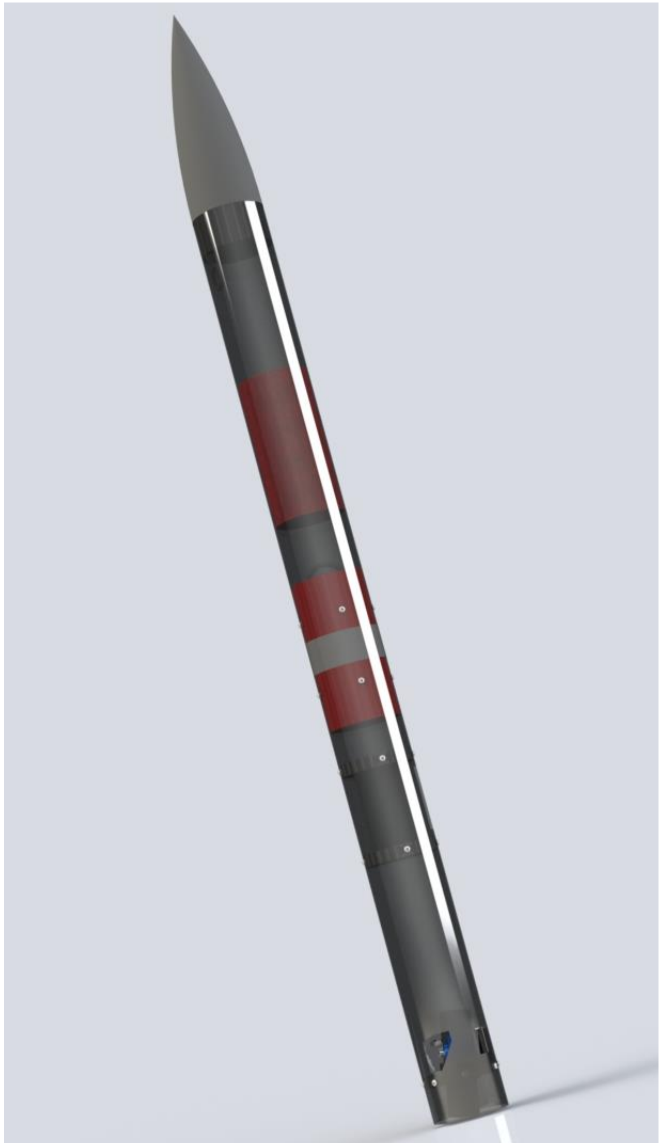


Anish Sankla

ENGINEERING PORTFOLIO

asankla@terpmail.umd.edu

Table of Contents

INTRODUCTION

Hello! My name is Anish Sankla and I am an Aerospace Engineering student at The University of Maryland, College Park. This portfolio is designed to supplement my resume by demonstrating my practical experience in engineering. I have had the opportunity to participate in many projects, both in and out of the classroom, which has enabled me to improve my critical thinking skills and add new skills to my toolbelt. It is my hope that this will allow you to better assess how my skills can be applied to your company. Thank you for looking at what I have created.

ABOUT ME

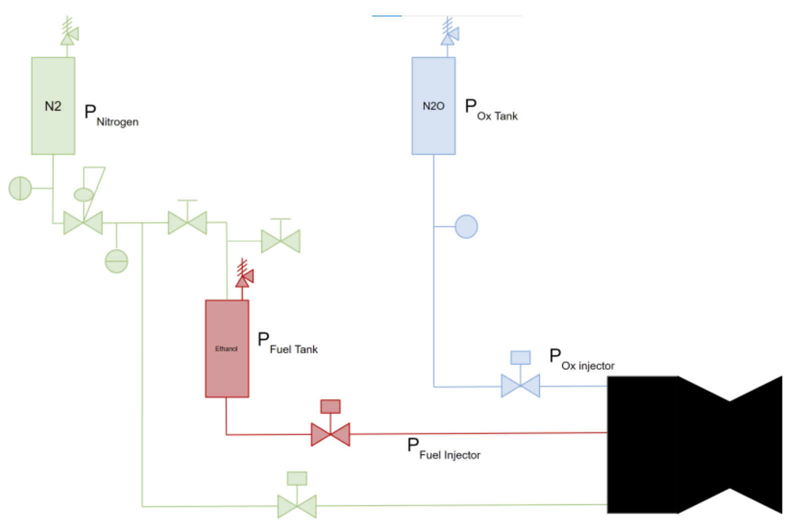
I have had an affinity to building ever since I was a kid, whether it be taking apart some of my toys or building spaceships with LEGOs. As a Boy Scout, I spent many nights staring into the cosmos and dreaming that one day I'd make something that explores the final frontier. That motive has not changed as I now spend most of my free time learning more about the space industry and where it's going. I've learned from an early age the importance of helping others through my scouting and volunteering experience, so I wish to create in a way that is beneficial to people around the world. Ultimately, I hope to make a positive impact as an engineer in the aerospace industry.

