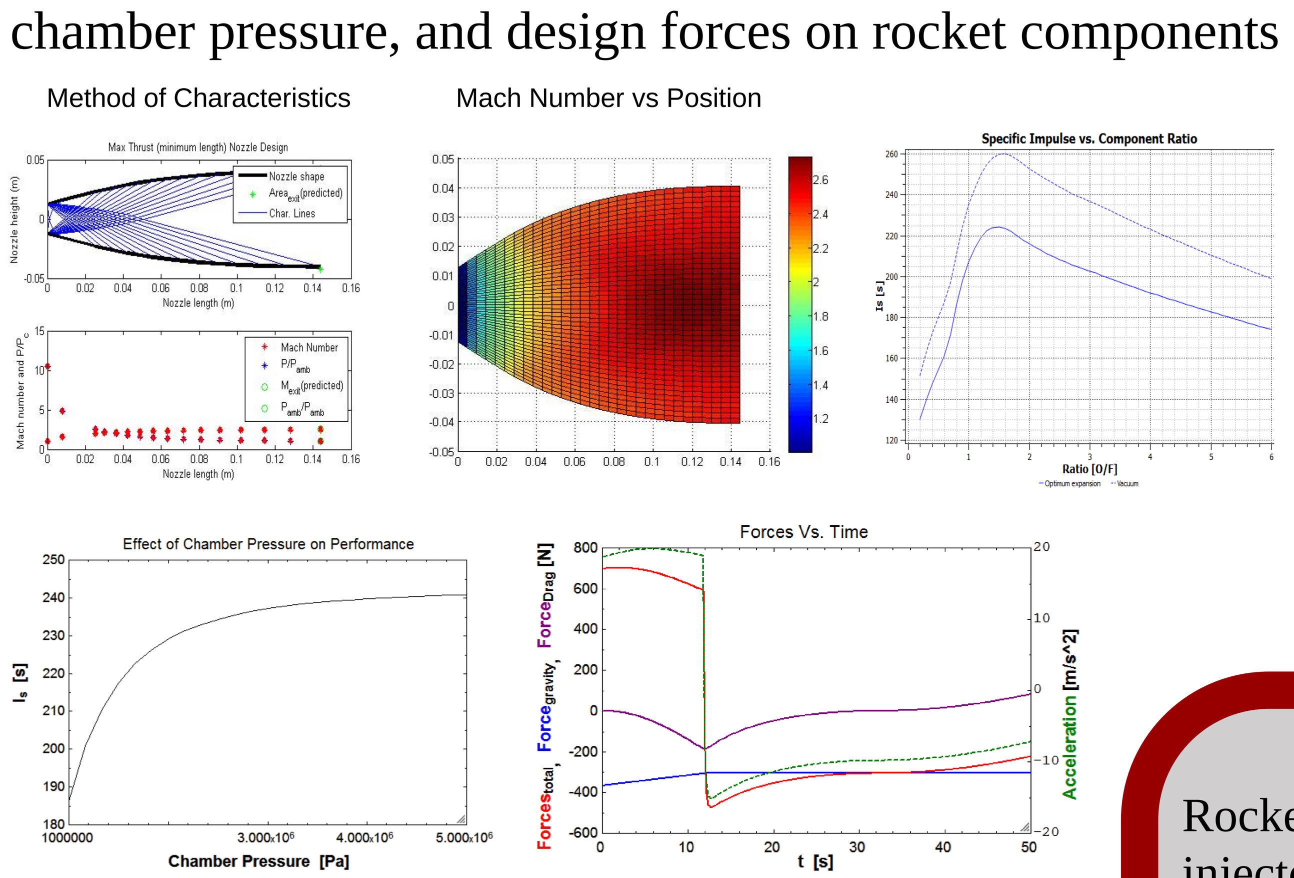
Washington State University's First Liquid Propellant Rocket Design

