls of cell phone overuse and the benefits of putting electronics to rest. The power of the offline glass lies not only in its ability to change behaviour for the time of its use, but its ability to bring the issue of smart phones and their potentially adverse impact on social behaviour to light. As Mauricio Perussi explains, "we do not intend to [actually] solve the problem." It is more of a community conversation starter, and seems to have positively influenced the way the people within Salve Jorge interact with one another. Online comments on the product range from critical and doubtful of their practicality to praise for the concept and reflections on the unfortunate necessity of such an innovation [4]. Thus while a few have gotten use this straightforward design, many have begun to discuss the more complex social issues surrounding the product.

The offline glass illuminates an aspect of mechanical engineering which is given little attention: the smallest alteration to a common object can not only change behavior during use, but change the behaviour of a community. Mechanical designs can be simple or sophisticated, yet have a huge impact on how you live your daily life. They can change your physical behaviour or merely your perception of your behaviour.

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Dam Projects and Social Impacts – The case of the High Aswan Dam

Ryan Logan

Throughout the history of human civilization, societies have relied on water in order to sustain their needs. Construction of dams is a fundamental process in water management. Dams allow for the control of river flows. Flows can be increased during dry seasons, and floods can be dampened in order to protect downstream communities. The control of such a powerful force of nature that is necessary for society can have immense social impacts. This essay attempts to describe social impacts that can result from the use of large dams to manage water. To aid in this description, the case of the High Aswan Dam on the Nile River is considered.

Many People think of engineering as a profession with a narrow technical focus. However, engineers serve the needs of society, and every decision has some kind of social impact. In some cases this impact is not the intended result of the project. Civil engineers engage in large infrastructure projects in order to make society more connected, safe, and provide for increased access to natural resources. The social impacts of these projects are inherently large in magnitude. For the purposes of this discussion, these social impacts might be divided into two categories. The first is the intended social impact of the project. The second are the social impacts that are not a direct goal of the project. These can be either positive or negative, and either large or small. Sometimes these social impacts can be foreseen and eliminated or mitigated, but sometimes they are unknown. These social impacts that are not direct objective of the design are perhaps the most often overlooked or ignored. Thus, this may be the critical area for an improved education and awareness among engineers.

The High Aswan Dam was constructed during the 1960s. The structure in its current form was the evolution of previous attempts to control the flow of the Nile River with smaller dams. The Dam severs several functions. It provides for hydropower, irrigation water, and flood mitigation to downstream Egypt [1]. The Nile River has provided fertile land for Egyptian civilization for millennia. The high floods deposited fertile soil for agriculture. When the water level lowered, these civilizations were able to grow enough food to sustain themselves. Although this river is the source of life for these civilizations, it is the only significant water source in the area. Thus, without the control of the river, the Egyptians were at the sole mercy of nature's variability. This sparked the historical and current need to control the river [2].

With the construction of the High Aswan Dam, as well as other dams on the Nile River, there were explicit objectives to benefit society. Many of these social objectives are apparent. The reduction of yearly floods allowed for larger amounts of the downstream land to be feasibly used for agriculture, which increased crop output quantities [3]. More food for Egypt means better quality of life for the people. These crops can be used to offset famine in the region, or exported for profit.

In addition to the benefits seen on a state-wide level, the impact of different individual social groups is important to consider. Here the farmers themselves as a social group can benefit from the increased farming efficiency. In general, high crop output for farmers can mean more profit, more access to technology, and a better quality of life. In this case, the increase of farmable land was not the only consideration. Individual farmers can get higher yields when they do not have to only rely on a single high flood per year. Managed and consistent water usage helps in this situation, so the farmers can have better yields. These positive effects for farmers are also an important consideration for social impact in terms of social justice. Often times, large infrastructure investments may favor those in higher socio-economic groups, because they are the once who can influence the decisions. In the case of increased agriculture through the control of the Nile River, all social groups may benefit because of their interconnected destiny. More food production is better for everyone, so all stakeholders have similar interests. However, this is not to say that the High Aswan Dam or other Dams on the Nile River or elsewhere do always provide benefit to different social group in all ways. There are areas of shortcomings to consider considering all stakeholders.

The generated electric power also provides a substantial benefit to the population. Power that is generated through the dam is supplemental to the benefit from control of the water. It can be thought of essentially as a "bonus" in addition to water management. This of course may be an over-simplification as there is an intricate relationship between the management of water and the generation of power, but it is still necessary to acknowledge hydropower as an added benefit. Power generation contributes to the social well being of the society. This is power that does not have to be generated through fossil fuels or imported at high prices. This economic benefit can be translated to a social benefit, as it can be a force to drive development in the country.

While there are many benefits that come with large dam projects such as the High Aswan Dam, there are downfalls as well. Negative social implications can also come as a result of environmental implications in large dam projects. With the Aswan dam, the effect due to changing sediment transport regimes is significant. Historically, the annual flood of the Nile delivered fertile soil into Egypt. With the implementation of the High Aswan Dam and other dam projects that have been historically completed on the Nile River, much of the sediment is trapped above the dam. This has a few different implications. First, there is a shortage of nutrients in the soil in the valley. Fertilizers must be imported where they were not previously needed. In contrast to the benefit of irrigation to farmers, this puts strain on this social group.

Additionally, the lack of sediment transport below the dam allows for significant erosion. This change in landscape might be a substantial impact for those living in the area, as well as local farmers. All of this sediment is trapped above the dam, which causes problems of its own. Decrease volume of the dam through

sedimentation can be an issue for the future prosperity of the water management. Volume loss through sedimentations takes away from the technical sustainability of the dam. The technical sustainability is related to the social sustainability through the economic impacts that may occur if the capacity becomes too low and more investment is needed to get consistent benefit. This is one area that can be mitigated through engineering practices. Implementation of appropriate dredging can increase the life of the dam and make sure it can continue to provide social benefit.

In the case of the High Aswan Dam, previous dams had been built in the area, and local communities may be somewhat adjusted. However, there can sometimes be significant displacement of locals when constructing large dam projects. When a dam is constructed the geometry of the river is changed. Upstream and downstream parts of the river are changed. This can be devastating to people who live in these areas. Sometimes these people may depend on the current state of the river for their way of life. An example would be communities who rely on fishing. The fish population could change, and affect these people's livelihood [4]. This can be a particularly significant social impact, because these people may not have the political influence to have a say in the projects. This is something that engineers should be mindful of during the planning and design process.

Finally, the political relationships in large water management projects like the Aswan dam must be considered. Water allocation between upstream and downstream states can be delicate agreements, or sometimes not agreements at all. The High Aswan Dam provides water management for Egypt, but the majority of the water originates in the highlands of Ethiopia. This allows for changing diplomatic relationships, which must now be considered.

Engineers must be mindful of the social impacts when involved in any project, especially large infrastructure projects. It may be impossible to prevent or foresee all potential impacts, but it is important to make a diligent effort to ensure positive social impacts. In the case of the Aswan Dam, the positive social impacts likely outweigh the negative. Careful prior consideration can help to ensure this for many projects. Strategies are often available to evaluate social impacts, so engineers should implore these when applicable. Most importantly, engineers should make a comprehensive effort to explore all potential social impacts associate with any project.

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A 'Green' Way to Do Business

Connor Maxon

Engineers are the facilitators of life, the creators of solutions, the intelligence and creativity of functionality. Their work often goes unnoticed and unappreciated by those who it greatly affects. All activities throughout the day are conducted in, on, by, and with some form of sought out design from an engineer, the most popular being structurally. As Winston Churchill said, "We shape our buildings and afterwards our buildings shape us." [1], In other words, design and placement of utilities, rooms, and furniture influence the way humans interact with their surroundings. Restrooms, a major facility used in every public and private building, utilize many features and technological advances to facilitate and promote human functions. With today's motto of 'going green' and reducing consumption, bathrooms across the world are doing just that while hygienically improving day-to-day life.