Liquid Rocket Engine

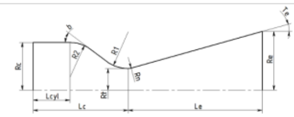
The reason for starting this project was to build a team working on liquid bi-propellant rocket engines and provide the students at UMD a new opportunity that cannot be found anywhere else on campus. UMD has not successfully developed and hot-fired a liquid rocket engine in its history and we hope to change that. By starting the team, I can help build a foundation of liquid rocketry knowledge that will hopefully end in the team working on building liquid-powered rockets after I graduate.

I started this project with a friend who had the same vision as me and with the help of our research advisor, we were able to hit the ground running. After research into the base knowledge needed, we started design work on a 100lbf engine with propellants of nitrous oxide (N2O) and ethanol. We chose these propellants as they were the easiest to acquire through our school, and we'd be able to scale these propellants to bigger engines based on experiences from other rocket teams which we had talked to. With the 100lbf engine, we'd be able to learn how to build ground system equipment (GSE) to feed the propellants into the engine block and how to use the resources on campus to machine the engine block ourselves.

We first determined a basic system architecture for the 100lbf engine. Our preliminary piping and instrumentation diagram (P&ID) includes valves, regulators, and gauges that will be needed for the successful operation of the engine. Gaseous nitrogen will be used for ullage pressure in our fuel run tank. We will use N2O as a gas for this first rocket engine. We chose to only have one valve in-between each propellant tank and the injector to simplify calculating the pressure needed in the run tank and limit the pressure drop from the run tank to the injector.



Design Parameters | Size and Geometry



```
Thrust and mass flow rates
-------------------------------------------
   Chamber thrust (vac):    0.50542     kN
 Specific impulse (vac):  238.72776      s
   Chamber thrust (opt):    0.44277     kN
 Specific impulse (opt):  209.13557      s
   Total mass flow rate:    0.21589   kg/s
Oxidizer mass flow rate:    0.17991   kg/s
    Fuel mass flow rate:    0.03598   kg/s

Geometry of thrust chamber with conical nozzle
-------------------------------------------
    Dc =   56.29  mm       b =   30.00 deg
    R2 =   73.50  mm      R1 =   10.55  mm
    L* = 1000.00  mm
    Lc =   88.49  mm    Lcyl =   29.41  mm
    Dt =   14.07  mm
    Rn =    2.69  mm      Te =   15.00 deg
    Le =   25.59  mm
    De =   27.59  mm

  Mass =   -8.90  kg

  Divergence efficiency:    0.98296
```

I used Rocket Propulsion Analysis (RPA) to determine mass flow rates for propellants and the profile for the engine block after choosing that we would want to reach a target pressure of 300psi in the combustion chamber. We also set our oxidizer to fuel (O/F) ratio to be 5 based on research papers we had read about N_2O and ethanol combustion efficiency. Now knowing our mass flow rates, I could then create a calculator which would determine the tank pressures needed in each propellant run tank. An assumption we made in our calculations was choosing that our pressure drop across our injector would be 20% of the chamber pressure, which is a value that we got after talking to a few liquid rocket teams about injector pressure drop. From here, we know that we will also have a pressure drop across the main oxidizer valve (MOV) and main fuel valve (MFV) so we can use the Cvs of each valve to determine the pressure drop in each feed line assuming that we want a constant mass flow rate in the feed system and that pressure losses due to short piping is negligible.

