Aerospace Engineering Program
Higgins Laboratories, Room 250
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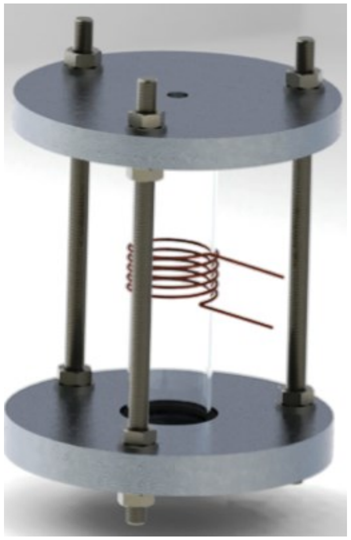
Worcester, MA 01609
http://www.wpi.edu/academics/aero.html

Worcester Polytechnic Institute

Aerospace Engineering Program

Project Presentation Day
Program
April 23, 2015



Judge Panel

Sergey Averkin
Postdoctoral Fellow
Aerospace Engineering Program
WPI

Frank Dick
Assistant Teaching Professor, Physics
WPI

Andrea Marinelli
Engineer
General Electric Aviation

Raffaele Potami
Research Data Scientist
WPI

Program

8:20-8:30	Opening Remarks Professor Nikolaos Gatsonis, Director, Aerospace Engineering Program
8:30-8:50	Diagnostics for a Supersonic Wind Tunnel Shea Bernardo, Lydia Johnston, David Viteri Advisor: Professor John Blandino
8:50-9:10	Design of a Cost Effective Drop Tower for Impact Testing of Aerospace Materials Shawn Ferrini, Latthapol Khachonkitkosol, Michael Strauss Advisor: Professor Anthony Linn Co-Advisor: Professor Maria Chierichetti
9:10-9:30	Vision-based Obstacle Avoidance for Small UAVs Sam Friedman, Kevin Hancock, Cy Ketchum Advisor: Professor Raghvendra Cowlagi
9:30-9:50	Passive Stabilization of Helicopter Sling Loads James Hitchen, Peter Guarino, Wesley Morawiec Advisor: Professor David Olinger Co-Advisor: Professor Raghvendra Cowlagi Sponsor: Natick Soldier Research, Development and Engineering Center (NSRDEC)
9:50-10:10	Helicopter Sling Load Stabilization with Active Control Dusty Cyr, Radu Morar, Joseph Sperry Advisor: Professor Raghvendra Cowlagi Co-Advisor: Professor David Olinger Sponsor: Natick Soldier Research, Development and Engineering Center (NSRDEC)
10:10-10:30	Design of a Plume Generation and Detection Systems Christopher Clark, Mitchell Greene, Madeline Seigle Advisor: Professor Nikolaos Gatsonis
10:30-10:40	Break
10:40-11:00	Gas Source Localization with a Mobile Sensing Ground Vehicle Mica Anglin, Mitchell Hunt, Matthew Myles Advisor: Professor Michael Demetriou
11:00-11:20	Design of a Helicopter Hover Test Stand Bror Axelsson, Jay Fulmer, Jonathan Labrie Advisor: Professor Anthony Linn Co-Advisor: Professor Maria Chierichetti

11:20-11:40	Micro-Aircraft Design Andrew Andraka, Daniel Cashman, Zachary Demers, Giovanni Di Cristina, Malick Kelly, Connor Pugliese, Ashley Rosano, John Schutes, Connor Sullivan, Nicholas Tosi Advisor: Professor Anthony Linn Co-Advisor: Professor Seong-kyun Im
11:40-12:00	Design and Fabrication of a Radio-Frequency Electrothermal Thruster Ryan Byrne, Scott Osborn, Zackary Tripp Advisor: Professor John Blandino
12:00-12:20	Compound Hydrokinetic Turbine Christopher McConnell, Jedediah Perron, Tess Royds Advisor: Professor Anthony Linn
12:20-12:40	Design and Testing of Kite-Powered Water Pump Concepts Caitlin Chase, Lindsey DeLuca, Aaron Marshall, Ronald Mazurkiewicz, Jr. Advisor: Professor David Olinger Co-Advisor: Professor Seong-kyun Im
12:40-1:40	Judges convene, students complete surveys, lunch
1:40	Award Ceremony

