

## **Mechanical Engineering Capstone Design Projects 2015**

### **Formula SAE Race Car Single Cylinder Engine Design**

The University of Waterloo Formula Motorsports team designs and builds a small open-wheeled formula-style race car to compete in the Formula SAE competition. Our project objective was to design and verify a FSAE-compliant powertrain to improve overall vehicle performance for the 2016 FSAE competition. Simulations and calculations were performed on the single cylinder engine to compare its efficiency with the four cylinder engine that has been used by the team in the past. We were responsible for designing and fabricating engine components such as the intake and the exhaust, and testing the engine on the dynamometer.

### **C7 Carbine Silencer Design**

A suppressor (commonly known as a silencer) is a device attached to the end of a firearm for the purposes of reducing the overall sound signature and muzzle flash generated by the engagement of a weapon. These benefits, the reduction of noise and light levels, will also provide tactical benefits from a military perspective as combat missions can be deployed from positions or reduced exposure. In partnership with Colt Canada, this suppressor was designed, built and tested with the C7 Rifle as its platform. The C7 is the primary weapon used by the Canadian Armed Forces.

### **OFSV Flow Shrouds**

The Off-Shore Fisheries Research Vessel (OFSV) is one of Canada's newly designed Coast Guard vessels. The vessel has a low operating speed making it a candidate for efficiency improvements. Flow shrouds homogenize the flow into the propeller region, increasing the propeller inlet velocity to improve efficiency. Operational requirements include sailing in ice infested waters as well as close interactions with wildlife; our flow shrouds protect the propeller from damage and reduce mutilation of wildlife typical in comparable systems.

### **3D Parking System**

The predominance of high rise buildings in the modern era is proof that it is less expensive to build up than out. This has created higher population ratios in most of the modern cities and thus created a scarcity of parking spots. In the recent years, a significant number of companies have arisen that address this issue by building major parking complexes. ParkSOLU team has pursued to target small land spaces within Toronto downtown, which are not fit for capital structures. The primary objective is to deliver a solution that utilizes modern mechanical and automation technologies to increase parking spaces to existing parking lots at a justifiable price. The modular nature of the design allows the solution to be applied to various parking layouts.

### **EMG Robotic Hand**

185,000 amputations are performed annually in the United States alone. In addition to the emotional trials one encounters when battling the loss of a limb, an individual must make the necessary lifestyle adjustments in order to compensate for the loss. Currently there are very few prosthetic hands available that provide natural intuitive control for an affordable price. REACH is attempting to change this reality. REACH's goal is to combine electromyography (EMG) and robotics to create a low cost prosthetic hand that will allow users to execute basic human hand functions with intuitive control inputs. By incorporating an EMG acquisition system, REACH intends to minimize the learning time required for a user to become proficient, while also empowering the individual to move forward following the loss of a hand.

### **Efficiency and Emissions Improvements of a Four-Stroke Snowmobile Engine**

As environmental awareness pervades the public consciousness the impact of recreational power sports has come under close scrutiny. This paradigm shift inspired the creation of the SAE Clean Snowmobile Challenge. This project, in conjunction with the University of Waterloo Clean Snowmobile Team, implements advanced control strategies, exhaust after-treatment, and thermodynamic improvements to produce a modified snowmobile to compete in the 2015 SAE Clean Snowmobile Challenge.

### **Zephyr Auto-dry Hockey Bag**

The Zephyr auto dry hockey bag allows players to dry their equipment without the need to remove it from the bag. With an internal air bus system and an “easy-plug” interface, along with a custom dryer unit, all of the equipment is guaranteed to be dried with a simple “drop and plug” action. Furthermore the bag is designed to remove any odor, and as a result users will no longer have to worry about smelling up their living spaces.

### **Cool Skins – Foot Cooling Device**

Erythromelalgia is a rare disorder which causes burning sensation, severe pain, swelling and skin redness in extremities. The pain can be reduced by cooling the affected area. The objective of this project was to aid those who are suffering from the disease by building a foot cooling device with ability of temperature control.

### **Aerobatic Aircraft Design**

The goal of our project was to contribute to the design of a twin seat monoplane aircraft that will be competitive in the unlimited category of competitive aerobatics. The goal was to design the steel-tube fuselage frame, carbon fiber wings and stabilizers, control linkages (for ailerons, rudder and elevators) and the pilot seats. The aircraft will be manufactured and assembled at a later date.

