nKhetan@bu.edu

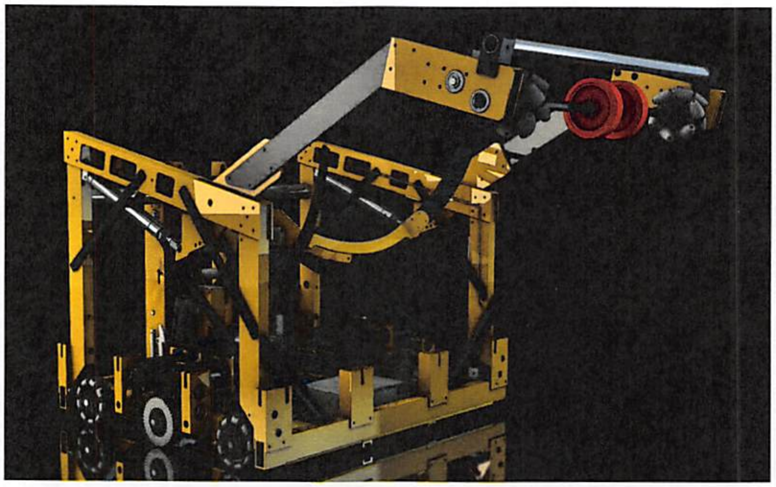
Portfolio

Nikunj Khetan

Render of 2015 Robot Model

2014 Robot Design

I contributed significantly to the design and fabrication of our 2014 robot. The robot was designed to play the 2014 FRC game Aerial Assist. The game involved picking up and shooting a 2ft diameter exercise ball while coordinating with two other partner robots to maximise points.



Render of final CAD model of 2014 robot

2014 Robot Collector Design

I worked on the design for our 2014 collector mechanism to suck a 2ft diameter exercise ball into our robot and load it into our shooter. I lead the prototyping effort to figure out our design parameters and contributed to the geometry specifications of the collector. I worked on the design of the gearbox and motor assembly as well.

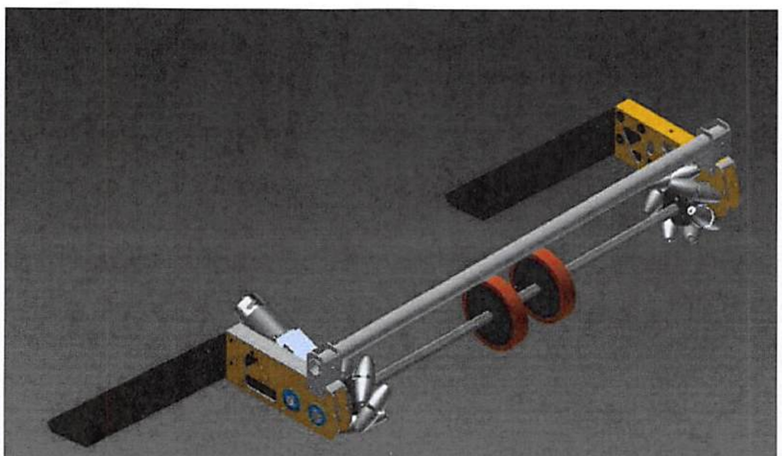
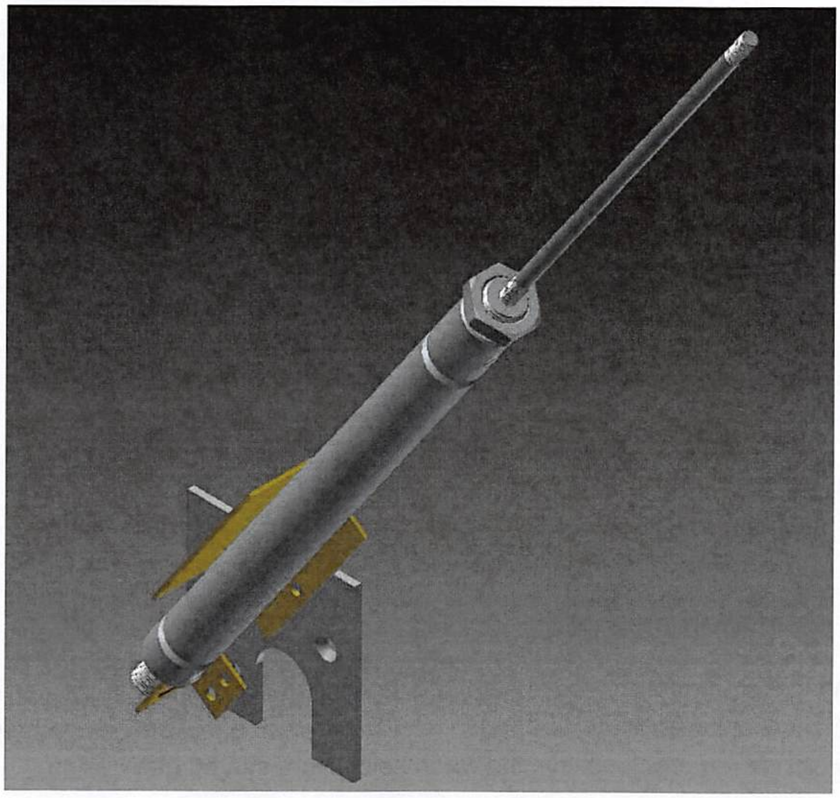


Image of CAD model of final collector design

2014 Robot Ejector Design

In the middle of competition season, we found that in the middle of a match, when the ball was loaded into our robot's shooter, we were unable to unload without firing the shooter if we decided we needed to pass instead of shooting. To alleviate this issue, I designed, machined and tested a pneumatic ejector mechanism to push the ball out of the robot shooter cradle even when it was loaded so we had the option to pass whenever we wanted too.