Design and Testing of Kite-Powered Water Pump Concepts

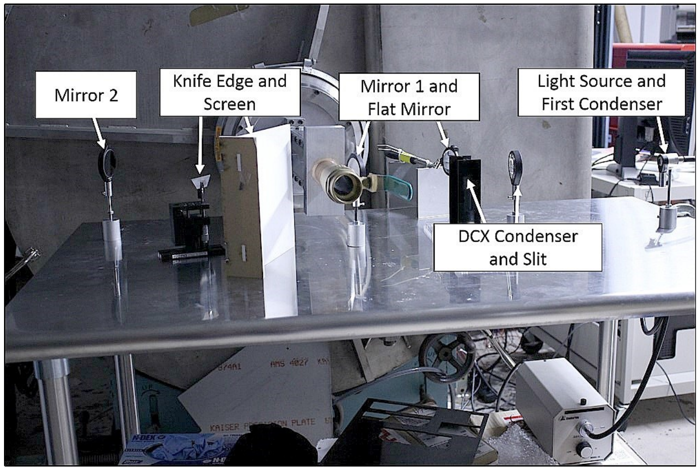
Caitlin Chase, Lindsey DeLuca, Aaron Marshall, Ronald Mazurkiewicz, Jr.
Advisor: Professor David Olinger
Co-Advisor: Professor Seong-kyun Im

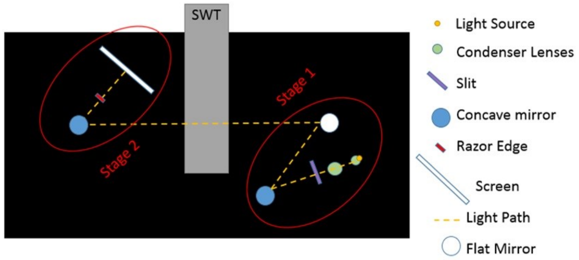
The goals of this project were to continue the development of the existing WPI kite-powered water pump, and to design, build, and test a new concept for low-cost water pumps for underdeveloped nations. To accomplish the first goal, testing and modification of kite depowering methods of the existing system were conducted in an effort to create a consistent periodic pumping motion for the rocking arm. The second goal involved creating a new system consisting of a rotating spool constructed from a bicycle wheel connected to a rotary windmill water pump. The rotary spool system was designed to achieve sufficient torque to turn the windmill water pump. Further field testing is needed to determine which design concept is the best option for providing water to underdeveloped nations.

Diagnostics for a Supersonic Wind Tunnel

Shea Bernardo, Lydia Johnston, David Viteri
Advisor: Professor John Blandino

The goal of this project was to design and improve existing diagnostics for the in-draft supersonic wind tunnel (SWT) at Worcester Polytechnic Institute. Diagnostics include a pitot system to measure static and stagnation pressures which can then be used to calculate Mach number, and a schlieren system for visualizing wave structures in the flow. Pitot system design and electronics used for the data acquisition system were evaluated. LabVIEW code for obtaining a Mach number using pressure measurements was written and validated through benchtop, testing. The schlieren optical system was also modified to improve image brightness, contrast, and resolution as well as to facilitate positioning of optical components. Schlieren system images were compared with pressure gradient results produced by a previous design group using computational fluid dynamics software and showed qualitative agreement.