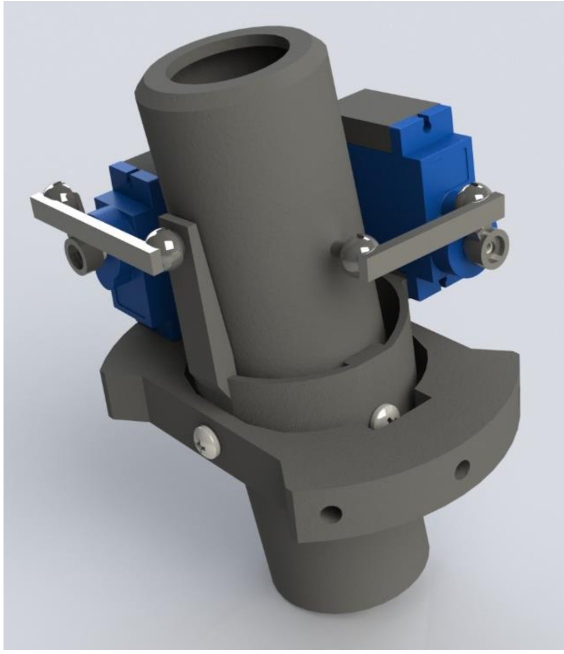
Inputs		
Parameter	Ethanol	N2O
SG	0.7916750251	0.057472
Density (kg/m^3)	789.3	57.3
mdot (kg/s)	0.03598	0.17991
Q (m^3/hr)	0.1641049031	11.30324
# Orifices	1	1

Constants	
Name	Value
Cv (MFV) (gpm)	0.11
Cv (MOV) (gpm)	1.4
Pipe Area (m^2)	0.00001641732232
Chamber Pressure (kPa)	2068.5
Head Loss Coefficient (K)	0.5
Injector Pressure Drop (kPa)	413.7

Output		
Name	Ethanol	N2O
Injector Orifice Diam (m)	0.001186564019	0.005111
Tank Pressure (kPa)	2719.294056	2986.310
Injector Orifice Diam (in)	0.04671502541	0.201245
Tank Pressure (psi)	394.3863751	433.1124

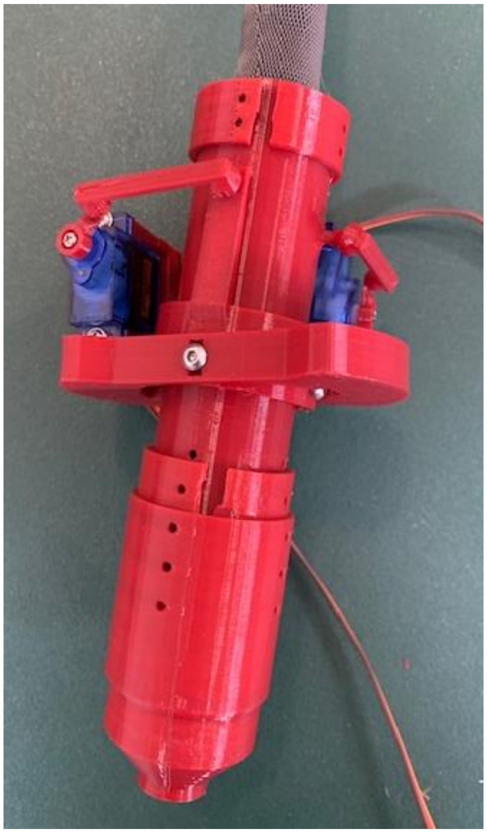
We are currently in the process of fine-tuning our calculations, designing the engine block itself, and acquiring all the parts needed to manufacture the engine and build the GSE needed for our first hot-fire.