### **Automatic Rain Canopy**

Getting caught in the rain without an umbrella is an inconvenience. There have been many advancements made to modern umbrella design such as high wind load strength and compact packing factor. However, if an individual does not anticipate a rain-shower and is therefore without an umbrella, all of this research is of no assistance. As such, we have designed a retrofittable solution that can be installed in public areas to shelter users from the rain automatically. #keepitdry

### **Ski Patrol Rescue Toboggan – Braking and Control System Design**

There are approximately 700 ski hills across North America and injuries occurring on these hills are commonplace. When a skier is injured on the hill, it is the responsibility of ski patrollers to safely transport the patient down to the base of the hill using a rescue toboggan. Issues with rescue toboggans currently on the market include insufficient braking and control, as well as high ergonomic strain undergone by the ski patroller during patient transport. There exists room for improvement in the overall safety of rescue toboggans. The objective of this project was to design, build, and test an improved braking and control system which can be easily installed on rescue toboggans presently in operation.

### **Line Striping Design**

The results of line striping are encountered every day in the form of lines painted on the ground in a variety of settings such as parking lots, sports fields, airports, and more. Line striping is notoriously time-consuming and precision is very difficult to achieve for anybody without substantial industry experience.

We decided that this task is a perfect candidate for automation, and so we have designed and built an autonomous line striper. Simply set it on the ground, provide it with coordinates, and watch it enact the painting process completely autonomously.

### **Space Frame Structure for Electric Vehicle (EV)**

To alleviate traffic congestions and resulted pollutions in large urban areas, electric urban vehicles are gaining high consideration. Urban vehicles derive their appeal from their ease of navigation in cluttered areas with higher energy efficiency. These electric vehicles have a different load distribution than the traditional internal combustion and hence a need exists to build a safe chassis for these vehicles that can bear all loads under shape constraints.

### **Biomechanical Generator**

The constant need for power on the go is a worry for most of us. Remember the last time your phone died? Portable power may be useful for more than just charging your phone while out. It can be an essential for an adventure enthusiast for communication and navigating back to their origin. Portable power can allow people to stay away from a power source for longer and not let your devices constrain your activity. The biomechanical energy harvester aims to provide a reliable energy source to people whose lives are or quality of lives depend on the longevity of their electronic devices. The wearable technology uses a gear system to amplify movements at the knee during walking to generate electricity without hampering motion.

### **Underwater Linear Positioning System”**

Our team has partnered with 2G Robotics to design, manufacture and test an apparatus that allows for lateral movement of all three of 2G’s laser scanners. The scanners will mount to the apparatus and allow 2G to accomplish in-house testing and verification of their device functionality. The project challenged the team with the requirements for the apparatus to operate in air and underwater. The underwater environment possesses risks and challenges that were unfamiliar to the team and allowed for growth and learning.

### **Cafécionado – Roast, Grind, Brew Coffee Maker**

The price of coffee continues to increase, while the quality continues to decrease. The team's goal is to allow the consumer to create quality coffee in the comfort of the home, quickly and easily with the use of a roast - grind - brew coffee machine. The machine also gives consumers an easy way to foster direct and fair trade, and enables sustainable conditions for the coffee farmers.

### **Collapsible Bear Proof Food Canister**

Traditionally, food has been hung in trees by backpackers and campers in an effort to store and protect their food from scavenging animals. A bear canister is the better alternative to this method and in some parks and wilderness areas, the use of an approved canister is mandatory. Bear canister designs are fairly consistent, typically a large, bulky, plastic jar made of ABS or Poly carbonate (PC). Space efficiency is a high priority for backpackers. As such, the team identified a need for a more portable device to prevent animals from accessing campers’ food.

### **High Security Bike Rack**

Bike riders put significant effort into properly securing their bicycles to conveniently located bike racks. Bike lockers for easy and effective protection exist, but are uncommon and restrict users to a single location. The goal of this project was to establish an in-between solution that is convenient, easy and effective at providing bicycle security. To achieve these goals, the system integrates modern technology

to allow paying users to use any system, at any time, includes a self-engaging lock (activated by the user) and, provides a set of secondary security devices to deter theft.