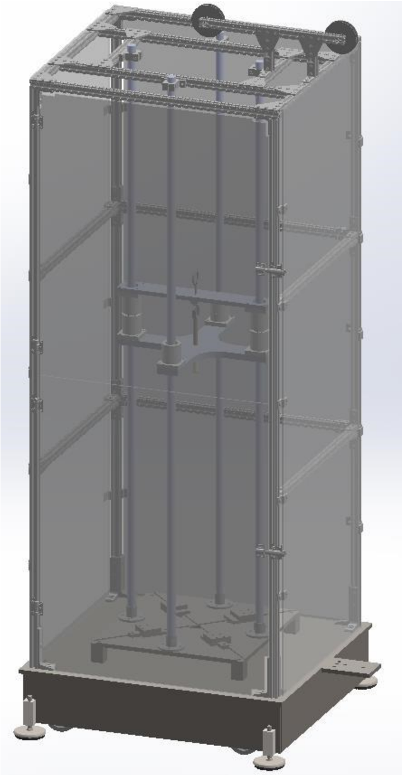




Design of a Cost Effective Drop Tower for Impact Testing of Aerospace Materials

Shawn Ferrini, Latthapol Khachonkitkosol, Michael Strauss
Advisor: Professor Anthony Linn
Co-Advisor: Professor Maria Chierichetti

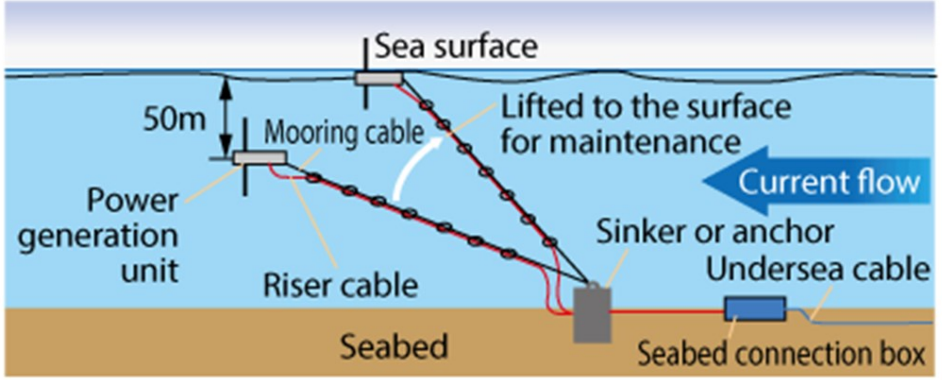
The unique challenges presented by the high performance and stringent safety demands of the aerospace engineering field require advanced materials. These materials are constantly being developed and refined, and a thorough knowledge of their properties and behavior is necessary before they can be put to use. Energy absorption is an important mechanical property that is most commonly evaluated by conducting impact tests. This project has developed a low-cost, reliable, guided drop tower for impact testing of novel aerospace materials. The project team has produced a complete design along with a user manual and bill of materials. It is anticipated that the final design will be used to fabricate and assemble a drop tower for future research.



Compound Hydrokinetic Turbine

Christopher McConnell, Jedediah Perron, Tess Royds
Advisor: Professor Anthony Linn