2015 Robot Arm Design

Render of final grabber design

Choosing a collection method

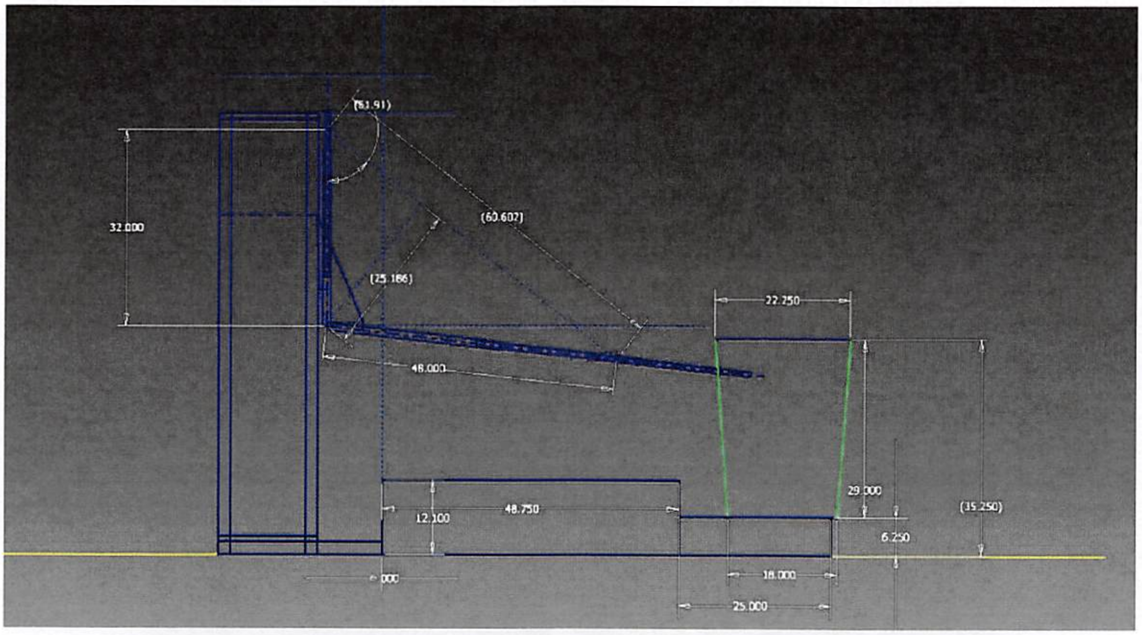
Once we came to the strategic assessment that acquiring the containers in the center of the field was vital to a winning strategy, we had to decide between a few options on how to do it. We had a few design requirements in mind when selecting a can burglar design

1. They had to have a speed greater than potential contenders on the other alliance
2. They had to securely grab the containers
3. They had to fit in a very small weight allowance (~3lbs)
4. They had to be usable in both the autonomous period as well as the tele-operated period
5. They had to overcome the obstruction of the landfill in either period

The conceptual designs we considered were:

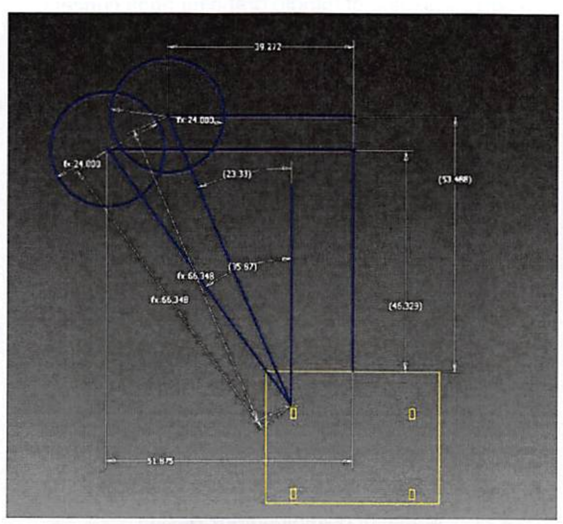
1. A dual wedge/funnel that could be used to funnel the containers off the platform in the center of the field while pushing the landfill out of the way making space for the robot to drive forward.
2. A two part arm with a tensionable hoop at the end which would bend outwards by means of pneumatics and secure the hoop around the midsection of the container by tensioning a rope around the hoop effectively grabbing the container.

3. A 3-part telescoping extender pole with a pneumatically controlled hook which securely grabbed onto the opening at the top of the recycling can by clamping and hooking onto the can at three separate points.