### **Shell Eco-Marathon Steering and Controls**

The Shell Eco-Marathon is a yearly competition where student teams from around the world compete to design and build the most energy-efficient vehicle. Our project is part of the Waterloo Shell Eco-Marathon Team, which has been building a car to participate in the 2015 edition of Shell Eco-Marathon Americas. Our team was responsible for designing, building, and testing the steering system, brakes, wheels, and other accessory controls for the vehicle.

### **Shell Eco-Marathon Chassis**

The Shell Eco Marathon is a competition where teams from across North America competes to achieve the best efficiency in their vehicle class. The UW team is in its second year, and we are designing and building an aerodynamic, durable, super-lightweight carbon fiber monocoque body for the 2015 vehicle.

### **Waterloo Hybrid Final Drive Team**

Formula Hybrid is a competition in the SAE Collegiate Design Series in which students design and build open wheel race cars with a hybrid powertrain and compete in a series of events. The final drive system for the 2015 Waterloo Formula Hybrid vehicle is a complete redesign intended to improve vehicle performance while maintaining reliability.

### **Camaro Powertrain Architecture Packaging (UWAFT EcoCAR3)**

Team 27 is assisting University of Waterloo Alternative Fuels Team (UWAFT) to develop a 2016 Chevrolet Camaro hybrid with the end goal of competing in and winning the EcoCAR3 challenge. The primary task of the team was to locate and integrate UWAFT selected powertrain architecture components on a Camaro, and complete CAD and waiver requirements as needed, for the EcoCAR 3 competition.

### **Hockey Skate Dynamic Redesign**

In partnership with Bladetech Hockey Inc., our team redesigned the traditional hockey skate to reduce impact loading on knee and ankle joints during hockey play with minimal effect on player performance. Using a combination of springs and damper mechanism adjusted for individual players, the risk of injury in the lower extremities is minimized during gameplay, allowing for a safer game for the participant.

### **Hot Blank Transfer Mechanism**

The purpose of this project was to create a transfer mechanism to be used in the testing of new hot forming die quenching technologies. 350 million parts per year, including the A and B pillars in cars are manufactured using hot forming die quenching. The research team at the University of Waterloo is testing the possibilities of replacing the existing roller hearth furnaces with the more energy efficient, cheaper, faster and more compact method of direct contact heating using a monolith mounted within a press. For their testing purposes they required a means of transferring the heated blank at 1000 °C from the heated monolith to the forming die within the same press.

### **“I KNEE'D YOU”**

The market for knee braces today primarily consists of braces for support. In an effort to improve post knee injury recovery there is need for a brace with a resistive torque for both exercising and stability purposes. Utilizing an existing knee brace and attaching a phone controllable variable torque applicator

on it, an environment similar to physiotherapy is created to exercise a user's injured leg under the safety and control of the brace without additional equipment.

### **MRI Compatible Biopsy Robot**

Risks associated with CT scans due to radiation have led to a drive for adoption of MRI guided medical procedures. The Center for Image Guided Innovation and Therapeutic Intervention (CIGITI) has developed an MRI compatible intervention device in response to such demands. This project involves developing an MRI compatible gantry and positioning system for said device. The objective is to provide CIGITI with a working prototype to support the continued development of a complete product.

### **Sustainable Furniture Design**

RH block consists of four members with a passion for contributing to children's growth. The opportunity to apply our passion presented itself through communication with North American foster homes. Research concluded that significant decreases in funding to such homes were leading to unsatisfied costs of operation and services. The team identified this problem as a potential area of interest, and designed a solution to this problem. Particularly, a convertible crib-to-bed design that not only serves the children, but also provides economic and spatial benefits to the homes was thus conceived.

### **Rocket Aeroponic Green Roof Panel**

As the urban agriculture sector continues its trending growth, a need for a practical, economical and versatile method for providing urban farmers with the means to grow produce is arising. We are working with Rocket, a Waterloo based urban agriculture start-up, to build a modularized, automated, aeroponic green roof system. Growing produce with aeroponics instead of traditional soil based methods increases plant growth while reducing water usage by 98% and fertilizer usage by 60%. By packaging this system into a modular green roof, we are taking advantage of underutilized urban spaces and targeting the green roof industry.