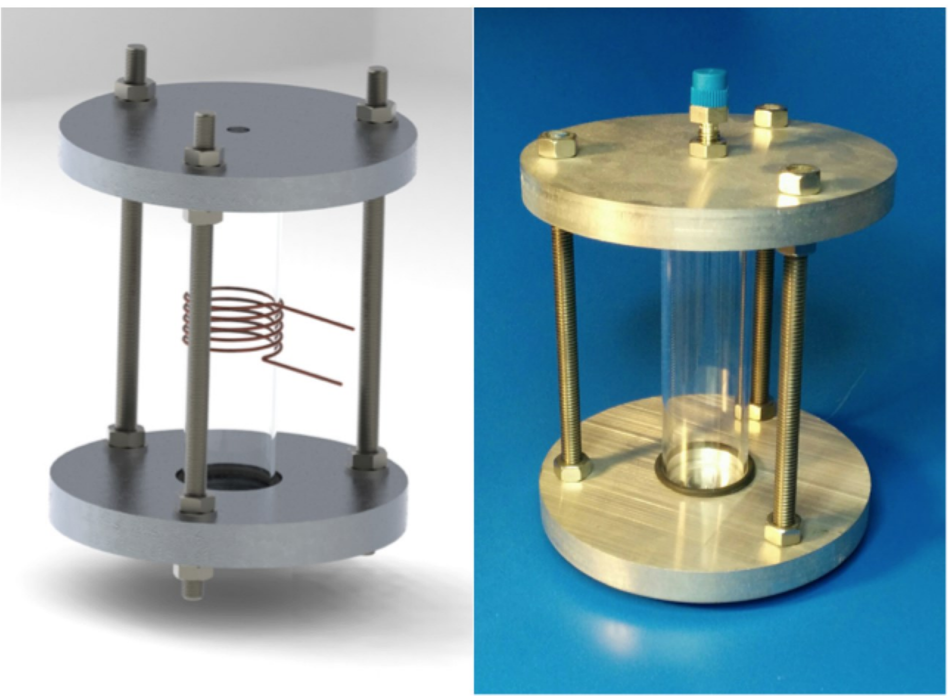
Energy production remains a priority for the future of mankind. While current nonrenewable energy resources have a finite life, renewable energy sources have the potential to extend the life of, if not replace, nonrenewable sources. This project investigates the concept of a compound hydrokinetic turbine, a device that can extract energy from flowing fluids such as ocean currents, channels or rivers. Conceptually, the device could also operate in air and thus be an alternative configuration to the conventional wind turbine. Also reviewed is availability of energy from ocean currents, the performance of airfoils developed for wind turbine use in water rather than air and various systems for mooring hydrokinetic devices in deep water.



Design and Fabrication of a Radio-Frequency Electrothermal Thruster

Ryan Byrne, Scott Osborn, Zachary Tripp
Advisor: Professor John Blandino

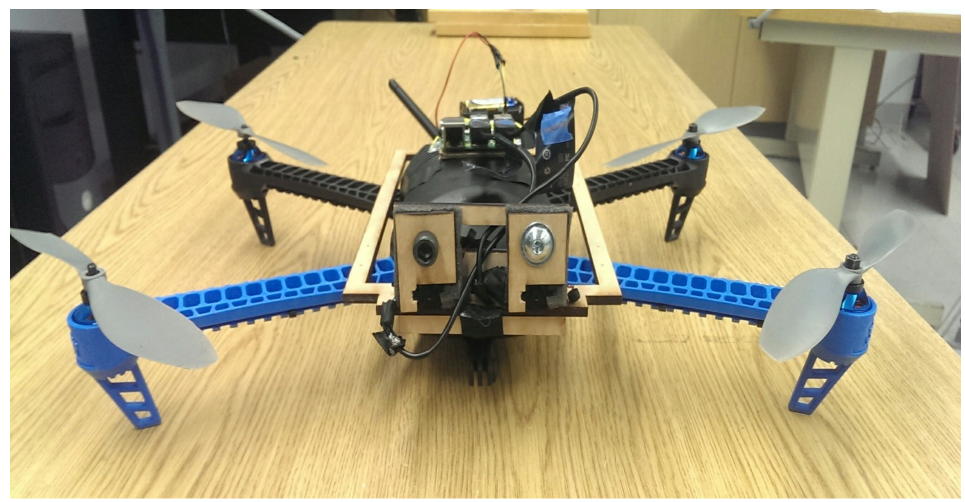
The goal of this project was to design and build a laboratory-model, radio-frequency electrothermal thruster to operate at 300 W using a 13.56 MHz RF power supply. The thruster was designed to include an interchangeable nozzle. Two numerical models were created. The first was a 0-D global model based on an energy balance in the discharge and implemented in MATLAB. The second was a heat transfer model generated using COMSOL multiphysics software. Materials and components were selected and purchased for the thruster structure, mounting stand, gas inlet, and discharge cavity. A matching network was required to minimize reflected power in the transmission line. After a review of matching network theory, a circuit analysis was performed to design the network and select components.



