Non-Homogenous HTPB/Paraffin Fueled Hybrid Sounding Rocket

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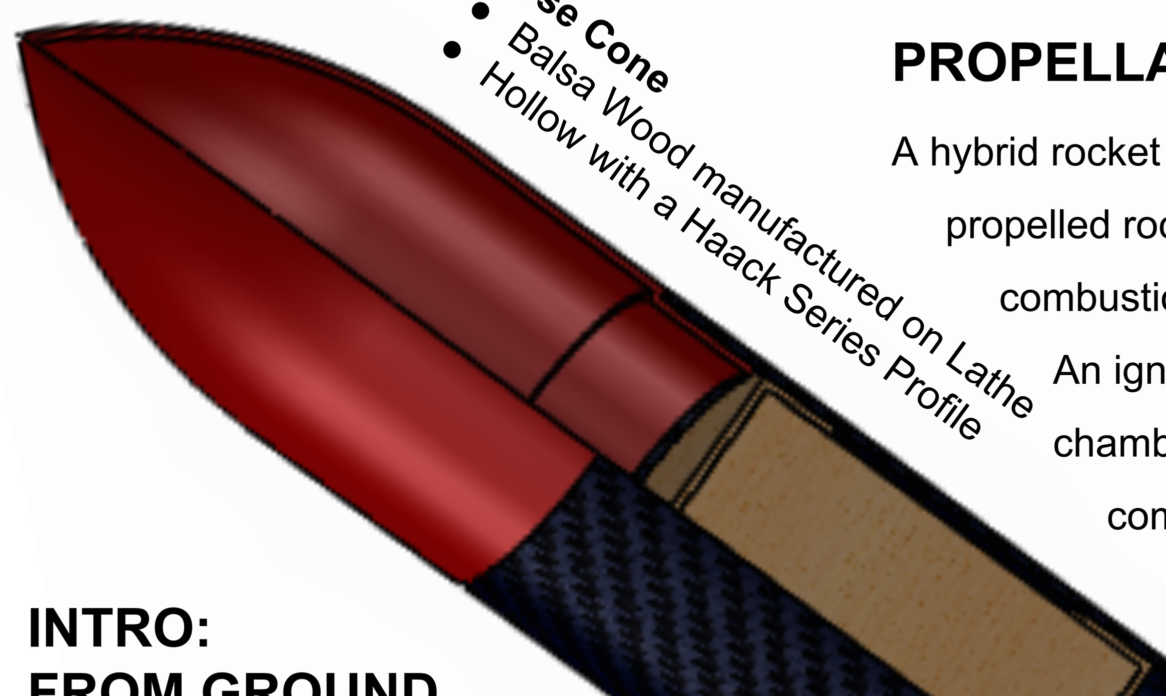
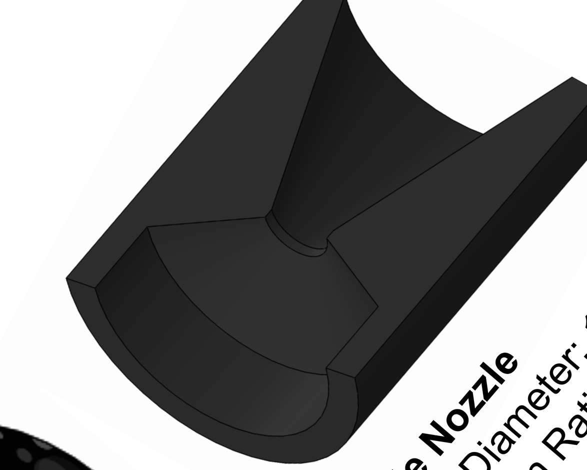