Lavatory, little boys/girls room, powder room, bathroom, and restroom are all terms spread throughout the community that all boil down to the same location. Airports, malls, gyms, office buildings, and even parks provide such a location for every human to conduct business. Key placement and new technology have increased human health and reduced the consumption of natural resources. With a global stride to provide sanitary environments while tending to the public's needs and expectations, engineers have found multiple means of integrating energy-saving devices into the social scene.

Technology has come a long way since the dawn of mankind. From toothbrushes to automobiles, technology has facilitated daily operations and increase personal wellness. Sloan, a popular plumbing company, has become the "…World's leading manufacturer of water-efficient solutions…"[2] through their designs. With a mission statement to "Passionately preserve the environment" [2], they have invented a 'waterless urinal' designed to save 6,552 gallons of water a year (in a household of four males each flushing a 1.5-gallon toilet three times a day) [3]. This serves as a convince to the users by not having to touch any germ-infected surfaces and reducing effort in the process while benefiting the environment. For those of the opposite sex or may have to conduct other forms of business, Sloan has also create a dual flush system for toilets. Unfortunately, this system requires a completely new toilet and cannot be integrated into existing toilets. The two flush systems is simply a valve that can supply two different quantities of water in order to complete the flushing process. By pushing the lever down, a lesser amount of water is used to flush the toilet in scenarios for women or small fecal matter. On the other hand, the lever can be pulled up to supply more water for flushing in the scenario where a lot of paper products must be flushed. This system is being seen more and more in new facilities as well as recently renovated restrooms. Subconsciously, everyone is working towards preserving the environment through a simple task.

Have you ever noticed the placement of sinks in a restroom? Typically, one must first pass by the sinks in order to reach a toilet. Therefore, making the order of operations fall inline with the direction of travel. First, one uses the designated toilets followed by the washing of the hands, then drying their hands followed by a garbage receptacle before exiting the facilities. This serves as a convince to the users as well as a promotional aspect to encourage hand sanitizing to reduce the spread of germs through other human interactions outside of the restrooms. The human brain is greatly reminded through the use of sight, justifying the positioning of the sinks. If the sinks were positioned farther away from the exit than the toilets, one would be more likely to leave the facility without even glancing more or less thinking about washing their hands.

Conventional sinks use a combination of knobs to provide different water temperatures while varying the amount of water flow. Even though this is a relative inexpensive method of providing water, technology has opened the market to new processes for providing water at a comfortable temperature while restricting flow without dissatisfaction to the users. These new sinks help to provide a green, touch-less solution without losing consumer interest with many beneficial results. By regulating flow, less water is consumed as well as less waste water being produced, preserving the environment. With temperature controlling, less energy is exerted in providing the water, reducing cost at the owner's expense. The motion-activated sinks help to reduce the chances of running water without any occupants in the lavatory and aid the hygienic duty of the restrooms.

Washing hands is senseless without some form of anti-bacterial substance as a means of cleansing. Most soap dispensers compose of a pump that dispenses soap in the form of liquid. All though this is a step towards hygiene, recent development has led to an automated dispenser that works the same way as a touch-less sink or paper towel dispenser. These touchless dispensers ration the amount of soap dispensed to an individual, which translates to fewer chemicals making their way down the drain. The dispensers also dispense soap in the form of high-volume foam lather [4] that requires less soap than traditional liquid soap while providing a higher level of germ-killing functions to a larger variety of germs.

Paper towel is a standard consumable item typically found in public restrooms. Throughout the years, the means of dispensing paper towels have evolved into a state where paper towels have become just one option of many to perform the same task. In many restrooms, paper towels are dispensed without having to physically touch any mechanical levers simply by pulling on or even gesturing towards an automated machine. This is just one way engineers have overcome the possible ways germs are spread between bodies. Not only is it a means of decreasing human disease, but it also serves as a means to ration consumption of natural resources. These machines require perforated paper towel rolls in predetermined lengths, which encourages the full use of a single piece of paper rather than wasting unused material that whines up in the garbage. A new form of technology that has been seen in renovated restrooms and new buildings are 'hand driers' that have eliminated

the use for paper towels all together at the expense of electricity. Although early developments of hand driers require a preset duration of time for the user to dry their hands, Dyson has created a new efficient drier that senses when the machine is in use. Dyson, a common household via vacuum cleaners, has created the Dyson Airblade Hand Dryer which claims to "achieve 90% dryness in about ten seconds, versus a conventional warm air dryer of 47 seconds" [5], saving time for the users, increasing hygiene, and reducing energy consumption. The design in these new dryers allows them to be placed under or at the edge of sink countertops for the users convince.

Restrooms seem to be a popular place used by the public frequently, but are not necessarily always in use. Restrooms are just an accessory to a structure and therefore are not the main function behind the operation of the building. When the building is closed, typically consumption of water, gas, and electricity decrease significantly. Although lighting in a lobby, office, or workspace may be required from sun up to sun down due to occupancy, restrooms do not need to consume power when they are not in use. In the past, this would require the occupant to switch the lights on upon entering and off after they leave. This is yet another hygienic point of contact within the restroom with a duty that falls on the user to conserve energy by turning off the lights. Many smaller bathrooms, such as gas stations or small shops, use a motion-activated switch to help aid this process. This is beneficial to both the operator and owner in many ways. First, this eliminates human contact and reduces the spread of germs, increasing the overall cleanliness of the facility and second, conserves energy when the restroom is not in use. Yet again, this is a simple and viable substitute for physical switches to cut costs, conserve energy, and increase hygiene in restrooms.

Human satisfaction is a key aspect to grasp in order to maintain a positive atmosphere. Engineers work hand in hand with other professions to strive towards this goal of providing a superb life style by reducing stress and concern of the greater public. These technological advances, although they may seem minuet, have provided a beneficial function to the users, owners, and the environment in crucial ways. With today's motto of 'going green' and reducing consumption, bathrooms across the world are doing just that while hygienically improving day-to-day life thanks to engineering integration and creativity.

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How a Camera Mount Revolutionized Video and Internet Content

Benjamin Paley

In 2002 Nick Woodman, the CEO and founder of GoPro, decided to make a minor design decision to change the basic video camera into a mountable, rugged camera to capture everyday personal activities. With this idea, Woodman managed to revolutionize the action camera industry and affected the world both socially and economically, building a billion dollar business in just 10 years. Now it is hard to visit any beach, mountain, skate park, movie or television set without running into dozens of these personal mountable cameras.

To understand the way one man revolutionized a whole industry from inside of his Volkswagen Van, one needs to understand the history of GoPro and factors leading to this design change. Nick began GoPro "after an online gaming service he started, Funbug, [that] went belly-up in the dot-com crash of 2000-01, taking with it $3.9 million of investors' money" [3]. After this failure, Nick moved back in with his parents. To clear his head and get away from his family he embarked on a surfing trip down the coast of California and into Indonesia where he lacked the ability to capture videos of himself surfing to share with his friends. Subsequently Nick began asking his friends about a "highly durable camera that Nick and his friends could take surfing" to which they responded, "I don't really want to buy one but I wish my friends had one to film me" [1]. That is when Nick started building prototypes for a wrist mount for existing cameras. In 2002, Nick founded Woodman Labs "from his 1971 Volkswagen Van which would be the parent company for what we know today as GoPro" [2].

Woodman started selling the cameras with a waterproof hard plastic case in 2005, selling about $350,000 of cameras to surf shops and through home shopping networks. After advice from friends, GoPro made the move from film to digital cameras. At this point, the camera only could handle "VGA video in 10 second bursts and [had] no audio recording ability" [2]. GoPro made a huge leap in 2008 when the cameras were manufactured with a fisheye (wide-angle lens) that is now their signature feature. That year GoPro began marketing the camera "as a mountable device, allowing people to now film themselves by attaching their cameras to ski poles, car frames and surfboards" [2]. In 2010, GoPro advanced the technology of their cameras by offering high definition 1080p video with a 127-degree wide-angle lens. Over the next few years GoPro continued to innovate their product through reduced weight, improved low-light capability, and improved speed to stay on top of their competitors and clinch "21.5% of digital camcorder shipments nationwide" in 2012 [2].