Vision-based Obstacle Avoidance for Small UAVs

Sam Friedman, Kevin Hancock, Cy Ketchum
Advisor: Professor Raghvendra Cowlagi

Autonomous obstacle avoidance is a fundamental desirable feature of all unmanned aerial vehicles (UAVs). Due to severe payload weight restrictions, small UAVs are limited in the number and type of sensors that can be carried onboard for detecting and avoiding the environment. This project describes an obstacle avoidance system based on two lightweight off-the-shelf cameras, and a small Raspberry Pi microcontroller. The system was designed to receive telemetry and sensor data from the UAV's basic autopilot and to return command guidance to avoid obstacles in the desired path. To implement this system, algorithms for object tracking and depth mapping using monocular and stereo camera vision were developed. Workbench tests and flight tests on the IRIS quadrotor UAV were performed.



Passive Stabilization of Helicopter Sling Loads

James Hitchen, Peter Guarino, Wesley Morawiec
Advisor: Professor David Olinger
Co-Advisor: Professor Raghvendra Cowlagi
Sponsor: Natick Soldier Research, Development and Engineering Center (NSRDEC)

Helicopter Sling Load, where a payload is tethered beneath a helicopter, is the most accurate form of aerial delivery used by the military. The inherent payload instability limits the airspeed and maneuverability of the helicopters and increases delivery time and exposure to enemy fire in hostile areas. This project focuses on reducing sling load instability using passive methods to control the payload motion. The team conceived and constructed two stabilization concepts, which used elevated, angled fins and a finned fabric design. These concepts were tested on a scaled cargo container and a scaled Humvee in wind tunnel tests. A TRex 700E scale model helicopter was also adapted to test the two concepts by adding landing strut and video camera systems.

Micro-Aircraft Design

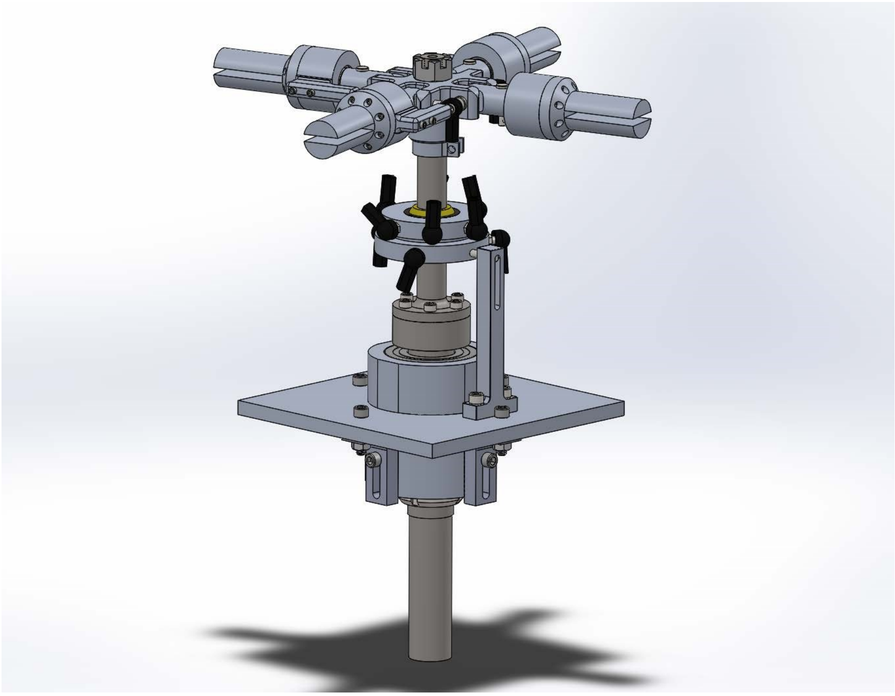
Andrew Andraka, Daniel Cashman, Zachary Demers, Giovanni Di Cristina, Malick Kelly, Connor Pugliese, Ashley Rosano, John Schutes, Connor Sullivan, Nicholas Tosi
Advisor: Professor Anthony Linn
Co-Advisor: Professor Seong-kyun Im