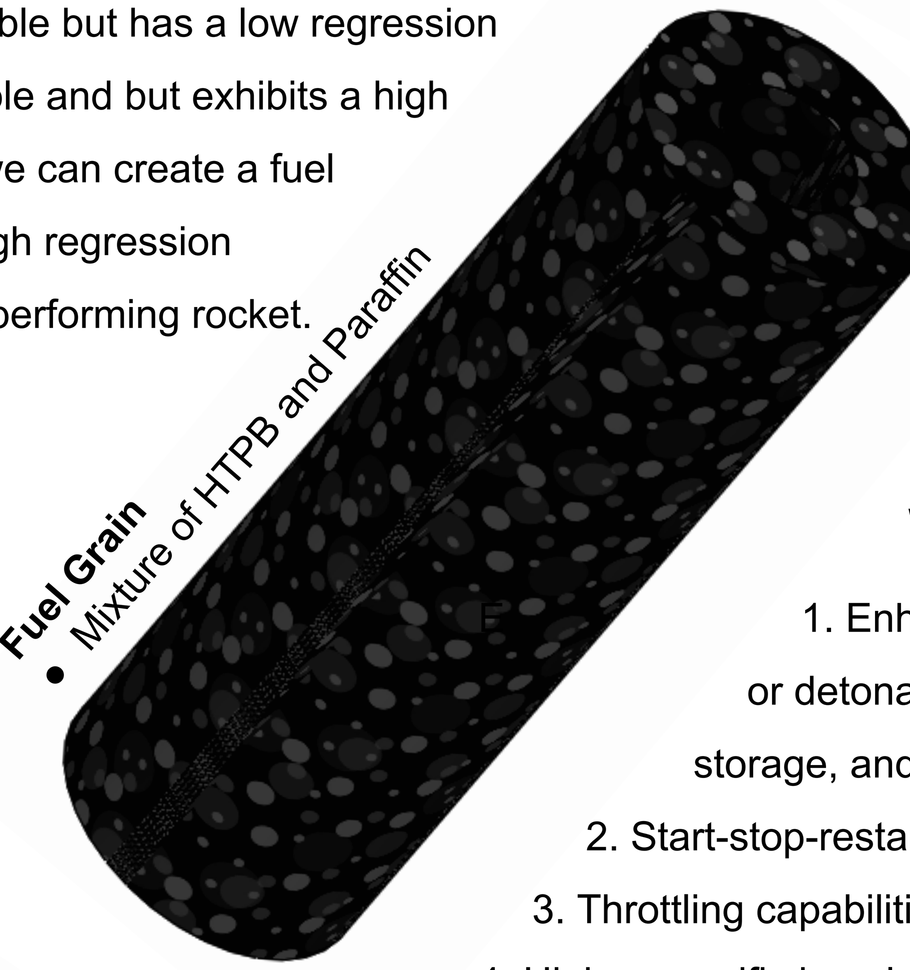
PROPELLANT 101

A hybrid rocket combines the simplicity of a solid propellant rocket and the efficiency of a fluid propelled rocket. Our hybrid utilizes a liquid nitrous oxide oxidizer that is injected into a combustion chamber which holds a solid non-homogenous HTPB/Paraffin fuel grain. An igniter combusts with the oxidizer, raising the temperature of the combustion chamber. This raised temperature melts the top layer of the fuel grain which combines with the oxidizer to produce more combustion.

WHAT IS NON-HOMOGENEOUS FUEL?

Non-Homogenous fuel is a fuel in which two chemicals are mixed together with only physical bonds to connect them. In our case this means our solid paraffin wax is mixed with our liquid HTPB to create a mixture which has the benefits of both HTPB and paraffin. HTPB is structurally stable but has a low regression rate while paraffin wax is structurally unstable and but exhibits a high regression rate. By combining these two, we can create a fuel that is both structurally stable and has a high regression rate. This is extremely desirable for a well performing rocket.