TVC Model Rocket



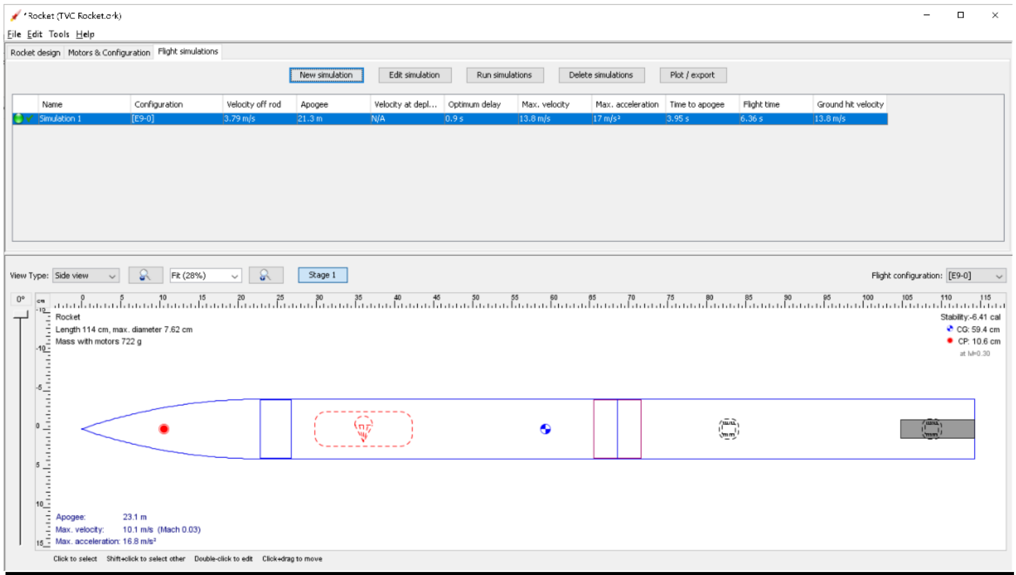
I chose to start this project due to the pandemic and the extra time I had on my hands. I was inspired by the work of BPS Space, a YouTube channel building Thrust Vector Controlled (TVC) model rockets, and decided that this project would be a good way of learning PCB design, control theory, and how modern rockets actively change the direction of thrust to stay upright.

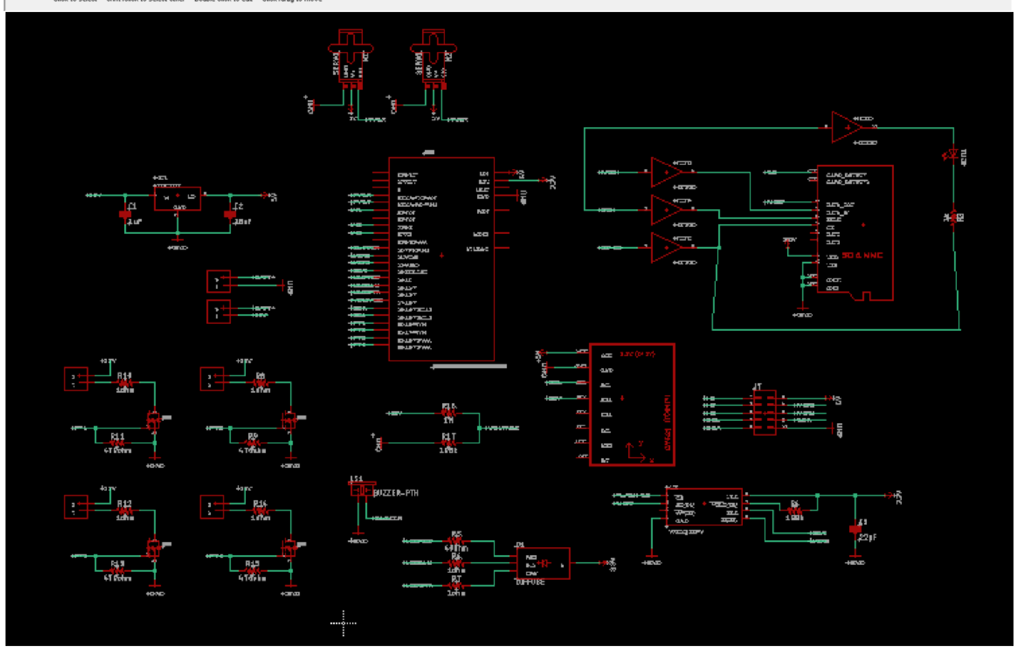
I started by designing a simple TVC module in SolidWorks and 3D printing it for preliminary tests. I discovered that there were a few structural flaws in the design and updated them in the second iteration which was stronger. The central motor housing is gimballed by two servo motors attached to ball and socket links.



After successful manipulation of the module using an Arduino Nano, I attached the module to a hose and 3D printed a converging nozzle in order to accelerate the water and increase velocity by decreasing cross-sectional area. The test was successful; however, the stiffness of the hose was creating too much resistance on the module, so I then moved to having the module work in tandem with an Inertial Measurement Unit (IMU).

Along with getting the TVC module to work correctly, I also researched PCB design and began creating an electrical schematic in Autodesk Eagle for my custom flight computer. As an added challenge, I am attempting to design the board without using any breakout solutions for the components, which is helping me learn more about the nuances of circuit design.





I designed the rocket for a 29mm class E/F motor and a 74mm body tube. I used OpenRocket to determine what the apogee would be and the rest of the dimensions of the Rocket. The rocket will reach a theoretical apogee of around 20 meters and has a length of 1.14 meters.