Side view geometry sketch of counterbalancing, retraction and deployment of 3 part extending arm

4. A two part, lightweight telescoping arm which was mounted at the base of the robot frame and grabbed the containers with a simple hook with ridges on its tip to increase its hold on the container. (partial render seen above)



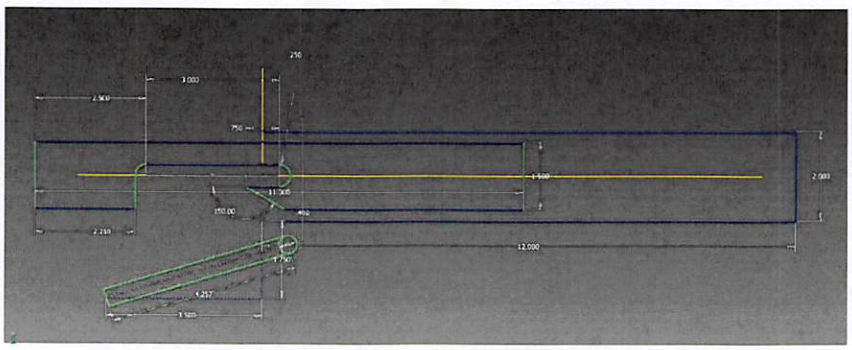
Top view geometry sketch of lightweight arm

Option 1 satisfied requirements 4 and 5 but were determined to be slower than other options. It was reasoned that if other options we had were faster, other teams would be able to create a faster system. Option two satisfied requirements 2, 4, 5 and depending on how it was implemented, possibly requirement one. However, due to the complexity of such a mechanism, its potential weight was deemed to exceed the weight limit. Option three had the same issue. While the initial design seemed to be quite effective in theory, it was estimated to weigh around 15 lbs for two arms. Option four was seen as the best way to satisfy all five design requirements.

Designing a hook

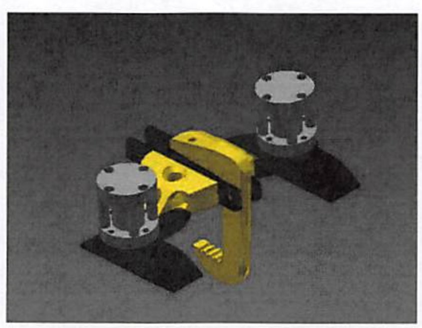
In designing a hook we sought to create a secure gripping method as well as address the issue of being able to use the grabber mechanism anytime during the match. We had three proposed hook designs to accomplish this as follows:

1. A spring loaded hook that grabbed the container at its handle



Side view sketch of handle grabbing hook concept

2. A spring loaded hook that could swivel in two directions allowing the container to be approached from any side which would hook onto the litter opening at the top and then pneumatically clamp down to secure its hold



Model of clamping hook design

3. A simple hook with ridges to hook onto the opening at the top which would rely on the speed of the arm and the robot driving to secure the container

Designing the arm

When designing the arm, several issues and factors had to be considered:

1. Deployment speed
2. Strength and flexibility to resist torsional forces from pulling a heavy container over a long length and insulate the frame itself from any warping
3. Telescoping the arm to reach the necessary length
4. Weight

Solving the weight issue proved to be key to addressing the other issues. For example, we originally telescoped the arm towards the containers by using a second pneumatic cylinder. However, by relying on a tensioned rope to pull the arm out into a telescoped position as the arm deployed enabled us to get rid of the second pneumatic cylinder on each arm saving approximately 1-2 lbs. Reducing the weight also affected the deployment speed. By having a smaller mass with the same bore cylinder, we were able to impart a greater impulse on the arm, thereby increasing the speed with which it moved towards the container. When testing the system, we were able to come close to matching the top teams that won the world championships.

Carbon Nanotube Research

Summary:

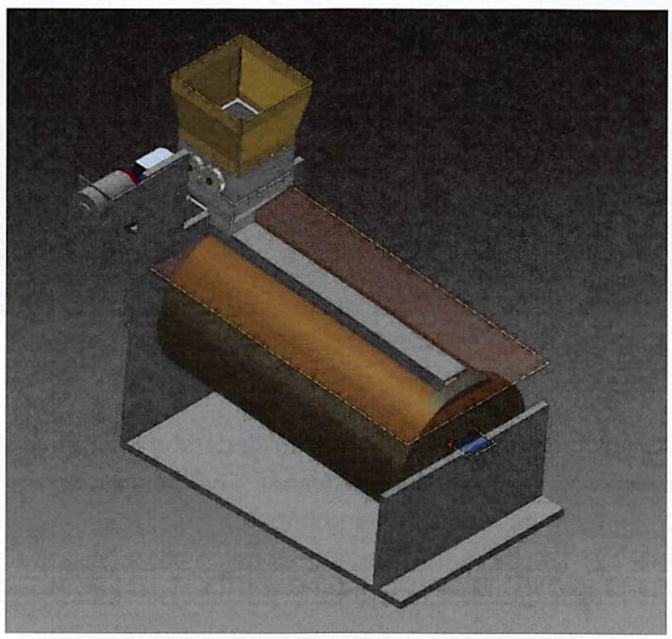
The goal of this research would be to make cheap, scalable carbon nanotubes. Carbon nanotubes (CNTs) are one of the most versatile materials known today. They have a vast number of potential applications such as filtration, semiconductors, biomedical devices, sensors, nanotechnology and structural applications. CNTs are also some of the strongest materials known; they are about ~57 times stronger and significantly lighter than steel. With such a wide array of applications and useful properties, CNTs could revolutionize the way we live. Some of the most exciting theoretical projects using CNTs include a space elevator, nanobots capable of fighting disease on a cellular level, intercontinental bridges and much more. However, producing these nanotubes is extremely expensive, and the single longest nanotube formed so far is only a few inches long. Most carbon nanotubes are made using a process called Chemical Vapor Deposition (CVD) where a gas is deposited onto a specially treated surface (substrate) with the help of a catalyst under carefully controlled temperature and pressure conditions. The dimensions of the substrates can limit the size of nanotubes reducing their yield and effectiveness. In order to make longer CNTs, longer deposition times would be needed allowing delicate catalysts to degrade and become less effective and reusable. In order to cut the cost of CNTs, the materials used in producing them need to be made reusable and the yield and length of CNT growths need to increase drastically. This is achieved by using a highly symmetrical, catalytic substrate stacked on top of a silicon wafer as a mold for continuous nanotube growth perpendicular to the wafer. This method would reuse its components and produce significantly larger yields of nanotubes compared to conventional processes.

Preliminary Design Concepts:

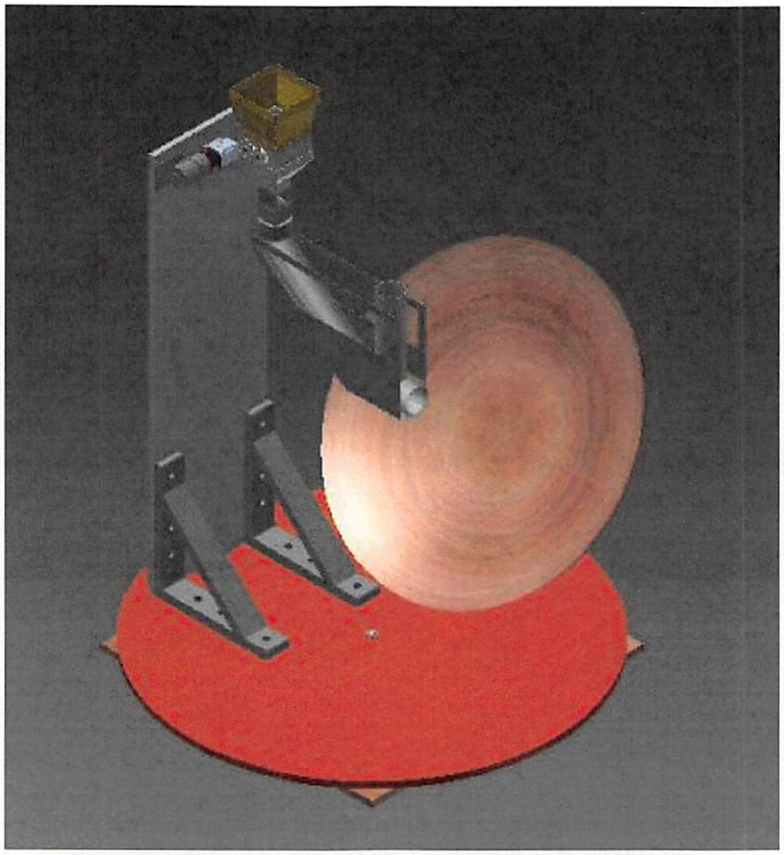
Initially, I was looking to design a complete system where any waste material was incinerated and the resulting gases were filtered for carbon content and then used to make nanotubes. The following design concepts were what I came up with:

Incinerator Design

In designing the system to create carbon nanotubes from trash, the first step was to extract carbon from the waste material. The easiest way to do that was by first breaking down the waste into a gaseous mixture from which carbon could be extracted. In doing so, I would have to be efficient with both material and energy resources to be able to reduce cost. Hence a gas fired incinerator would not be viable as it would require the input of another resource which could just be directly used instead of trash. I focused on the design of an electric incinerator at first but that proved to be too energy intensive and complex so I shifted focus to a solar incinerator. Both models used a custom designed shredder to break down the trash into smaller components increasing the combustible surface area. The solar furnace was mounted on a turntable which could adjust to variations in the sun during the day (change the angle of the dish mount, change the position of the dish mount etc.) The electric incinerator relied on a rotary kiln to displace the contents and accelerate incineration inside the system.