### **UWAFT EcoCAR 3 Powertrain Testing System**

Our project is concerned with aiding the University of Waterloo Alternative Fuels Team (UWAFT) during the first stages of their participation in the EcoCAR 3 Competition, in which they will hybridize a Chevrolet Camaro and compete with other North American Universities in 2018. Our group was tasked with designing and building a robust testing system, which will provide a safe and efficient platform for the UWAFT to verify selected hybrid architecture and components.

### **Low Cost Piston Pump in Cherangany, Kenya**

In several developing countries, people still do not have easy access to potable water. In partnership with the Kenyan Kids Foundation Canada, Team #MOO has developed a low cost piston pump for hand dug wells made primarily from local Kenyan materials that will increase the amount of water that both the humans and the cows receive daily. This will greatly impact the quality of life by increasing health and income by increasing milk production.

### **Wind Tunnel Sting Mount**

The University of Waterloo is performing research to maximize the efficiency of riding a bicycle. Wind tunnel testing is required as part of this research. Our team is responsible for designing and manufacturing a support system for this testing. The system will ensure that precise aerodynamic measurements can be taken in the wind tunnel from a model (bicyclist). In order to extract accurate measurements, the support system must prevent fluid induced vibrations. Flow disruption, wind tunnel blockage, and angle adjustability were considered in the design of the system. The overall objective is to

successfully implement the final product in a University of Waterloo wind tunnel. The implemented product will be used by our team and future students to conduct wind tunnel experiments.

### **Automated Palm Tree Climber and Sprayer**

Our design project objective was to design and build a robot capable of climbing betel nut palm trees and applying fungicide to the nuts at the top of each tree. This task is presently performed by skilled tree-climbing labourers, however said labourers are in short supply. The robot is simple enough to be operated by unskilled labour.

### **Tailoring the acceleration profile of a crash sled using a secondary energy absorber**

Individual component crash testing is more economical compared to a full vehicle crash test, in verify the crashworthiness of a vehicle component, but it's difficult to correlate data from these two methods. This is because there are multiple energy absorbing systems acting together in a full vehicle crash test, and the part of interest will experience a force profile different from individual component crash test. The project's goal is to tailor the acceleration profile of the crash sled so that force profile the part of interest experiences in an individual component crash test matches that of a full vehicle crash test.

### **Electronic-CVT for UW Clean Snowmobile Team**

The UW Clean Snowmobile Team competes annually in the SAE Clean Snowmobile Challenge and is always looking for reduced fuel emissions and improved driving efficiency. This project intends to improve the operation of the snowmobile clutch/CVT by replacing the mechanical flyweight mechanism with an electronic version that can be programmed to give optimal performance in different driving scenarios.

### **MBLOK**

Easy sharing without cloud using P2P connection and smart storage management. An Enterprise File Sharing and Sync EFSS solution that combines the benefits of the Cloud simplicity and local storage. MBLOK manages all files including those too big or too private for the cloud by storing them locally. It provides remote access and sharing capabilities with any platform. If connection reliability is an issue, MBLOK can double as a wireless drive. The result, files are always at your fingertips. The design project involves thermal analysis of the enclosure and overheating mitigation.

### **High Endurance Survey Vehicle**

Current surveillance and surveying vehicles do not possess the endurance, range, or payload capabilities necessary for widespread industrial use. Our team has worked hard to develop a low cost, extremely high endurance survey drone that is tailored to industrial and surveillance applications. This will facilitate a broad range of new uses for small scale drones in addition to providing a platform that is better than existing solutions.

### **Solder Otter**

In an interdisciplinary collaboration between Mechanical Engineering and Systems Design Engineering students, Solder Otter is a simpler and safer consumer soldering iron for electronics designed with Makers in mind. By mitigating the frustrations associated with potential burns and irritations from soldering fumes, Solder Otter offers an improved soldering user experience and allows Makers to better focus on completing the task at hand, soldering, so their projects may be completed faster.

### **MiCam 360**

Capturing the sound produced by a single sound source can be a difficult task in a noisy environment. The Visualcoustics team has set out to develop a system, which is capable of isolating sounds within a dynamic visual field. This system uses a 360° camera as a visual input, paired with a custom SoundField microphone that isolates sound using Ambisonics technology. This product will allow the user to pan and zoom across a pre-recorded video and only hear the audio that is present within that captured visual field.