Single Frame Reaction Wheel

To give myself an introduction to the world of control systems and PID control loops, I undertook this project inspired by the Cubli, which is a cube powered by 3 internal reaction wheels that allow it to jump up and balance on any of its edges and corners.

I decided to start with one reaction wheel that I would try to get to balance on one of its corners on an axle. I used an old motor from an RC helicopter, a hall effect sensor, and an IMU, all connected to an Arduino Nano. I embedded 3 magnets into the inertial wheel so that RPM can be calculated using the hall effect sensor, while roll angle and angular speed are calculated from the IMU. The design was first made in SolidWorks before it was printed out using my 3D printer.

My first tests involved getting the frame to jump from side to side by rapidly changing the RPM of the wheel, thus rapidly changing the angular momentum which results in an opposing rotation to conserve angular momentum. After these tests, I moved to attempting to balance the frame on its corner using a simple PID loop that I tuned. The frame at its best was able to successfully balance for 15 seconds before dropping.

The main problem with this design was attempting to use a linear PID controller on a nonlinear system, and on the next iteration I plan on tackling this as I get more knowledge on control theory.

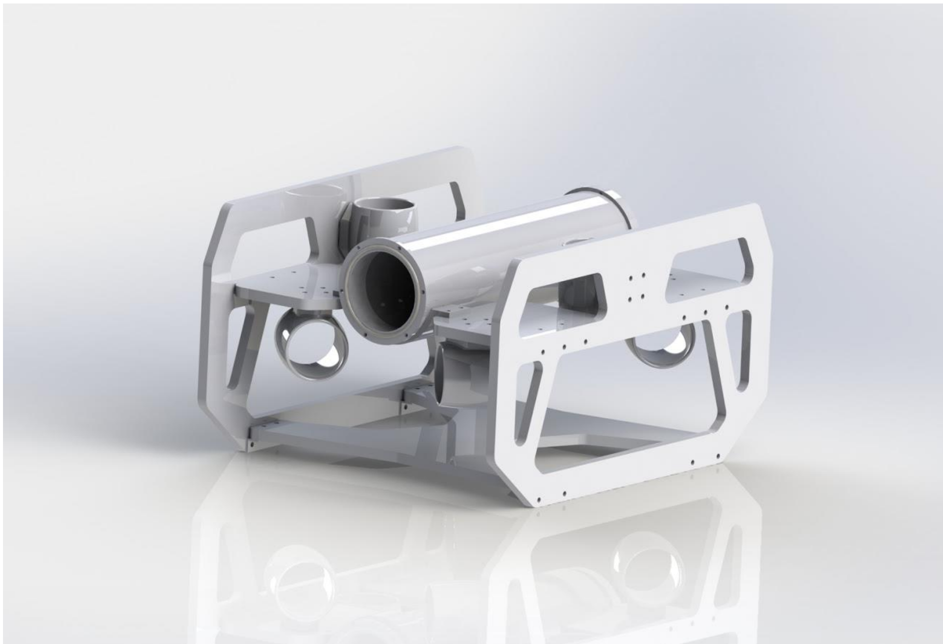
F4 Spring 2020 CADathon

This robot was designed in a week by me and a teammate for a hypothetical FIRST Robotics Competition game, which involved the scoring of footballs and gym weight plates. The design and renders were both done in SolidWorks.

There was no cap in the rules on how many footballs could be held, so we optimized our robot for football acquisition with a hopper and launched them using a simple catapult design with a cam and surgical tubing. The plates are acquired through a simple slot and secured by a large pancake piston. The plate is moved to the desired height by an elevator with cascading rigging, meaning the inner carriage moves proportionally to the first stage. The drivetrain is a swerve drive, meaning each wheel is individually powered and can rotate, so the robot can move in any direction while in any orientation.

The design placed 9th out of 100 submissions.