GoPro socially influenced the world through consumer support and social media. Now, it is hard to visit any corner of the Earth without seeing a few GoPro cameras capturing sports, nature, police training,

military missions, television/movie production, etc. The reason behind this is that a GoPro "transforms mere mortals into human highlight reels" without the necessity of a cinematographer and for under $400 [3]. As Kash Shaih, the Senior Director for Global Communications at GoPro stated, "It's a pretty powerful cycle we have… If you buy a camera and create amazing, high-quality, wide-angle video and you post it on YouTube or Facebook and then I see it, I'm like…I want a camera to create the same thing" [4]. This cycle GoPro created in the social media sphere drives people to keep buying GoPro cameras and create their own videos, expanding GoPro's sales and demographics.

Coming from a CEO that does not own a Twitter, Facebook, or other social media platform it is impressive the way GoPro has influenced the social media sphere. On Instagram GoPro is ranked the 8th most followed account with 1,831,901 followers [5]. If you search #gopro on Instagram, it will return "310,216 photos even though GoPro has posted fewer than 300 photos" on its account. GoPro's YouTube Channel accounts for "more than 208 million video views" made up of GoPro and user made videos "all appended with some variation of 'shot on my GoPro'" [6]. GoPro also generates an immense following of 7,166,182 fans on Facebook.[7].

GoPro, which began as a surfing specific camera, has grown to adopt an amazing wide range of possible uses. Some of the various uses include professional surfers, skiers, "Hollywood directors", "the NFL has tested them in their end zone pylons to capture touchdown replays", "the Rolling Stones deployed them on stage", and "police forces and U.S. military have started to incorporate the [GoPro] cameras into training exercises" [3]. GoPro has received praise from many industries, athletes, and magazines including executive producer of Lucasfilm, Rick McCallum, Gear Junkie, CNN, Red Bull, New York Times, and Men's Journal just to name a few [8]. Through the amazing success of the camera, "the National Acadamy of Television Arts and Sciences has recognized the company with a 2013 Technology and Engineering Emmy® Award in the category of Inexpensive Small Rugged HD Camcorders" [8].

Looking to the future, GoPro aims to increase its social impact by gaining even more recognition and customer base through shows and sponsoring events very much like Red Bull's recent marketing schemes through televised events. The airline, Virgin America, recently started offering a GoPro television channel for in flight entertainment "featuring a 2 ½-hour string of GoPro videos that are refreshed every two months" [9]. GoPro is also working with Microsoft to produce their own channel that should be available on the Xbox gaming consoles. As Michael Mott, the general manager of Xbox apps said, "What their product produces is so compelling, it doesn't feel like advertising… it's a genuine expression of the creativity and craziness of what their users are capturing" [9]. Recently Vail's 'Teva' Mountain Games changed to the 'GoPro Mountain games in their 12th edition. The games had 53,579 spectators, which was a 22% increase from the year before.

With this increase in spectators, Vail saw a 23% increase in economic impact with $4.7 million infusion "this figure includes approximately 5,391 room nights booked in Vail as a direct result of the event" [10]. On top of the numbers of spectators the event was televised on NBC Sports Network, Universal Sports, Outside TV, Spike TV, Grind TV, CNET and 9News resulting in "over 400 editorial media stories, resulting in over 180 million impressions" [10]. Simply by sponsoring an already popular event, GoPro managed to bring Vail's Mountain Games to new levels with their brand name and content while continuously growing the popularity of their product.

What is almost as impressive as GoPro's impact socially on the world is their economic impact in just over a decade of business. Starting with selling $350,000 of merchandise in 2005, GoPro ended 2012 with sales of $521 million. GoPro has achieved exponential profit growth; "the company has doubled its bottom-line sales every year for eight straight years…[and] another double [is] expected once the 2013 numbers hit the books" [11]. In December GoPro "was the highest-grossing imaging brand at Best Buy, knocking out Sony for the first time in the chain's history" [3]. GoPro has managed to surpass all of its competitors including the company, Cisco, which acquired PureDigital Technologies for $590 million in 2009 as an "ongoing effort to establish itself as a major player in the consumer electronics market" [2]. However, in just two short years Cisco decided to pull "the plug on the Flip from PureDigital…shutting down the division completely and cutting 550 jobs" [2]. GoPro has managed to almost monopolize their industry niche through their faithful consumers even though many competitors possessed the technology to compete.

Through GoPro's immense success, the company has managed to make several other companies extremely successful including Ambarella and InvenSense. Ambarella "manufactures the internal systems-on-chips that power the entire lineup of GoPro's Hero wearable cameras" and InvenSense produces the "super small gyroscopes and accelerometers that are used for motion tracking in consumer electronics" [11]. Through GoPro and a few other sources Ambarella's "profits are expected to hit $220 million" in 2016 which is "more than double what it made in fiscal 2012" [11]. By developing this simple engineering design change, GoPro is contributing to the economic success of multiple other companies.

GoPro, with the simple design change of a mountable camera, has managed to create a revolution for the action video camera in just one decade. As one of the many GoPro sponsored athletes, Kelly Slater, said, "[GoPro has] quickly monopolized the idea in a way Band-Aid or Q-tip has where everyone refers to these types of shots as GoPro shots" [3]. In GoPro's 11th year Nick is confident in the future through "building solutions tha enable people to capture and share life experiences…and as a result GoPro is growing virally via [users'] content creation and sharing" [2]. A simple design change has changed the camera industry, started a social media movement and created significant economic growth.

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The Influence of the Internet

Matthew Runas

Computers have become an asset to almost all people's everyday life. Nearly every class of every type of person uses computers for some reason or another. Kids use them for entertainment, students for their schoolwork and research, parents for communication purposes, and employees likely for their work lives. It is virtually impossible for people in today's society to get away without some form of computer. Computers would not be nearly as valuable, however, if it weren't for one key component: their ability to access the Internet, and a further subtopic in that is not only the ability to access the Internet, but the capability of wireless access to the Internet.

According to a survey done in May 2013, more than 2.4 billion people use the Internet worldwide, and 70% of those people use it daily. In North America, more than 78.6% of the population uses the Internet, and 37.3% worldwide. The use of mobile devices to access the Internet, whether that is a laptop or cell phone or other wireless device, doubles every year and was roughly 10% when the survey was taken. These are just a few numbers of how many people use the Internet and how integrated into our daily lives it has become. As a result, it is expected that if you live in a decently modernized area, you have semi-high speed Internet access and use it on a frequent basis.

As aforementioned, the way different people use the Internet differs highly depending on the person and their needs, yet the Internet can still easily supply whatever is necessary for them. Many of these ways overlap, but to name a few, the survey yielded the following results: 62% of users use it for research, 50.1% banking, 58% shopping, 15.2% meeting people, 62.2% finding out information about health, 43% making travel reservations, and 45.5% looking for jobs. These are just seven of the many ways the Internet could be used. Some websites are even so popular that this survey yielded that they are near and above 100 million views monthly, Google being the highest at 188 million. Communication is another huge side of the Internet, as mentioned before. 144 billion emails are sent daily, of which almost 70% are spam, and Gmail is the most popular email provider with 425 million active users. Social network users spend an average of 3.2 hours per day on their social networking sites. 1 billion Facebook users, 800 million YouTube watchers, and millions more on twitter, Google+, LinkedIn, and Tumblr.

All of the above numbers retarding the Internet prove one point: society as it functions today would crash without it. The Internet is so multi-faceted it caters to almost anybody's needs. In today's society, kids are so used to talking through multimedia like cell phones or social networking sites and instant messengers, they rarely go out of their way to see each other in person. Even just ten years ago, kids played outside substantially more than they do now. Instead of people in a workplace going to each other's offices and cubicles

to talk to each other, they can quickly type up an email to convey their point. Communication has changed so much now that the younger demographic started using abbreviations a some years ago such as “lol,” “lmao,” and other such acronyms so they have to type less and can communicate their feelings faster.