From Left to right: Connor McBride, Matt Will, Lucas Verge, David Nguyen, Mack Bailey, Mario Reillo, Marshall Crenshaw, Justin Stanton, John Feiler, David Estrada, Kevin Cavender, Andrew Doornink, and Zach Hein, with Franco Spadoni and Den Donahou not pictured here

The Maths

Engineering Equation Solver, Rocket Propulsion Analysis, and Matlab were used to develop models and determine design parameters. The models were based on desired flight characteristics. Some critical design parameters included fuel and oxidizer mass flow rate, thrust chamber pressure, and nozzle diameter. The figures below show critical design plots used to design the bell nozzle, select the fuel mixture ratio, chamber pressure, and design forces on rocket components



To Infinity and Beyond!

A group of students with no prior rocketry experience sought to research rocketry in order to design and fabricate a low cost liquid propellant sounding rocket within a 16 week semester. Our team goal was to learn as much as we could about rocketry and to aim high.

The overall objective of ME 483 Applied Rocket Design was to compete in the 10th Intercollegiate Rocket Engineering Competition, and to prepare students for careers in the aerospace industry.

Spray and Pray

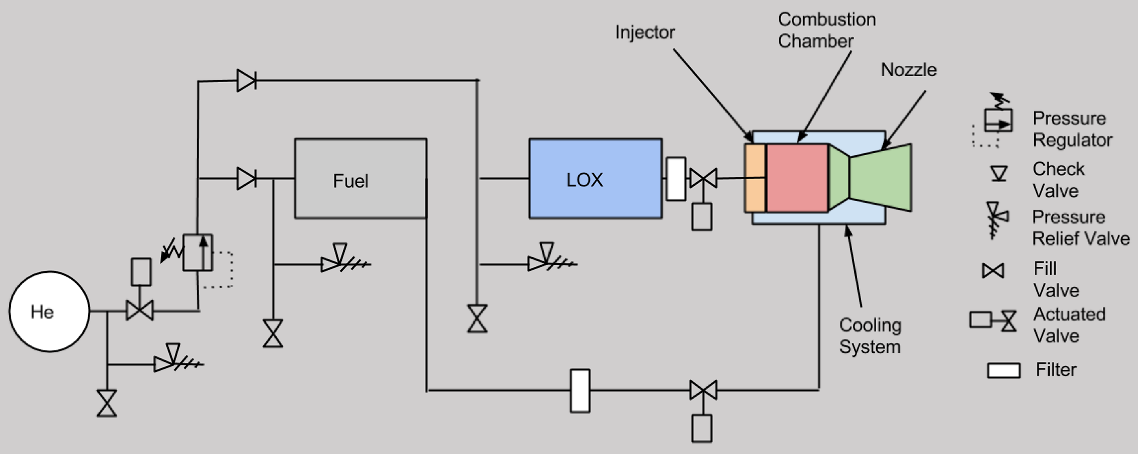
Injectors focus streams of fuel and oxidizer to allow them to mix and create an atomized cloud in the combustion chamber.

The design of the injectors influence the mass flow rate and mixture ratio of fuel and oxidizer into the engine. The volume, pressure, and temperature of the combustion chamber is also influenced by the injector design.

Our injector is based on a pentad style where 4 streams of liquid fuel impinge on a single stream of gaseous oxidizer. This component was designed to be simple to manufacture and give an acceptable fuel oxidizer mixture. Three design iterations were necessary to streamline the manufacturing process. CAD models and MasterCam code focused on DFM principles which gave both a clean surface finish and low machine time.

Rocket Arteries

Rocket feed systems control the flow of fuel and oxidizer to the fuel injector. This feed system utilizes high pressure gas to pressurize the propellant tanks and force fuel into the combustion chamber.