FIRE Program AUV Research Project

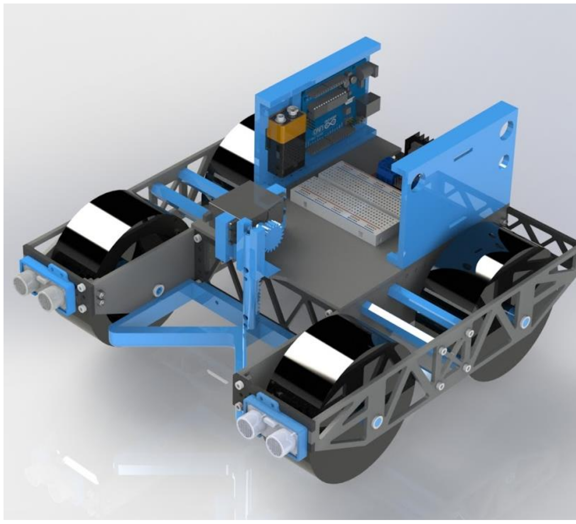


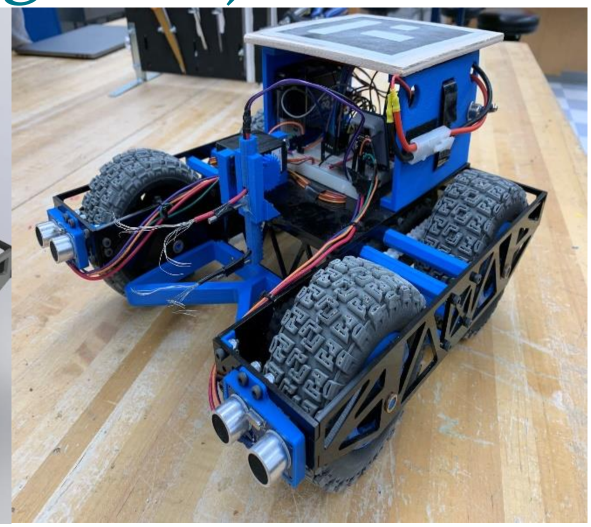
This project was being done for a research program I was a part of at The University of Maryland, however, the project was never brough to completion due to the Pandemic. My partner and I were designing an Autonomous Underwater Vehicle (AUV) which will be a platform for identifying and acquiring objects underwater using machine learning. Along with this, we would have attempted to implement different control systems to test their efficiency underwater, including buoyancy engines and reaction wheels.

The chassis design is inspired by the Blue Robotics ROV, which has a central cylindrical pressure vessel housing all the electronics, and 6 props for yaw, roll, and depth control. The frame will be made from HDPE for its low water absorption and the central pressure vessel housing the electronics will be made from acrylic with O-ring secured endcaps.

A prototype buoyancy engine was made with a small syringe and a 3D printed plunger adapted to a servo motor by a bolt, turning the servo's rotation into linear movement by the plunger. The work on reaction wheels from my other project would also have been used to create a module for the AUV.

OSV Design Project





For *ENES100: Introduction to Engineering Design,* my 8 teammates and I designed and fabricated a WIFI controlled robot for a competition among over 50 groups. The objective of the class was to design an Over Sand Vehicle (OSV) capable of traversing a large sandbox with randomly placed obstacles and would have to complete 1 of 5 challenges, all autonomously. The challenge we were assigned involved interfacing with a payload, reading an ASCII character from it, and sending that character back to the main computer.

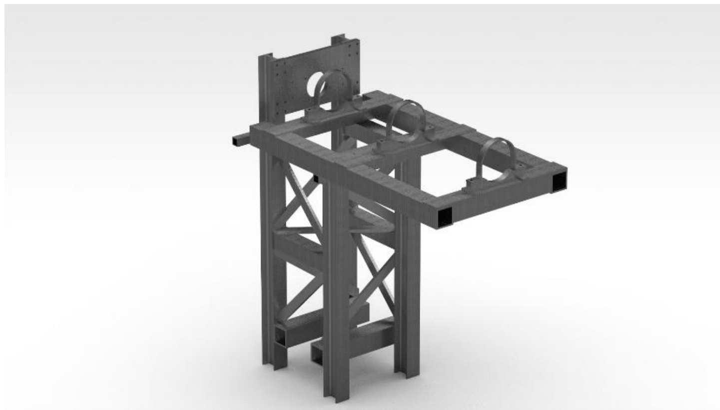
As the only one with prior CAD experience, my main task on the team was to oversee the design of the robot and teach my other teammates to use SolidWorks and Autodesk Inventor efficiently. I designed the main chassis to use a parallel plate configuration and direct drive to the rear wheels with acetal chain running to the front wheels. The whole robot was designed in SolidWorks before any of it was manufactured to make sure that all parts fit theoretically.