The idea behind the Internet was an incredibly good one: having an information superhighway. This way, the geniuses of the world could share their brilliant ideas with each other with just a few clicks of a button. This idea, however, was quickly drowned out when the general public got their hands on it as it became more commercially accessible. Things like the “icanhazcheezburger” memes and other similar products of the Internet started creeping up everywhere. This makes the Internet substantially more children friendly and less genius-focused, which caused the rapid growth even more. The demand for such a product that allows this much inter-connectivity became huge rapidly, and it became a big job market, so it grew rapidly. As Walter Michka stated, “The Internet will allow the world to stay connected, they promised, to share the human condition, united in one social universe. Or maybe we’ll just tweet each other Instagrams of food.” Sadly, it is true that this is what the Internet has turned into. Websites like Pinterest make things like sharing ideas and recipes so easy since that is what they were designed to do. At the same time, you can be completely unproductive with them and potentially waste hours of your time by staring at pictures of cute kittens or watching videos of people trying to do stupid things and hurting themselves.

Another complication with the Internet is that, while it does make communication far easier so people who need to communicate for something like sharing ideas, it also makes it far easier for people trying to send their hatred to another person or group of people. One of the primary uses of the Internet for social communication is Twitter, where popular stars and famous musicians or artists can tweet just about anything about their life and get some sort of roaring response. Depending on the people following their tweets, it could range from extremely happy or jealous responses, to extremely angry responses. Sometimes, small digital fights will take place between two famous musicians. Two popular producers in the Electronic Dance Music industry started a digital fight with each other when one thought the other copied his song and changed a few minor things without giving any credit to him. Twitter, putting a very small limit on the number of characters you can tweet in any one message, makes these fights longer and more drawn out, and they almost never yield any sort of happy result. In the aforementioned fight, Deadmau5 picked a fight with Wildstylez accusing him of ripping chords out of one of this own songs, in a very passive-aggressive manner at that, as you can see below based on their tweets:

> Wildstylez: Download StraightForward @hardstylecom bit.ly/LCM004SF #hardstyle #harderstyles #rave
>
> Deadmau5: @wildstylez @hardstylecom cool rip bro. cool.

Wildstylez: @deadmau5 heard this on the radio right before I started the track youtube.com/watch?v=t13g4S… But thanks anyway.

Deadmau5: @wildstylez cool story. why don't you just rip that off too? making music is hard.

As is evidence from the above conversation, not all communication is good. The Internet has made all communication easier, not just the good communication.

One more major issue with the Internet brought up by Michka is that the Internet can be about as far from truthful as you can get. Using extremely rash examples, Michka says "The truth is pretty much the last thing you should expect from the Internet--- whether it's obviously photo shopped pictures of Obama pledging allegiance with his left hand or Marty McFly's DeLorean displaying various dates as the future he went back to…" Despite all of the other types of things you can do when searching on Google, you unfortunately cannot filter out "truths" from "lies." Wikipedia, due to the fact that anyone who can access it can edit it, attempts to do this by having a small army of people checking it fairly frequently to see when things get changed and if they are cited or not for truthfulness, but even then it can still take a while. As a test one time, I edited a random Wikipedia article on something and threw in an extra sentence saying "This is a test." It took the website less than one hour to take it down. Later that week, I tried the same test again on a different Wikipedia article, and it took them three days to take it down. This proves that, even with people constantly working to keep the truth on the Internet, it is still impossible to do constantly, day in and day out, year round.

The Internet was a brilliant idea originally, especially given the original target demographic. However, once it started growing and the target changed, and especially once the economy got even just a slight grip on it, it lost it's original intent and became a giant mess of pictures, abbreviations, and useless information. The engineers that designed it had an incredible goal in mind, and it is unfortunate to see most of its use going downhill so quickly. That being said, it is also unfair for anyone to criticize it too much without recognizing the fact that they likely use it for purposes other than it's original intent as well. I am included in the population who uses it for both useful and not useful ways, and I do accept that. The Internet has changed society so drastically and so quickly. Humans went from being outgoing being to far more introverted and scared people. Despite all the great things the Internet has done, I do hope that a way will be discovered to limit the not useful parts of it so people can continue socially growing and undo some of the social devolution that has happened recently.

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Are You Alarmed Yet!?

Mark Shaver

The prevalence of alarms and audible warnings in our lives is alarming! A simple engineering choice to have a device create an audible alert is a basic engineering decision that typically has very little impact on cost or overall design. However, the repercussions of this common decision have had significant unintended societal impacts. The prevalence of audible alerts in our lives is desensitizing us to needed alerts, alarms are causing harm, as opposed to adding safety, and what engineers have deemed alarm worthy is inaccurate and causing negative societal and environmental impacts.

Many of the audible alerts we encounter in our daily lives are necessary and effective in their intended design, but even these essential alerts have been diminished by the volume of alarms, beeps, buzzers, rings, sirens, and bells we encounter daily. We are all becoming alarm fatigued, important audible alerts are just becoming noise. The most commonly abused alert has to be the morning wake up alarm. Engineers have even designed “The Snooze” button, which is essentially a method to ignore this important alarm. However, the concept of just turning off an alarm and not having the alarm incur any kind of action is a dangerous concept. On March 29th 2013 Army veteran Michael Deal died at the VA Central Iowa Healthcare System hospital hours after RN Bernard Nesbit had turned off his monitoring alarms. One of these needed alarms was set to alert staff to any drop in the patients' blood-oxygen levels, the unfortunate cause of Deal’s death. When Nesbit was asked if he had turned off Deal’s alarms he responded, "Yes, the alarms were always going off”. [1] This example of alarm fatigue and our reactions to alarms is not an isolated case; Alarm fatigue tops the list of the 10 biggest health technology hazards and many hospitals are actively addressing the alarm problem. Boston Medical Center reduced audible alarms by 89% in just one year through a pilot program that aimed to prevent "alarm fatigue" and from this program overall noise levels fell from 90 to 72 decibels. [2]

This high volume of alarms in a hospital is easy to understand and the importance of an alarm in a hospital setting should be treated with its designed respect. However, the drop in alarms and overall noise the hospital was able to achieve points out the over alarmed state we live in. If we continue to increase audible alarms and engineer devices as we currently do, the designed alarms will not have their intended results. In fact, the impact of adding additional alarms to our already noise filled lives may have negative health impacts. The World Health Organization warns that even for those who think they can tune out or ignore the loud noises of daily life, physical tests show otherwise. There are increased levels of stress hormone and elevation of resting blood pressure in many people exposed to loud noises, even when they claim to not be affected.. [4]

For many people every day begins with an audible alert and from this point on, every other significant action in our daily lives has been determined by an engineer to be audible alert worthy or not. We have alerts

in most new cars that inform us when a seatbelt isn't being used, a specified high speed has been exceeded, a car is in your blind spot, you are backing up too close to an object, etc., etc. However, the design of alerts related to energy, conservation of fuels, or pollution is greatly neglected. The closest most new vehicles get to alerting the user in terms of conservation or being "green" is a brief message regarding low tire pressure. Having proper tire pressure is easily the simplest method by which a person can increase their fuel mileage, but does this receive anywhere near the equivalent alarm an unused seatbelt or open door might? Of course not, in fact, it is likely the only reason tire pressure has a brief musical alert is in regards to immediate performance and safety. Once again, simply adding additional alarms to your car is not the answer, but removing some of the current alarms that do not work and replacing them with audible alerts for needed items may be an effective solution.

The loudest and most ineffective alarm on cars has to be the "car alarm". With some estimates stating that 95% of all car alarms that go off are false alarms. [3] In fact, the alarms have become so commonplace and a false alarm so standard that nobody thinks a crime is occurring when one goes off. A recent survey found that fewer than 1% of respondents would call the police on hearing a car alarm. [3] Even New York City has attempted to make car alarms illegal within the city. Yet, car alarms are still commonplace on many vehicles and any decrease to car alarms will not be from appropriate alarm management, but simply more effective theft prevention technology. If instead an equally annoying alarm went off when our vehicle was polluting excessively and perhaps not just the standard service engine soon or check engine light, how significant the impacts could be on pollution.