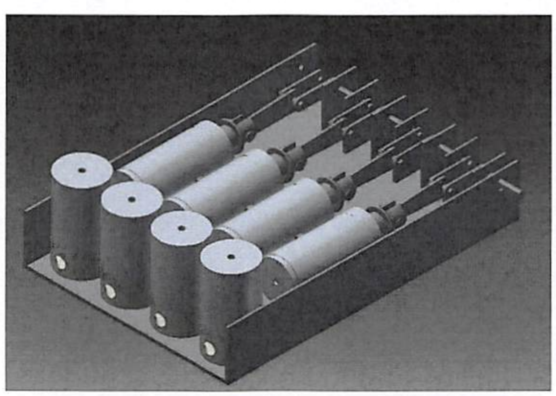
Model of electric rotary kiln incinerator



Model of Solar furnace

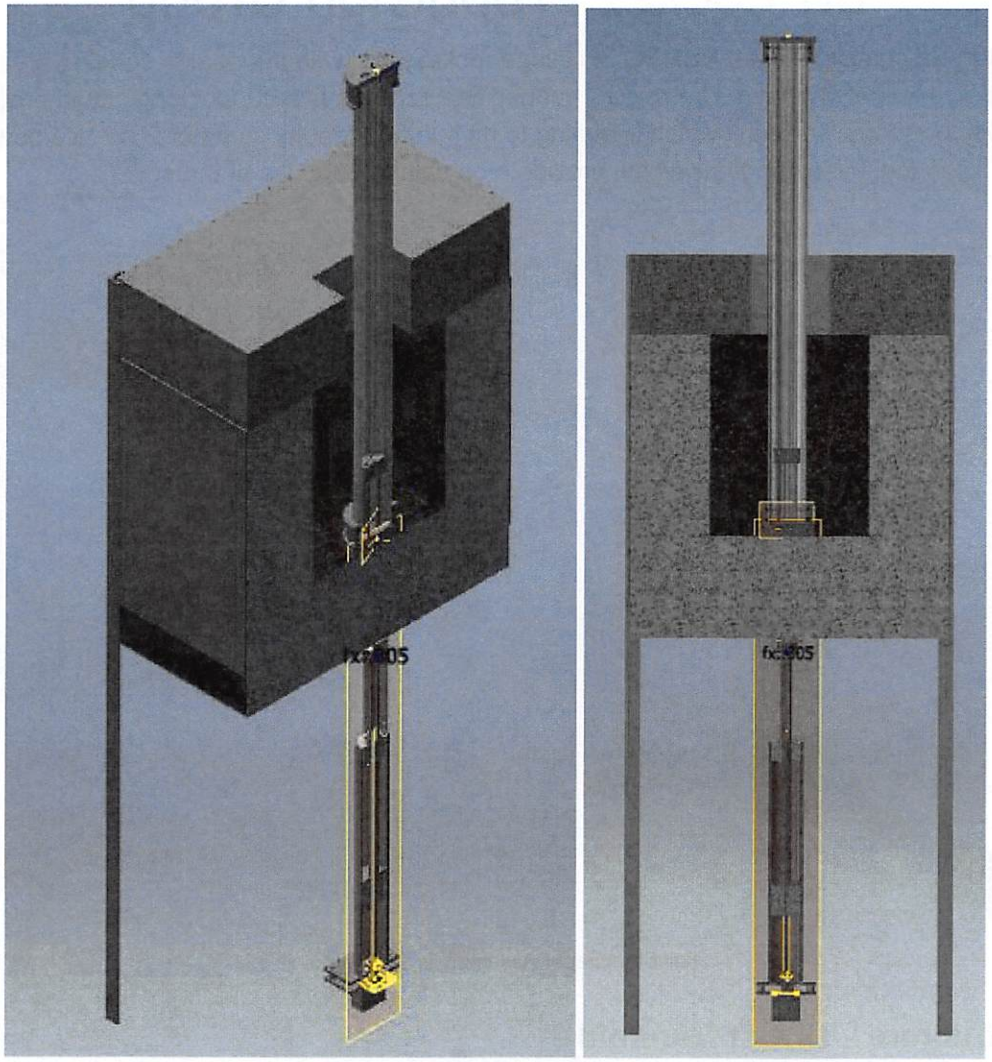
Filter Design

There were several stages to the filter so as to maximize carbon capture and ensure no pollutants were released from the combustion chamber. The catalytic converter completed any unfinished combustion so as to get as much carbon as possible. A specialized HAS filter absorbed and released CO2 for use in the nanotube forming process, and finally, an acid/base scrubber cleaned up an radical agents that formed in the previous processes.



Model of fluidized bed filter system with pump, filter chamber and redundancies

Linear Actuation Design:



Half-section views of current design. Doesn't include plumbing, lid and electronics, including heating elements. Design currently is in the works.

BU Rocket Propulsion Group

At Boston University, I joined BURPG, a college rocket team with the goal of sending a custom-built rocket to space. Our rocket, dubbed Starscraper, is a 30 foot long, liquid propelled, thrust vector controlled beast which is aiming to hit 400,000 feet by summer 2017. It's powered by two liquid fuel based engines which provide a combined 3000 lbs of thrust.