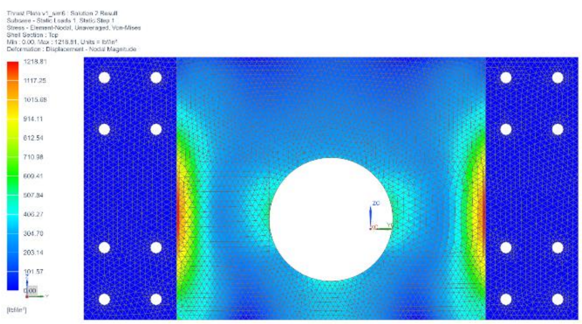
Apart from the chassis, I was also responsible for the electrical subsystem. This involved calculating the operating voltage and current draw of all electrical components, including the motors which were chosen for torque requirements to overcome friction in the sandbox, choosing a battery which would fit our power needs, creating an electrical schematic for the subsystem, and then soldering and wiring the whole robot.

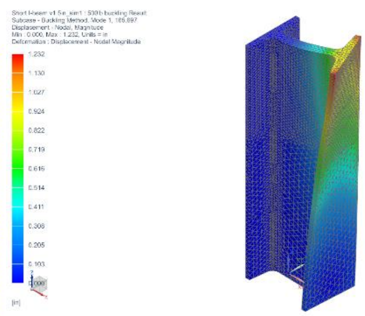
The first iteration of the OSV was laser cut from wood to make sure that it performed as expected, and then after a few design changes and aesthetical additions, the final design was cut from black acrylic and 3D printed.

Our OSV was the only one in our section of 5 to complete the course, and out of all the sections, we won the craftsmanship award for our robust design and manufacturing methods.

Large Rocket Motor Test Stand



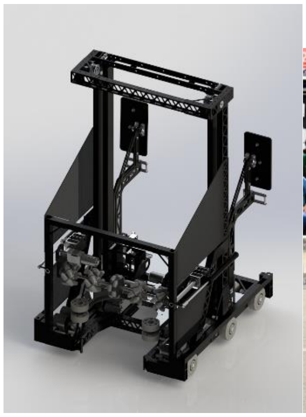




As a member of the vehicle engineering sub team on the Terrapin Rocket Team at UMD, some of the work I did as a freshman involved learning how to use Siemens NX and its simulator to perform Finite Element Analysis (FEA). Already knowing how to use SolidWorks, my transition to NX was seamless and I ended up helping other teammates who were struggling with the software.

My first project while on the team involved working on the design of a large test stand capable of supporting a custom rocket motor that can produce up to 600lb of force. My responsibility was to perform FEA on various load bearing parts of the stand in preparation for a design review with our faculty advisor. The analysis was done using the NX Nastran Solver. The FEA depicted here is of stress analysis of the main thrust plate and buckling analysis of the short I-beam.

FRC 2019 Season Robot



This was our 2019 robot that competed in the FIRST Robotics Competition. The game was Destination: Deep Space, and the objectives of a match included scoring the orange balls on a tall tower, however, circular panels first must be placed on the tower otherwise the balls would fall out. In the final 30 seconds of the match, teams would have to scale the platforms pictured above.

As mechanical captain, I was responsible for making sure that our build season ran smoothly since we only had 6 weeks to build the robot. Before the season started, I would teach new students proper tool handling in our engineering lab and take stock of materials and hardware that we had, and what we needed. I also had the responsibility of operating our CNC router and teaching others how to use it.

The first week involved prototyping mechanisms for manipulating the game pieces and once mechanisms were finalized, we started designing the robot in SolidWorks. The design was constantly iterated on, but the main base stayed the same.

The drivetrain is a single-speed, 6-wheel tank drive where the center wheel is dropped an 1/8th of an inch to better turning. The balls are collected through an extending roller arm that has mecanum wheels on it, directing the balls to the center cutout in the chassis. The claw that manipulates both the panels and the balls can move through the elevator to intake on one side and place on the other. The elevator is another cascading design where the carriage moves proportionately to the first stage.

The climber went through almost 20 iterations (including configuration changes) before the suction pad design was chosen. The pads are machined from aluminum and were custom designed by me. We modified vacuum pumps to adapt to a FRC rated motor and using a check valve and a foam seal, we were able to produce around 1000lb of suction force, allowing us to lift the whole robot off the ground as the suction arms were attached to the elevator. The robot performed exceptionally well and received a technical award at every competition it went to.