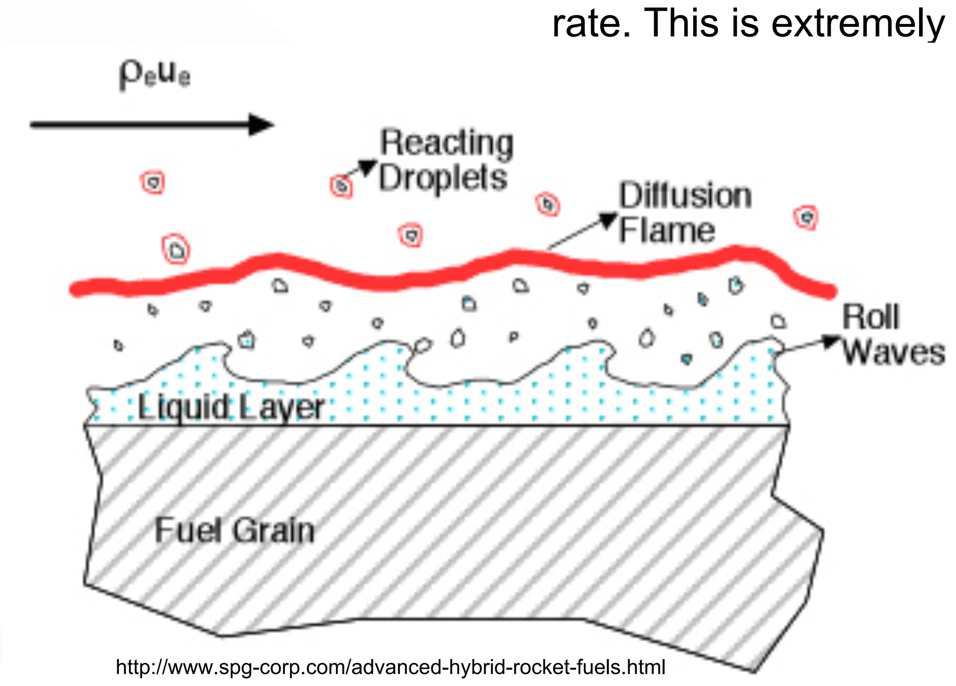




INTRO: FROM GROUND ZERO

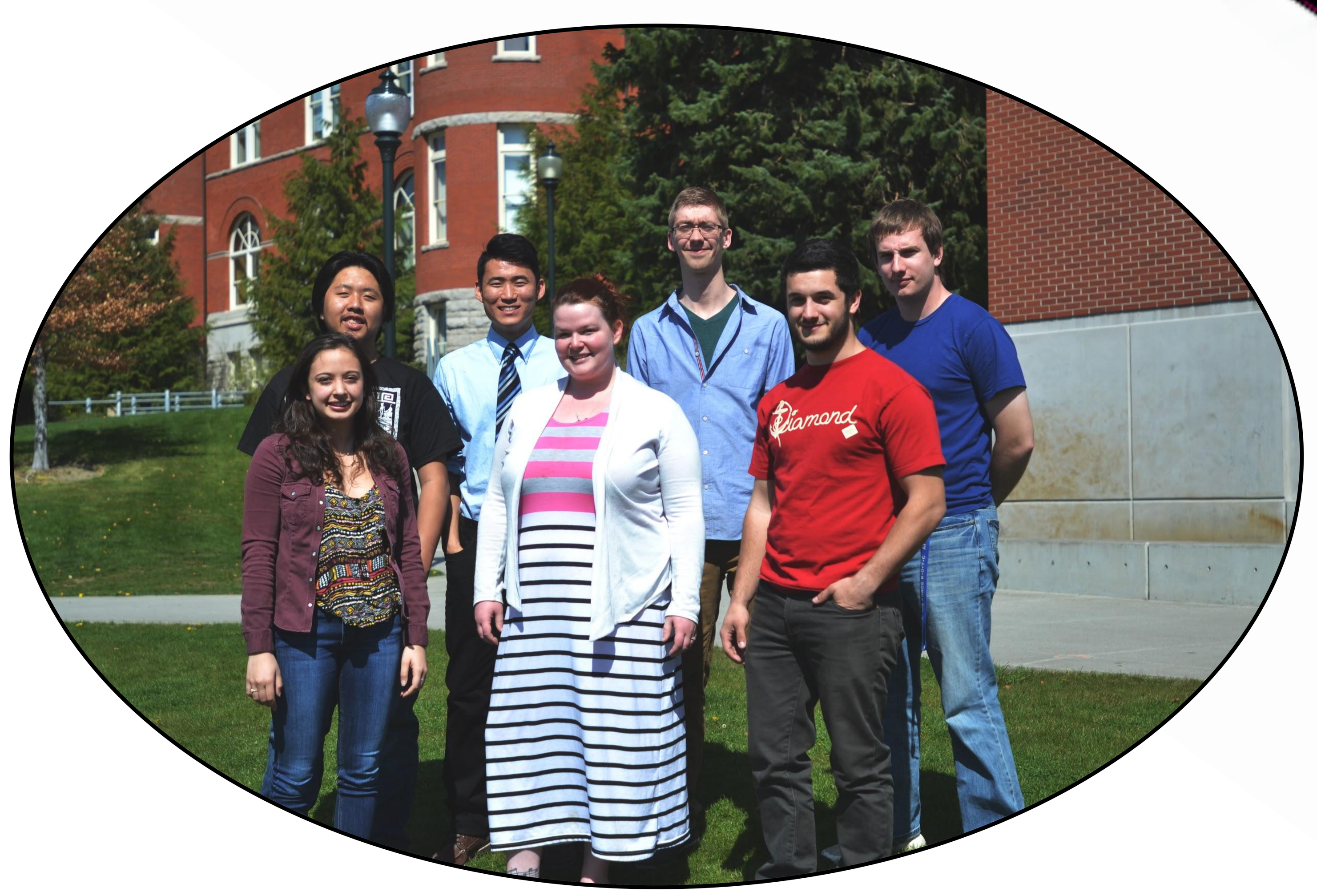
In the spring of 2015, a new class was started at Washington State University titled Applied Rocket Design. The class was divided into three teams of undergraduate mechanical engineers each with a different type of propulsion system. Through a generous donation from Paul Laufman, each team was provided with a $3,000 budget to design, build, and test a sounding rocket. At the end of the semester, the three rockets were scheduled to launch and compete in the Experimental Sounding Rocket Association competition.