Adding to our car alarm fatigue is the high amount of audible alerts in our homes. Within a few minutes in your kitchen you may be beeped at or alerted when: your oven has preheated, your cooking timer has finished, you left the refrigerator open, you set something on top of the electronic stovetop controls, the batteries are low in your thermostat, remote, or clock and your smoke alarm or carbon dioxide alarm could be going off! However, have engineers deemed leaving the water running, forgetting to turn off a lights, throwing a recyclable into the trash, or anything related to green/environmental issues to be alarm worthy? Of course not, the closest my house has become to informing me of green issues is a little green leaf on my fridge to let me know when it is saving me energy and an optional green lever on my water saving toilet. In a world already full of alarms we have failed to engineer audible alerts to help us reduce, reuse, or recycle. While simply adding additional alarms to our lives is most likely not the answer, rethinking what deserves an audible alert may be.

Alarms are needed and without alarms our daily lives would be more difficult and dangerous, but at what point do we have too many alerts and how do we determine if something is audible alert worthy or not? It seemed for many years audible alerts were limited to fire alarms, emergency sirens, and timers/alarm clocks.

With only these few areas providing noise in order to achieve the desired response we observed great success. From this initial success we have gotten carried away and added additional alarms and noise to our lives. Even the initial emergency alarms and sirens we need don't have the impact they once did. In many areas of our country, traffic doesn't get over for the ambulance behind them. There isn't the enforcement needed to justify the action to the "overexposed to sirens" driver. Similarly, when a college student hears a fire alarm they don't react with the importance or speed they once did as a younger student. Instead, they pack their things and slowly leave the building, if at all, there definitely isn't any speed, urgency, or possibility of leaving behind personal material items. So, with needed failing alarms and with the continual addition of more and more audible alerts into our lives are we reaching a failure point, or perhaps we already have. Maybe when we deemed the completion cycle of our clothes dryer to be alert worthy and not the action of throwing a recyclable can in the trash we had already failed.

Hopefully, with continued focus on the importance of the environment and the concepts of reduce, reuse and recycling we will eventually see the need for these areas to have their own alerts. Along with this focus if we continue to become aware of our surroundings and realize the excessive alerts and noises we are bombarding ourselves with we can hopefully engineer a solution. Just because we can simply add an electromagnetic or piezoelectric alert to a device as an engineer, doesn't mean we should. Attempting to put safety first may actually be achieved by leaving an audible alert off, or at least having a user off-switch for it. Possibly, with the correct management and the addition of differing types of alerts a livable balance can be achieved, but management will the key. If we have set safety colors, diagrams and signals in our lives, maybe a set system for all audible alerts will be needed.

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The Engineer's Desire to Help:

Pitfalls of product before people in humanitarian design

Brian Stack

Engineers possess a unique skill set, particular mindset, and influential status that can direct the actions and lifestyle of entire populations. Ownership of such broad reaching influence demands a high sense of duty, as reflected by the Code of Ethics for Engineers [1]. The general guidelines, which the Code of Ethics establishes for the professional engineer, can be expanded on in practice by first making critical analysis of prior efforts to make societal change through engineering. The following takes a critical look at three examples of humanitarian engineering projects in an effort to see where engineering projects fail to serve and where potential for success might be found.

An article by Nieusma and Riley uses two case studies as a backbone to analyze engineering for development [2]. The first is an academic collaboration in Estelí, Nicaragua. It was intended to be a mutual collaboration that emphasized product development without western technology transfer. The US students were to learn about the culture and local needs of the community and the Nicaraguan students were to benefit from the US technical education. Professors from both countries were supposed to share the burden of instruction for the mutual benefit of all students as well as successful production of a useful product to promote the local economy.

This project quickly fell apart due to many factors. From the start, communication limitations in planning the project served to cripple the development of a strong program. Language was also a barrier as US students and faculty overestimated their ability to converse and due to the absence of the anticipated translator. The Nicaraguan professors placed themselves in the role of students. They saw the Americans as authoritative and strove to gain technical knowledge from them. Also the Nicaraguan players were not from Estelí either. So both the American and Nicaraguan students and organizers lacked understanding of the ultimate needs of the beneficiaries. Another pitfall to this project was the monetary driving influence. The funding for the project steered the end product to be a tangible form of technology. In order to sell the project to public and private grant sources a physical idea was needed which capital investors could wrap their head around. This is contrary to the more effective mode of developmental aid adopted by the Canadian division of Engineers Without Borders. David Damberger explains the shift from a focus on product development and delivery to an emphasis on the development of functional systems [3]. EWB touts their product as spreadsheets not technology. The importance of training business strategy, money management, and resource development is what EWB strives for in order to deliver lasting development over short-term technology flounder.

The second case study presented by Nieusma and Riley seems to address many of the pitfalls in the first. The project was for rural electrification by an NGO based in Colombo, Sri Lanka. This project had a longer time frame and therefore had more opportunity for local knowledge acquisition, educational campaigns, and ultimately community ownership. A training and technology transfer plan was in place so that locals could take ownership of the project in implementation and future operation. The project was designed to utilize local resources and had potential to expand the beneficiaries of the technology to other communities.

Again like the first, certain pitfalls doomed the project. Existence of outside funding pushed the need for a tangible and functional technology product. Because of the prospect of "free technology", the locals may have quelled any disagreements or ulterior desires for fear of losing out on a handout. This kind of misalignment of needs is echoed by examples given by Robert Lupton in Toxic Charity [4]. Lupton notes through an interview with the Nicaraguan director of Opportunity International: "entrepreneurship declines as dollars and free resources flood in". This presents another dilemma. In order to conceive, plan, implement, and manage, locals would need the technical expertise to do so. If they had that, wouldn't that remove the need for aid in the first place? If the argument were that the best, most successful projects would be a result of local control and ownership, then technical knowledge is required. If technical knowledge is required, then the aid programs should focus on technical education, not technical solutions. This argument leads back to the new mindset of Engineers Without Borders that was mentioned previously.

Recently a humanitarian project titled Project Daniel has been implemented in the war-torn Nuba Mountains in southern Sudan [5]. The project delivered a 3D printed prosthetic arm and the technology to repeat production to the regional hospital. Some of the key differences here are that the project was designed to transfer technology and training to the local people. The project made use of existing infrastructure and an American doctor who had been imbedded in the area for eight years. The doctor and hospital structure were key bridges between the western and local cultures. Another key difference is that the need for help came from an immediate catastrophe. Lupton points out "we respond with immediacy to desperate circumstances but often are unable to shift from crisis relief to the more complex work of long-term development" [4]. In this case the crisis of war provides an immediate need and it is possible that the 3D printing technology provides long-term development. In the broader context of war this solution is only one small aspect and doesn't address the bigger picture of war. If a broader perspective solution were to be tackled it may look at ways to structure the local community so they are safer amidst air attacks, or better able to defend themselves or fight back. It may possibly include community structure for responding politically to the warring acts. This is all speculation, but attempts to define the difference between the small-scale response and a broader impact response.

I feel this last statement is where engineering for change runs into trouble. Ultimately large-scale political and social structure campaigns may be needed to address the big picture. In Sudan the problem is casualty of war. In Sri Lanka civil and political planning were the cause and solution to the energy needs there. The project was scrapped when large-scale grid power was finally supplied to the area. In Nicaragua cultural and political needs could also be seen as the "problem" with Estelí. So, the question becomes: "How and where do engineers fit in?" In my opinion, Project Daniel is a great example of Engineering for Change that is effective and sustainable. It uses and teaches engineering tools to uplift an underprivileged people. It is an engineering response to a people problem. Without playing in politics an engineer can make a difference in this situation using his own tools and skill set. This statement falls within the comforting confines of the engineering mindset. That is, it is comfortable to dwell within a narrow technical focus because it uses the skills that we know best. It is comfortable for us to put our faith in theories and outcomes that develop from tangible calculations and quantifiable tests. In addition, I believe there is another engineering mindset that is a contributing influence towards a positivistic mindset. That is the mindset that a perfect solution should exist. Similar to the Engineering Problem Solving methods we are taught at school, the belief that perfect solutions should exist feed the need to believe in positivism. The result is a need to hold something tangible at the conclusion of a project. We want to be able to put our stamp on a thing that says "this will work, it is effective, it won't fail, and nobody's gonna get hurt". This must be a result of our education and the pending responsibility for the health and wellbeing of others we will have as PE's. We learned as a fundamental practice, through our education, that engineering has a solution. For the entirety of our principle exposure to engineering practice we are shown that when given a problem there is a solution. In order to adopt a non-positivistic approach to a problem we have to accept that we must guide and let lose our control of the outcomes.