An unmanned aerial vehicle was designed and built for the AIAA Design Build Fly 2015 competition. To meet the mission requirements, including speed and weight, the aircraft is designed to have a 10-foot wingspan and 14 inch chord with dihedral and a conventional tail wing configuration. To minimize the weight without durability cost, tubular carbon fiber spars and balsa ribs were used to construct the wings. The 5-foot fuselage consists of bulkheads made from balsa ply connected longitudinally by carbon fiber tubes. An 18 inch diameter propeller driven by a brushless DC motor generates the thrust. The aircraft has a 5 pound payload capability. By combining detailed analysis of aerodynamics, structure, and material with flight test, the team has refined the aircraft design.

Design of a Helicopter Hover Test Stand

Bror Axelsson, Jay Fulmer, Jonathan Labrie
Advisor: Professor Anthony Linn
Co-Advisor: Professor Maria Chierichetti

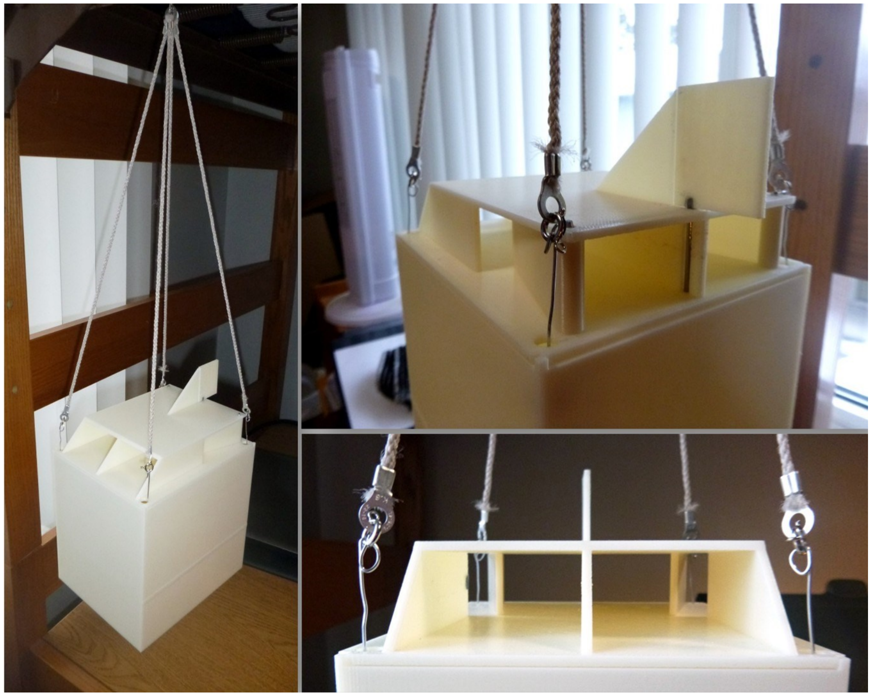
The development of helicopter test stands allows for the testing and development of various components of helicopter rotor head and blade designs. The goal of this project is to design, build, and test a fully articulated helicopter rotor head system for future implementation on a hover test stand. The stand will be used to measure the forces and moments at the blade roots and the strain along the blades. The design of the rotor head is modular, allowing for the type and number of blades to be changed as desired without major disassembly of the test stand. The design is based on a fully articulated, four bladed rotor head with a custom fabricated swashplate and driveshaft. Additionally, a safety system was designed to ensure the safe operation of the hover test stand and protect the users in the case of failure at maximum rotor speed. The recommended data acquisition system for measuring stresses and strains is a light based system that uses fiber optic technology to accurately collect and transmit data from the rotating blades to data analysis equipment in the stationary frame.