Full Starscraper Assembly in Solidworks

Aft Structure - Thrust Manifold

In order for the rocket to maintain a stable heading, the thrust produced by its engines needs to be directed at an angle to the rocket's axis in order to correct for any deviations from the rocket's flight path. There are two methods by which this could happen, Liquid Injection Thrust Vector Control (LITVC) or Gimbaling. In LITVC, fuel is injected into the engine or combustion chamber at different angles to produce variations in the direction that the thrust leaves the engine. In a gimbaled approach, the entire engine is rotated about the rocket's axis in any direction to change the direction of the thrust. We chose the gimbaling method to solve this problem. One of the drawbacks of gimbaling is that the plumbing or the tubing system that delivers the fuel and the oxidizer to the engine becomes very intricate. To simplify and better integrate this plumbing, I designed a custom made thrust manifold that combined several functions in the engine section into a single assembly simplifying the plumbing significantly.The

Thrust Manifold internally split a single oxidizer (OX) feed line into two separate channels that delivered OX flow to each engine.

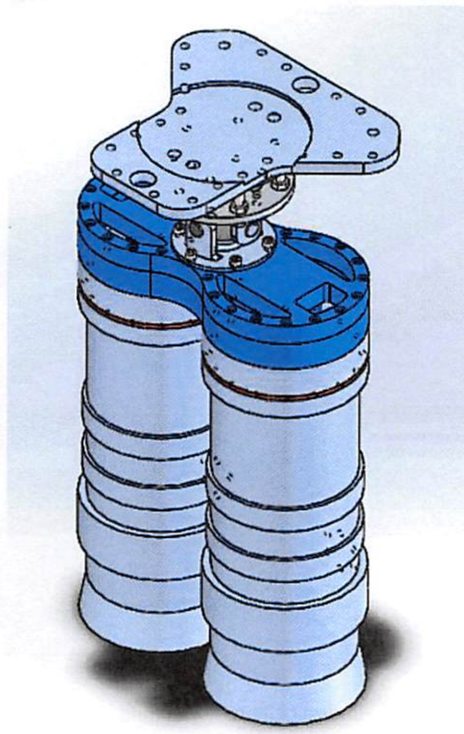


Image of Gimbaled Aft-Structure with Thrust Manifold highlighted

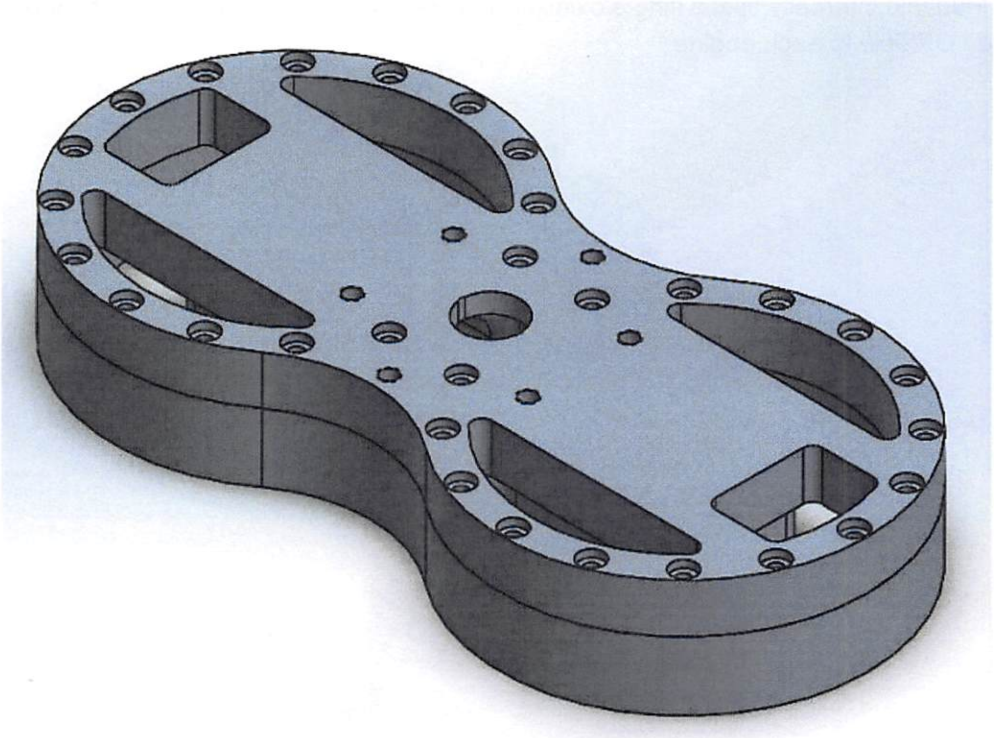


Image of Thrust Manifold

Design Requirements:

- Flow:
  - Minimal interruption to flow of OX from MOX feed to OX dome
  - OX channel should maintain ¾" diameter
- Dimensions
  - Should not exceed engine profile
  - Thickness of overall manifold <= 1.5"
- Mounting
  - Should be able to mount ring joint yokes as well as attach to ox-dome