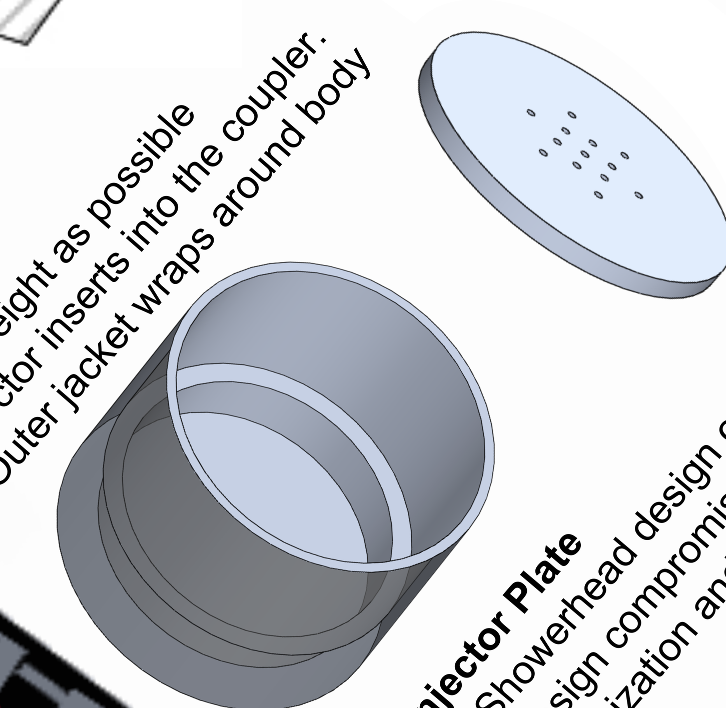
Oxidizer Tank
• 6061-T6 Aluminum
• Threaded Bulkheads
• Optimized for 750 PSI



WHY HYBRID?

1. Enhanced safety from explosion or detonation during fabrication, storage, and operation
2. Start-stop-restart capabilities
3. Throttling capabilities
4. Higher specific impulse than solid rocket motors
5. Higher density- specific impulse than liquid
6. Relative simplicity = low overall system cost compared to liquids
7. Easily refueled and reused