Helicopter Sling Load Stabilization with Active Control

Dusty Cyr, Radu Morar, Joseph Sperry
Advisor: Professor Raghvendra Cowlagi
Co-Advisor: Professor David Olinger
Sponsor: Natick Soldier Research, Development and Engineering Center (NSRDEC)

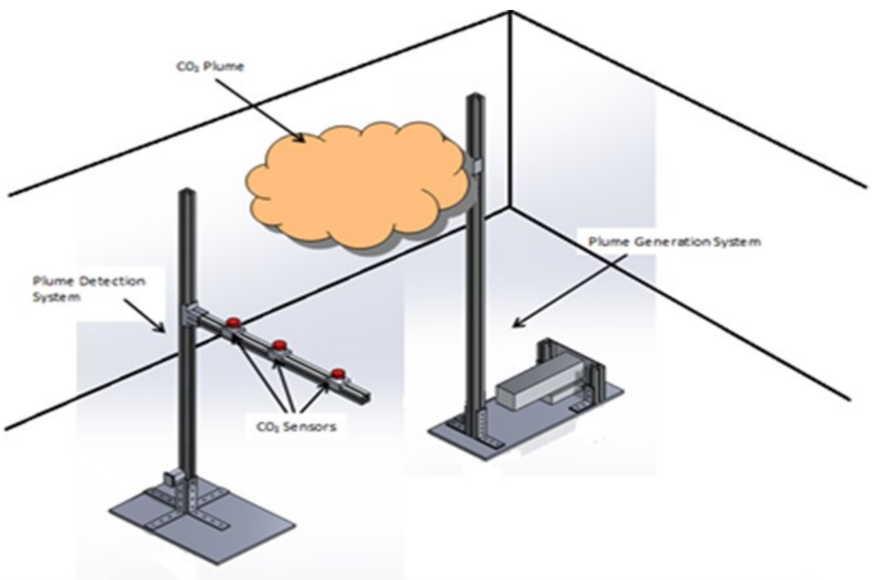
Helicopter sling loads are widely used for cargo delivery in all branches of the military. However, sling loads are inherently unstable in flight, which is hazardous. This project designed a system, called PARAS, to stabilize sling loads using active control methods. The PARAS system redirects airflow over the sling load, using a rudder and pipes with control vents, to create stabilizing forces and moments. This project involved mathematical modeling, simulation, and wind-tunnel testing of a PARAS system for a 1/17 scale standard sling load cargo container. Stabilization of yaw motion and lateral sway motion of the sling load were investigated using the LQR control algorithm. An Arduino microcontroller was used to collect measurements and to actuate the control surfaces with servomotors.



Design of a Plume Generation and Detection Systems

Christopher Clark, Mitchell Greene, Madeline Seigle
Advisor: Professor Nikolaos Gatsonis

The project presents the conceptual design of plume generation and detection systems for ground experiments with sensing robots. The plume generation system provides controlled carbon dioxide concentration profiles and consists of a pressurized tank, a pressure regulator, a flow meter, and a nozzle placed on a stand. The carbon dioxide plume is modeled with the 3d advection diffusion equation and numerical simulations provide the required release rates at the nozzle exit. Nozzle dimensions are estimated using 1d isentropic nozzle theory. The plume detection system consists of three carbon dioxide sensors placed on a horizontal arm that can be repositioned vertically on a stand. Structural analysis is performed for the plume generation and detection stands in order to minimum deflections.



Gas Source Localization with a Mobile Sensing Ground Vehicle

Mica Anglin, Mitchell Hunt, Matthew Myles
Advisor: Professor Michael Demetriou

The project focuses on the development of an experiment for an olfactory terrain vehicle localizing a moving gas source inside an enclosed environment using gas, airflow, and proximity sensor. The experiment simulates the movement of an unmanned air vehicle (UAV) tracing the source of a leaking gas from another moving aircraft. A literature review was conducted to aid in the understanding of technologies and processes that have been used in similar experiments. The main accomplishments of the project include the selection of major design components such as the gas, robot, and appropriate gas sensors. Other accomplishments include the design and manufacturing of a sensor mount as well as the development of a robot motion control algorithm using Matlab and Simulink code and simulations.