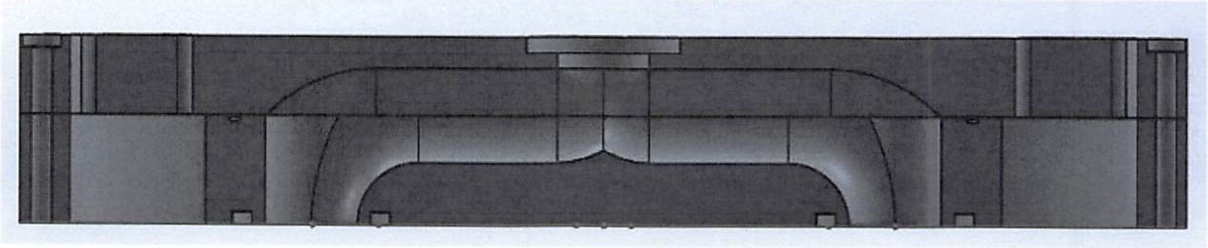
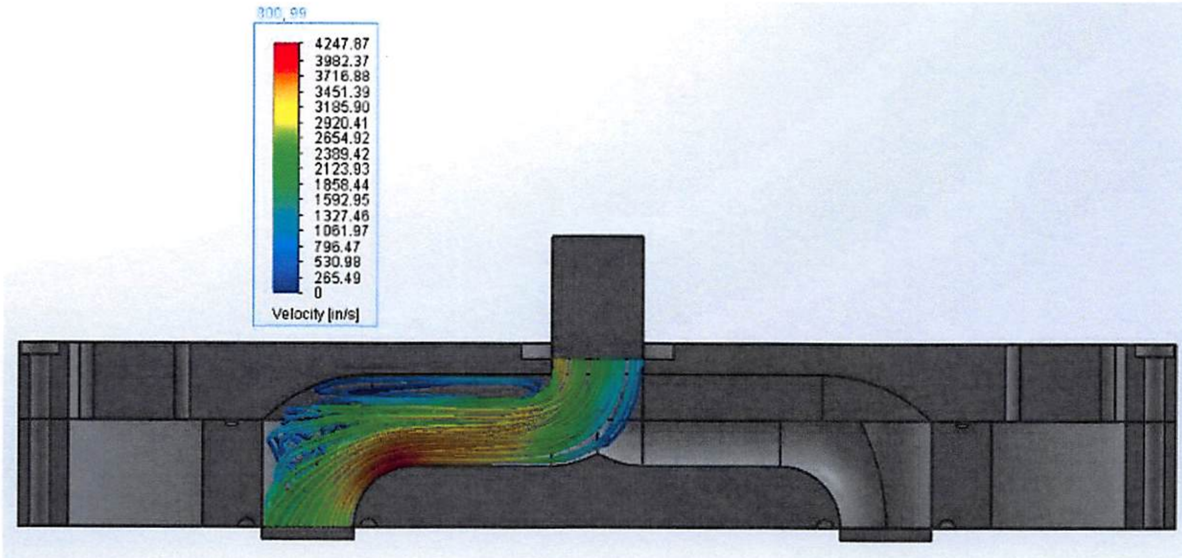


Image of internal channel

Flow Analysis:

- Resolved flow separation issues by arcing channel from center plane to outlet
- Analysis indicates limited flow separation around outlet
- Input pressure: 900 PSI, Output Pressure: 400 PSI



Stress Analysis:

- 6061 Aluminum: 35,000 PSI yield strength
- hand calc stress across base: 500 PSI
- Max von mises stress: 741 PSI
- Factor of safety based on hand calc: 70
- Factor of safety based on solidworks: 47

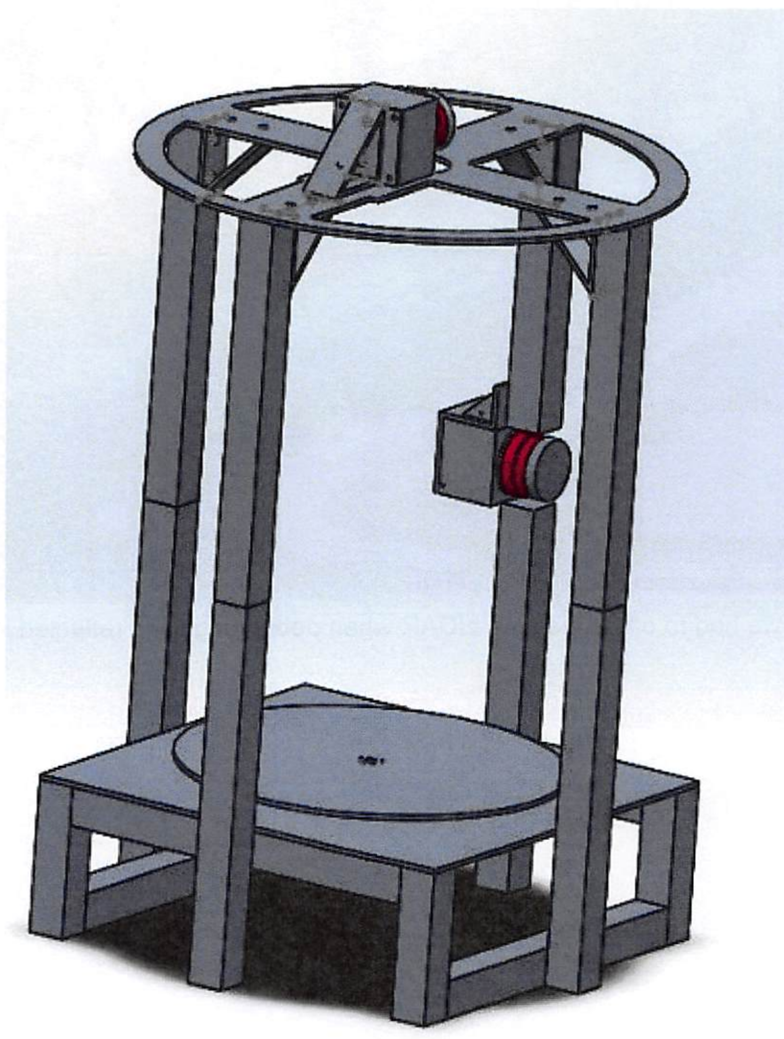
Sealing:

- Face seal between two sections can use standard o-ring according to parker representative. O-ring has been speced and fitted for given space, they will send us a sample
- AS568B-206 o-ring for static industrial phase seal against ox-dome
- Sealing and connection to MOX feed TBD based on bellows

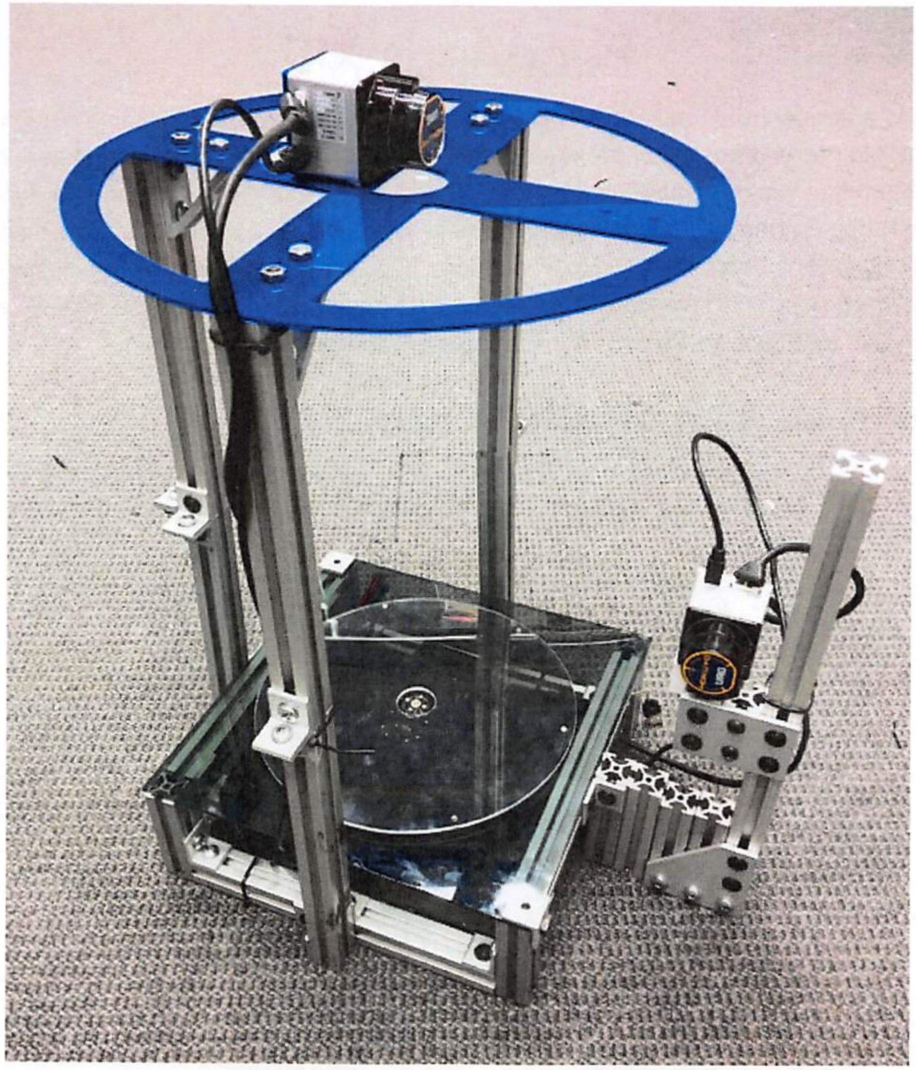
PennApps XIII

PennApps is a semiannual hackathon hosted by the University of Pennsylvania's engineering department. I joined a team of my friends and we built a 3D scanner over a weekend in January for the competition. We designed the scanner in solidworks and wrote the code for it in ROS (Robot Operating System). The scanner essentially had an object on a turntable which was scanned along two planes/axes by LIDAR sensors. This produced two separate Point Cloud Files which were merged to create our 3d image. The scanner got us into the final 10 at the competition and also won us an award for our use of rapid prototyping.

Github repo link: https://github.com/anuragmakineni/laser_scanner



CAD model



Final Design, we had to offset the side LIDAR when debugging, isn't reflected in the model