In conclusion, our role as engineers in the arena of influential change should be to provide pinnacle nudges to the underserved in order to promote their advancement in the societal pool. Careful consideration is then tasked upon us to ensure that our contribution does not erode opportunity into a slippery slope of dependency. It is also our responsibility to first educate ourselves in the unique culture of those in need so as to distinguish a relevant contribution to a solution that does not strip the beneficiaries of their cultural identity. An important consideration is also ensuring that our efforts as privileged helpers is not to further broaden the hierarchal gap by placement of our technical expertise in a superior realm to the local beneficiary. Lastly, our efforts should keep as a primary objective a solution that is sustainable. Not just sustainable in the environmental respect, but sustainable in implementation and lasting effect. Our solutions should aim to "teach men to fish" and not just "give a man a fish", as mused by M.E. Cannon [6].

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Mile per Gallon Readouts: Changing Driving Behavior Through Feedback

Kevyn Young

In the last decade, fuel economy of cars has become increasingly important. As gas prices have risen to prices as high as $4.00 per gallon in the United States, many motorists have had more incentive to adopt more fuel efficient driving habits. One design decision that has been made in response to this has been the addition of the mile per gallon readouts to the dashboard of new cars. The addition of this display has provided motorists with an active feedback system on their driving performance, and has proved to be useful in instilling fuel efficient driving behaviors in motorists.

The average price of gasoline in 2004 was $1.85 per gallon [1]. In 2013, the average price of gasoline had risen to $3.48 per gallon [2]. This is a significant price increase easily seen in the cost of driving for a year. If a car that averaged 25 miles to the gallon was driven 15,000 miles per year, the price increase in gasoline would be equal to $(\$3.48 - \$1.85) * \left(\frac{15000}{25}\right) = \$978$ per year in increased costs. As many commuters drive more miles than this per year, the cost of driving has significantly increased over the last decade. This near doubling of gas prices has pushed many people to be more conscious about their driving habits as their wallets feel the pinch

In order to appeal to the fuel efficiency consciousness that the public has begun to take on, car manufacturers have provided a large variety of options for consumers to save on fuel. Gas-electric hybrid vehicles have become prevalent with models such as the Toyota Prius, while electric cars have finally begun to show up on the market with models such as the Chevrolet Volt and Tesla Model S. The introduction of these new fuel efficient models has been a large, visible change in how car manufacturers are addressing the issue. They often overshadow the addition of smaller design and design philosophy changes that automobile manufacturers have employed in order to both improve raw performance, as well as to help motorists save fuel. While an obvious design change would be to design more fuel-efficient engines, the addition of user interface dashboard readouts for things like battery charge/discharge monitoring (in the case of hybrids and electric vehicles) and mile per gallon gauges (in the case of petroleum powered vehicles) has been effective in changing driving behavior to increase fuel efficiency. Of particular interest is this addition of mile per gallon readouts, which are usually found in both hybrid vehicles and regular, petroleum-only fueled vehicles.

There are two aspects to mile per gallon readouts that have been added to new cars. The first is the real-time mileage display, which gives instantaneous feedback to the driver about how efficiently they are driving. This is the most important feature of these readouts when it comes to affecting driver behavior [3]. The other aspect is the trip mileage display, which shows the mileage of the last tank of gas or trip taken. While

this is important when looking at fuel efficiency, many people already calculate their trip mileage to either see how efficiently they are driving, or to get an idea of how well maintained their vehicle is [3]. As a result, this addition provides less of an obvious impact to human driving behavior than the addition of instant feedback. Furthermore, the addition of this part of the gauge would not have produced a large impact on driving behavior since this increase in gasoline prices due to many motorists being already conscious of the same data that it displays.

The addition of fuel efficiency feedback devices on human behavior has been studied to a somewhat limited degree. In 2009, The University of Vermont Transportation Research Center performed a study in which they examined the effects on driving behavior with the addition of the mile per gallon display. In this study, they compared an experimental group of drivers to a control group with no mileage readouts in their vehicles. The experimental group either had aftermarket devices attached to the dashboard that were used to display feedback and record mile per gallon data for the study. A tip sheet was also provided to the experimental group in order to help coach better driving behavior [3].

This study's goal was to determine if the addition of instantaneous feedback devices to automobiles had an effect on fuel efficiency and general driving behavior. Over the period of three months the control group didn't show much change in overall fuel efficiency. However, the experimental group showed an increase in fuel efficiency after the introduction of the dashboard-mounted feedback device after the first month of control. Furthermore, after the feedback device was taken away, the experimental group still showed a higher (but not as high as with the device) fuel efficiency than the control group. This showed that driving behavior was indeed changed due to the addition of the feedback device. Overall, the study observed a 7.5% improvement in the fuel-efficiency (measured in miles per gallon) was achieved with the addition of these readouts to the automobile [3].

Additionally, from my own experience, I can bear witness that the addition of instantaneous feedback on fuel efficiency when driving changes my own driving behavior. Normally I drive a 1993 Jeep Grand Cherokee which does not have any kind of instantaneous feedback on fuel efficiency. The only way I know how efficiently I am driving is when I fill my gas tank – something that happens usually about once a month during the school year. This does not equip me to analyze the effects of my driving behavior as I drive. Instead it provides me with an average that is often wildly affected by the weather, the number of hills I have to climb, etc. As a result, driving efficiently is often an afterthought. However, I do occasionally drive a 2007 Honda Civic Hybrid. This vehicle has an instantaneous feedback display for miles per gallon on the dashboard. I often find when driving that I look at this gauge as often as one looks at the speedometer in order to gauge how efficiently I'm driving. By seeing how the gauge responds to different driving behaviors I am able to decide

how to most efficiently drive and choose a driving behavior in a specific situation based upon its feedback. Indeed, when I am consciously aware of this gauge, the average efficiency per trip when I drive increases.

In a report by the National Renewable Energy Laboratory (NREL), mile per gallon readouts were noted to have the potential for having a broad impact on the driving behaviors of the general public [4]. This is due to both the "high penetration rate" and ease of access to these readouts as they are increasingly common in cars [4]. Due to their integration into the dashboard, they are easy to look at and use, and don't require any installation or extra cost on the part of the motorist. This makes them highly advantageous to changing driving behavior, especially if some kind of coaching mechanism (instructions, tips, guidelines, etc.) is provided with the mileage readout [3] [4].

On a single automobile scale, a 7.5% increase in efficiency as shown by the University of Vermont study for a car that usually averages 25 miles per gallon equates to the car now averaging $25 * 1.075 = 26.875$ miles per gallon. This represents a savings per year of $\left(\$3.48 * \frac{15000}{25}\right) - \left(\$3.48 * \frac{15000}{26.875}\right) = \$145.67$ for someone that drives 15,000 miles in a year at the 2013 average price for gasoline. Not only does this increase in efficiency benefit the individual motorist economically, but it also benefits the environment and society. Carbon emissions from a vehicle that experiences this increase in efficiency will inherently be less. Another report from the NREL explains how driving behavior affects efficiency:

> "Even without changing the vehicle powertrain, such extreme adjustments result in dramatic fuel savings of over 30%, but would in reality only be achievable through automated control of vehicles and traffic flow. Considering the effects of real-world driving conditions, efficient driving behaviors could reduce fuel use by 20% on aggressively driven cycles and by 5-10% on more moderately driven trips." [5]

Compounded over a large number of vehicles the potential effect of adding mile per gallon readouts to automobiles is great. Furthermore, these efficiency gains are often brought about by a reduction in aggressive driving [3]. This could be beneficial to society and potentially make the overall driving experience better for society as a whole.