Air Frame
• ⅛" thick Carbon Fiber
• 94" length
• 4.5" outer diameter

3,2,1 - LIFT OFF

Desired Impulse: 5100 N-s

Total Weight: ~40 lbs

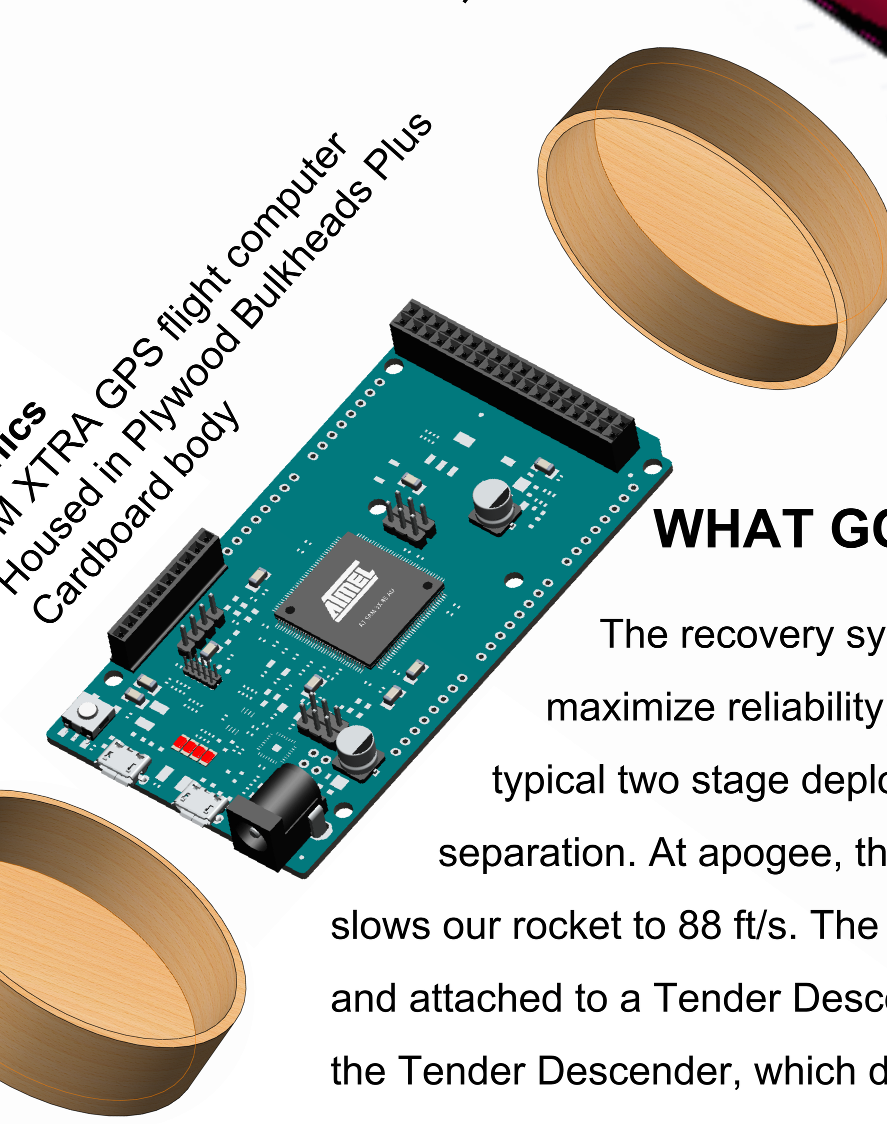
Projected Thrust: ~1900 N

Overall Rocket Height: 8 Feet

Desired Altitude: 10,000 Feet

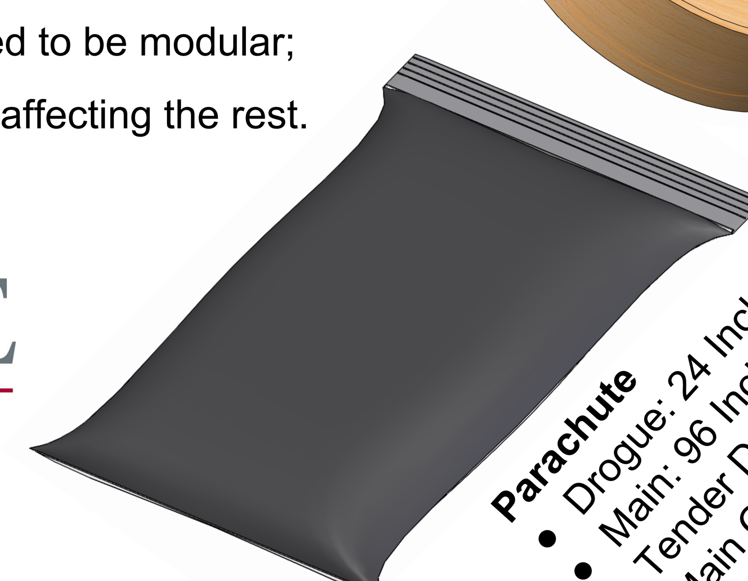
SYSTEM DESIGN: INEXPERIENCE MEETS ENTHUSIASM