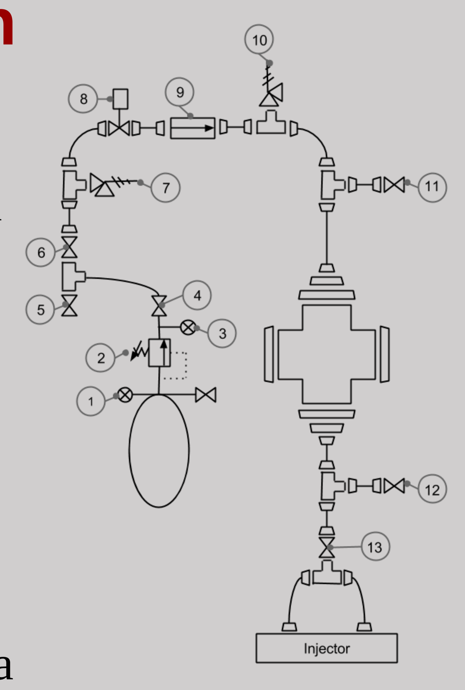


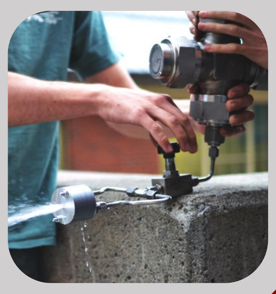
Propellant Selection

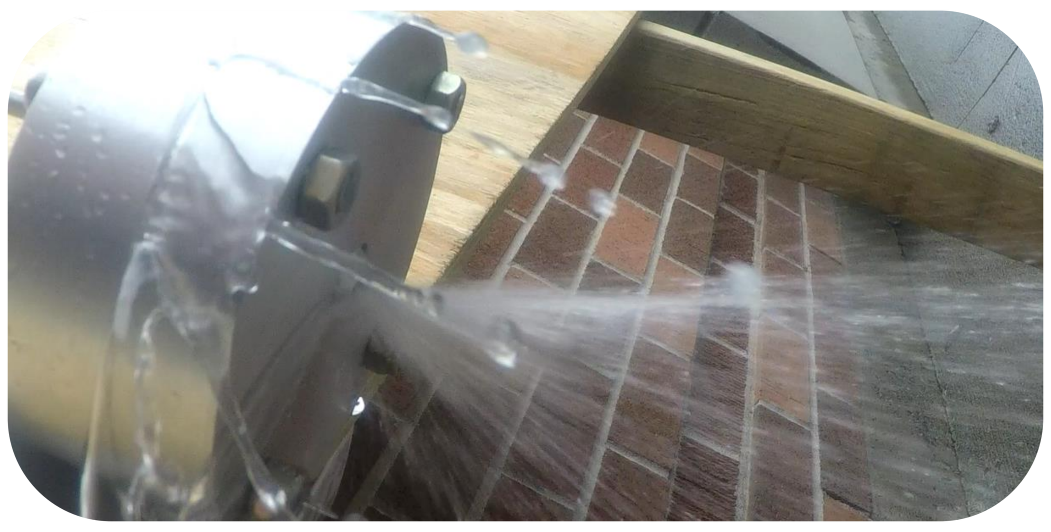
Ethanol and LOX were selected as our fuel combination because of the high energy density. Ethanol is readily available and is easily handled. LOX handling presents a significant challenge, however the size savings are worth the difficulty.

Test System Design

The test system is designed to test high pressure components and various injector designs. In the system, the maximum pressure in the helium tank is approximately 1,500 psi regulated to 650 psi in the rest of the system, with pop safety valves at 750 psi. The lowest pressure rating on a single component is 1,200 psi, giving a factor of safety of 1.6.







The Results Are in…

From the completed tests, we can see the strengths and weaknesses in our design. Sealing the injector face was done with an indium seal. The injector version 2.0 successfully tested at 100 psi. Next step is to test at higher pressures to characterize the injector close to the final design pressure.

Fire!!!

Thrust chamber was designed by using the characteristic length and the Method of Characteristics. Some constraints were in-house manufacturing abilities, material compatibilities, and manufacturing time.