With over 246 million registered vehicles in the United States, an increase in efficiency due to a change in driving behavior from the presence of these instantaneous feedback gauges represents something significant [6]. If each of these 246 million automobiles were to experience the small 7.5% jump in efficiency exhibited by the Vermont study, the environmental, societal, and overall global effects could be huge. Not only would people save money, but the presence of gas mileage readouts in automobiles affects the environment and global society as a whole.

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The Rumble to Prevent a Tumble

Brian Zook

Imagine a group of college friends who are extremely excited as they get ready to take a road trip for spring break. They pile into the car and begin driving along the highway to the warm sunny beaches in California. All is well until about 1 am when the driver falls asleep and the car runs rapidly off course at dangerous speeds. When these accidents happen there are so many preventative actions that can be made to avoid such devastation. Often times the passenger is burdened to keep the driver focused and attentive or the driver should not be at the wheel if exhausted. All of these solutions require constant human involvement to be successful. Engineers however have developed a continuous solution to prevent such catastrophic accidents through the use of a rumble strip. Rumble strips are life-saving bumps along the edges of highways and are utilized to vibrate the vehicle and alert the driver if it is heading towards the edge of the road. In this essay, the impact of rumble strips on stakeholders, social, and economic impacts will be analyzed.

To begin any engineering project, the stakeholders must first be identified to cater to the needs of all parties. When considering a major project for a highway often times the rumble strips can be overlooked or considered a minor portion of the project. On the contrary the rumble strips in fact are vital to preventing a number of accidents. The main stakeholders in the construction of strips on the side of major roads are the motorists and passengers in the vehicles. These stakeholders are the ones at risk of veering off course or getting struck by a car which sailed into on-coming traffic. According to the Federal Highway Administration, "Driver inattention comes in many forms including distraction, daydreaming, fatigue, and alcohol or drug impairment [1]". With the recent technological improvements with cell phones, the use of texting has created significant problems with the drivers attention. The strips have reduced some accidents with distraction however are only placed along freeways leaving non-highways still susceptible to driver error. Clearly, motorists are the significant stakeholder and primary concern when designing the rumble strips.

Another stakeholder included in the discussion for adding the strips along thousands of miles of highways across the nation are tax payers. Governing officials must ultimately decide if the cost of implementing the strips across the major roads is necessary and justifiable. The economic impacts of the tax payer's dollars versus the benefit is the main question in determining if the rumble strips are an efficient use of the government's budget. Obviously the government wants to keep the general public safe but at a reasonable cost. For this reason research was conducted by the Federal Highway Administration. They concluded "Long sections of relatively straight roadways are most likely candidates for the installation of shoulder rumble strips. Highways with twisty and hilly foregrounds have low rates of accidents due to inattention. [2]." This analysis makes sense to only pursue construction on the flat monotonous sections of

road rather than pay for every mile of highway across the nation to keep the tax payer's interests included in the project.

Economically, the cost and feasibility of installing the rumble strips is relatively affordable. The grooves can be cut out in the existing asphalt which is called milled-in. Another technique is called rolled-in where the ridges are shaped while a new section of roadway is being paved. The last method to create the ridges is called forming. Forming simply has a mold which is pressed into fresh concrete and hardens with the roadway. All of these methods are viable options which require significant labor hours. The addition of the rumble strips creates jobs which help boost the economy. Therefore rumble strips has a positive impact economically and are beneficial to more than just the drivers.

When considering the environmental implications of installing the rumble strips, the design is not harmful to the environment. The roads constructed significantly impact the environment however the strips cut out in the shoulder leave a relatively moderate footprint. The machinery utilized to create the grooves may release pollution into the air but all job site equipment has emissions testing to ensure any contaminants are below the legal limit. Although the environment has a limited impact on the community in this case, there are several opposing parties protesting the development of shoulder strips.

In opposition to the implementation of rumble strips are neighbors who live relatively close to freeways. Neighbors complain about the significant noise levels produced from cars travelling at high speeds over the bumps. In Chapel Hill, North Carolina residents complained about the noise which some claimed sounded like machine gun fire whenever a car rolled over the strips. A study was done and concluded "Close to the sidewalk a noise level of 60 to 77 decibels was attained depending on the type and speed of car. This exceeded the cities Noise Ordinace Level of 60 decibels. [3]". Similar cases also involved the removal of rumble strips in Reno County as well as the London Borough of Bromley. A good case is made by the residents living along side of highways, a solution to compromise with the residents and ensures safety is to construct sound barriers in residential areas. This is one possibility to satisfy the residential stakeholders however will affect the tax payers. All engineering projects must maintain a balance to keep all parties happy and maintain a balance.

Often times the social implications of a project tend to influence stakeholders as well. Similar to the residential neighbors affected by sound, other parties have found issues with the rumble strips as well. In Johnson County, Kansas a plan has been implemented to allow buses to travel along the shoulder of the highway when traffic slows to under 35 miles per hour, this proposal is requiring the removal of rumble strips for the sake of the buses route [4]. This motion to remove the rumble strips for the sake of easy transportation

is a calculated risk for the motorists passing through the section of highway, but the town officials determined the social impacts were a higher priority.

Another social stakeholder who has had issues with the use of roadside strips are cyclists. In active towns such as Golden, CO, the biking traffic is quite heavy and can be extremely influential in the town's plans. For this reason, roadside strips are often only found along highways where cycling traffic is rare. Cyclists complain of the bumps and damage done to the bikes but more importantly cyclists typically avoid the shoulders and ride in heavy traffic where serious accidents occur. Drivers sometimes are forced to make a dangerous lane change which may cause an automotive accident or remain in the lane causing a collision with the bike. These issues must not be taken lightly, the purpose of the rumble strips are to prevent the loss of life and damage. If the introduction of rumble strips do in fact cause more accidents than they prevent, then certainly the strips must be removed in narrow sections or widen the road to accommodate space for the rider.

Although there are several parties who disagree with the use of the rumble strips, the majority of the population is in support of the strips. In today's world there are so many distractions to affect the driver whether it is a text message, a bill board, or a late night when the driver struggles to stay awake. All of the distractions affect the person behind the wheel very frequently and as the mass number of motorists continues to increase, the risk of accidents will proportionately increase. For this reason the case for rumble strips can be made. By driving over the rumble strips one vibrates the vehicle thus alerting the driver of the severity of the situation. Human nature takes over and immediately focuses all attention on the road. This human instinct is used by engineers to prevent countless accidents and tragedies. The design is relatively easy to install and affordable. Engineers have used human nature in abundant ways to make the result a more effective success. Current data clearly has proved that the addition of strips has significantly reduced single car accidents. Countless instances where a driver has taken their eye off the road and been alerted with a number of bumps have occurred. This simple design has saved a remarkable amount of lives and prevented damage. Road side rumble strips are clearly and effective tool to ensure the safety of pedestrians, nearby structures, and of course passengers and motorists.

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Engineering Design Program
College of Engineering and Computational Sciences

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A Call for Design Projects

On behalf of the students and faculty of the College of Engineering and Computational Sciences (CECS) Engineering Design Program, I would like to recognize the special contribution of our project clients. A program like ours, which relies upon external clients for projects, can only be as good as the projects that our clients submit.

The projects on display today and the projects underway this semester were selected by the students from approximately 55 projects that made it through our evaluation process. In order to find those 55 suitable projects, we responded to more than 120 project inquires last year alone. As the program continues to grow, our need for high quality projects continues to increase. In addition to the Senior Design Program, we now also have a Graduate Design Course and a new Engineering by Doing initiative in the college. These new programs provide even more, meaningful ways to partner with students at Mines.

I'd like to invite you to submit a project for the Fall 2014 or Spring 2015 academic year. You can start the process in one of several ways:

(1) Fill out the project submission form which can be found on the next two pages in the Trade Fair Program. If you leave the form with the registration table we will review your submission after the event,
(2) submit your project ideas directly through the Senior Design Website (http://cecs.mines.edu/25763-php), or
(3) send an email with questions to: *design@mines.edu*

If you, or someone you know, have a good challenge for a group of highly motivated students please consider becoming a client. The role of client can be a very rewarding way to support the next generation of engineers. Thank you for your support, past – present – and future, of the CECS Engineering Design Program at the Colorado School of Mines.