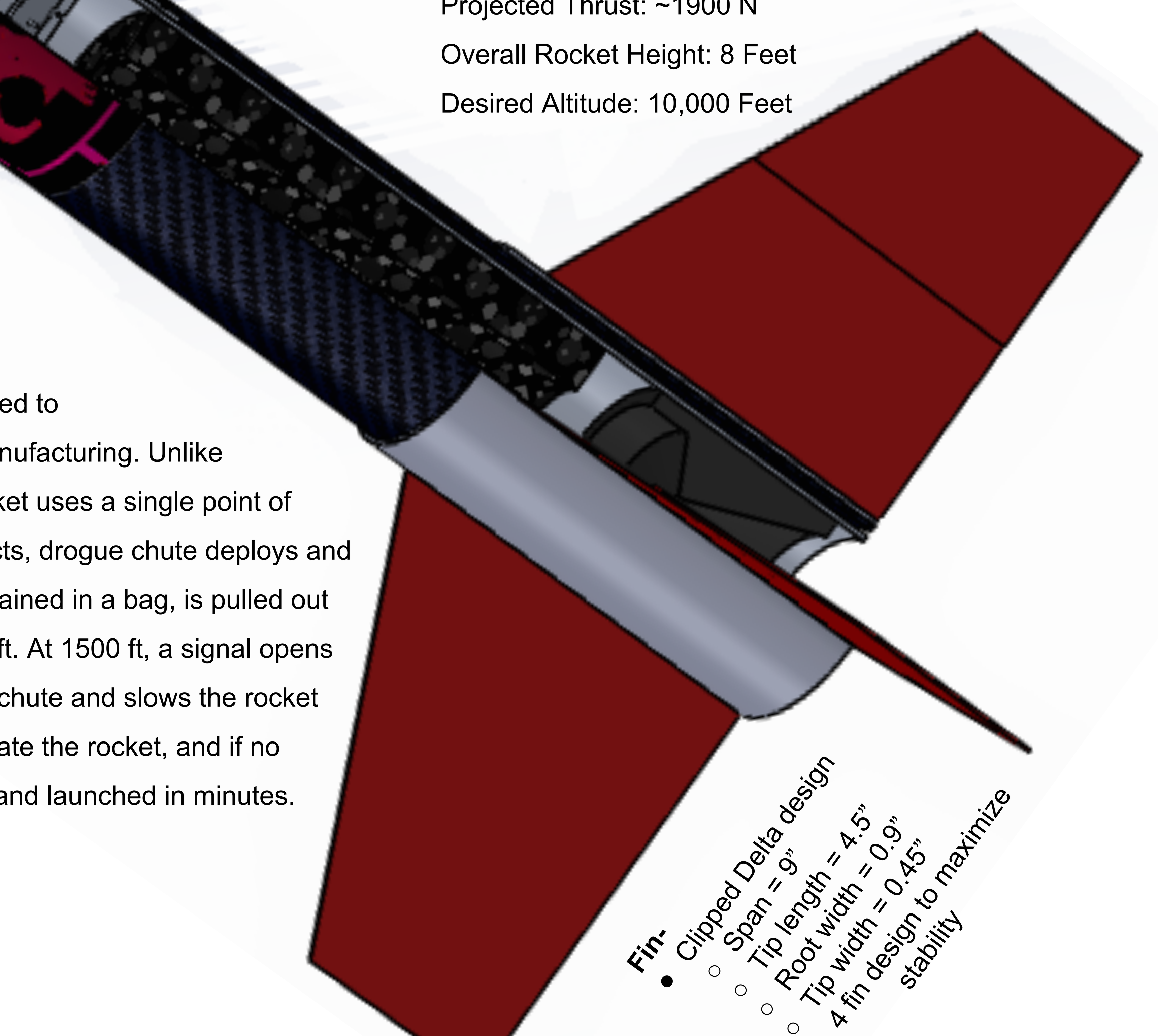
The students had no prior experience or knowledge to propel them to an easy design, just abundant enthusiasm. As a function of the class, each week was divided into major design challenges that built upon each other; the teams prepared and presented to the class the knowledge and decisions they had developed that week. This collaboration allowed the teams to build upon one another's failures and successes. The engine system was the most complicated part of the design. The properties of a hybrid engine is determined empirically, meaning that our design process was based on assumptions that could not be confirmed until tested. To overcome this challenge, the rocket was designed to be modular; every component was meant to be replaced individually without affecting the rest.



WHAT GOES UP . . .

The recovery system was designed to maximize reliability, and simplify manufacturing. Unlike typical two stage deployments, our rocket uses a single point of separation. At apogee, the nose cone ejects, drogue chute deploys and slows our rocket to 88 ft/s. The main chute, contained in a bag, is pulled out and attached to a Tender Descender until 1500 ft. At 1500 ft, a signal opens the Tender Descender, which deploys the main chute and slows the rocket to 20 ft/s. A GPS tracking system will help to locate the rocket, and if no damage is present, the system can be refueled and launched in minutes.





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