Sincerely,

Jered Dean
Teaching Associate Professor
Director, Engineering Design Program

CSM Fall 2014 Project - Due 8/15/2014
CSM Spring 2015 Project - Due 1/15/2015

CSM Fall 2014 Graduate Design Project - Due 8/1/2014

PROJECT TITLE:

Client: *(Client Name)*

(Name)

(Address)

Client Contact Person: *(Address)*

(Phone)

(Email)

Anticipated Disciplines: (please mark appropriate boxes with an "x")

Civil		Electrical		Environmental		Mechanical	

1) Please provide a paragraph description of the design problem, including constraints, design goals, and applicable background.

2) Please provide a brief description of the desired outcome/deliverables of the project (i.e. conceptual design, paper design, prototype, etc).

3) What Budget to you believe will be necessary to support the project? *$*_____

CSM Fall 2014 Project - Due 8/15/2014
CSM Spring 2015 Project - Due 1/15/2015

CSM Fall 2014 Graduate Design Project - Due 8/1/2014

4) How much of the budget are you willing/able to provide? $_____

5) Project funding can be handled through several mechanisms. Which would you employ? (Check all that apply)

As client, we will directly pay for the expenses (i.e. we will internally purchase and provide materials and reimbursements) ☐

As client, we will make a donation to the Colorado School of Mines Foundation for Engineering Senior Design for this project ☐

As client, we will provide funds to the Division of Engineering to be used for this project (via check) ☐

As client, we will provide funding through a formal agreement with the Colorado School of Mines Office of Research Administration (required for projects with a budget of $10,000 unless funded directly by the client) and subject to CSM overhead policies. ☐

6) Are there intellectual property considerations that will require an agreement? ***(Yes or No)***

(Please note that as a State School, CSM can only agree to certain legal language. We will supply a template upon request.)

7) Will a CSM Confidential Disclosure Agreement (CDA) be required? ***(Yes or No)***

(Please note that as a State School, CSM can only agree to certain legal language. We will supply a template upon request.)

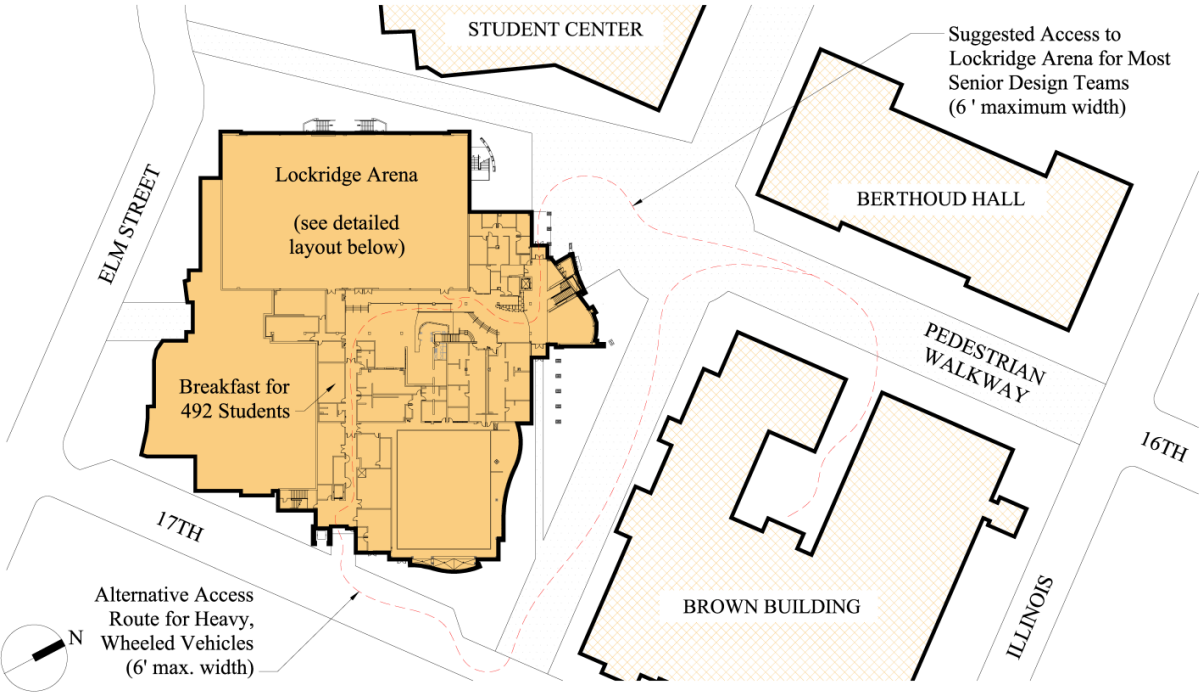
8) This project will be staffed by _____ *team(s). (Are you willing to support more than one design team concurrently working on the same project? If you are willing to work with multiple teams, please contact one of the senior design leadership faculty - listed below - to discuss how this might work.)*

9) Please provide an estimate of the number of engineering hours that you anticipate will be required to complete the project?

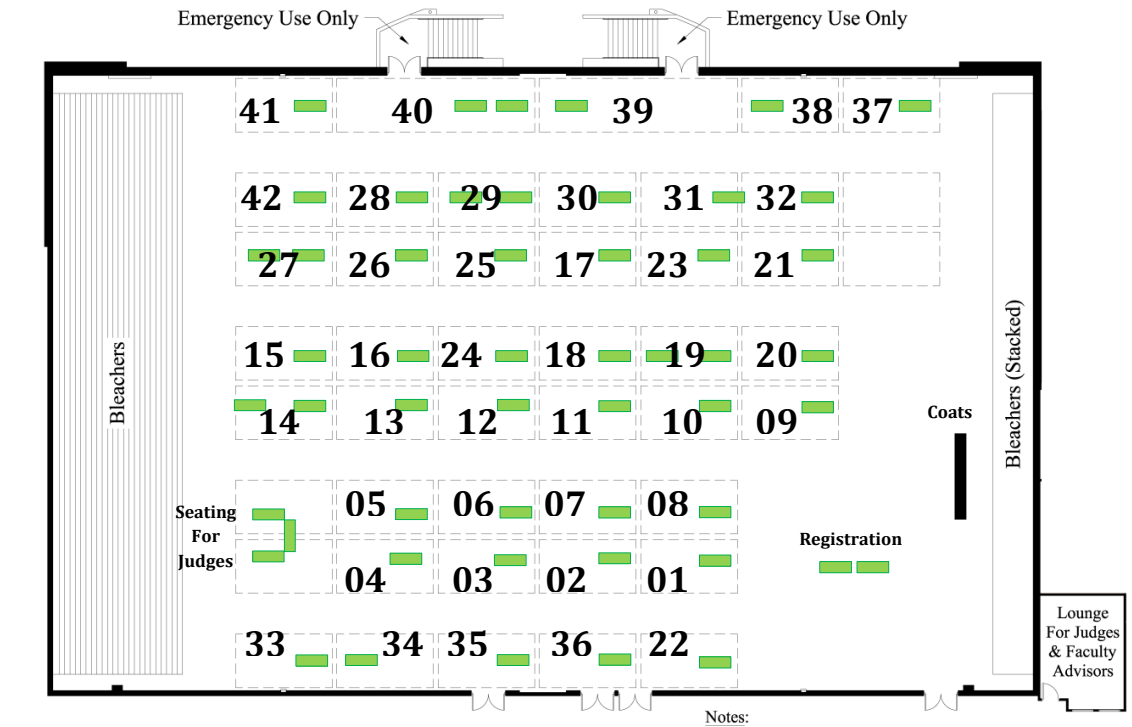
10) Are there any special issues or considerations that we should be aware of in consideration of the project

Please submit completed project proposals (Word format preferred) to design@mines.edu

Notes



LOCATION PLAN - CECS SENIOR DESIGN TRADE FAIR



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LOCKRIDGE ARENA

Notes:

1. The dashed lines indicate space for each team. Most teams receive an allocation of 10' x 18'.
2. Each team is provided one 6' standard folding table, unless the team has specifically requested a 2nd table.