Background

The Waterloo Rocketry Team will be participating in its 4th annual IREC competition with this year's 9th IREC. The Waterloo Rocketry Team has a proud history of designing, testing, and building rockets for this competition. In 2011, the team developed "WRT 1", our first ever hybrid rocket and the only one in the competition that year. In 2012, the team developed the "Eridani", a propane based rocket that was over 15 feet tall and 12 inches around. In 2013 the team developed the "Silver Brant", a liquid nitrous oxide and HTPB hybrid rocket, which sadly concluded with a frozen injection valve on the launch pad. This year, the team has developed "Vidar", another liquid nitrous oxide and HTPB hybrid, based off the previous year's design. This rocket has been designed for the amateur category and hopes to have a successful flight all the way to 10000 feet altitude.

The Engine

Vidar's engine is an N-class rocket engine designed to provide 15120 N-s of impulse, and it is entirely student designed and built. The combustion chamber is made of 1/4" thick, 4" OD aluminum pipe, measuring 23.5" in length. This chamber has been designed to withstand pressures of over 2000 PSI, which is much higher than the 350 PSI predicted by both our simulations and multiple engine tests. The combustion chamber houses a 3.5" OD PVC pipe around the fuel grain, for the simplicity of transferring the fuel in and out of the chamber. The nozzle at the end of the combustion chamber is a straight walled converging diverging nozzle machined out of a solid block of graphite.

The Injector System

This year's rocket also includes a completely redesigned injector system, designed to eliminate the possibility of a frozen valve that plagued our previous rocket. Instead of a check valve based system, this year's rocket incorporates a shower head injector with a ball bearing plug for the central filling hole, based off of Hypertech's system. The shower head has 6 holes drilled into it, providing an equal flow rate for the oxidizer for each of the fins of the fuel grain.

The Recovery System

The recovery system this year consists of both a drogue and a main parachute. The drogue chute is a 3 foot dome chute and the main chute is a 8 foot Taurus chute. They are each stored within their own separate fiberglass sections towards in the top sections of the rocket. Upon reaching apogee, the onboard Ravens will trigger the drogue chute to deploy by pressurizing the cabin and shearing the shear bolts holding the sections together. Each section has a 38g CO_2 canister to pressurize the section. The CO_2 ejection mechanism is a reversed engineered Rouse-tech CD3.The main chute deploys once the rocket descends past 3000 feet altitude, in a similar fashion to the drogue chute.

The Aerodynamics

The rocket has a Von Karmann style nosecone, which will be epoxied into the top of the drogue chute section. The nosecone consists of 10 pounds of concrete with a 3D printed blue polycarbonate shell. Since the rocket is not expected to go supersonic during the flight, the nosecone did not have to be designed to withstand as high of temperatures and pressures that the solid rockets will see. The fin-can is a welded aluminum tri-fin system, connected to the rocket through a radial bolt pattern. The maximum dynamic pressure of the rocket is predicted to be 113.5 N. The rocket has been designed to have a stability of 2.2 calibers off the launch rail.

Vidar Rocket Specifications

Launch Weight: 65 pounds

Overall Length: 131 inches

Outer Diameter: 4 inches

Class: N Class engine with 15120 N-s Impulse

Max Thrust Output: 400 pounds

Predicted Burn Time: 8.0 seconds

Max Q: 113.5 N

Solid Fuel: 1.5 kg of 90% HTPB, 10% Aluminum Powder

Oxidizer: 6 kg of Liquid Nitrous Oxide held at 700 psi

Designed Flight Altitude and Range: 12000 feet and 20000 feet respectively

Recovery System: 8 foot Taurus Main Chute and a 3 foot Dome Drogue Chute

Flight Avionics: Two Ravens for flight critical operations, student built data logger, and two onboard cameras

Updates since the 8th IREC

This year's "Vidar" rocket is almost entirely student designed and built. Our team members have spent the past year refining and testing all aspects of the design, in order to maximize the probability of a successful flight occurring. We have conducted multiple engine tests, hydrostatic tests, recovery tests, injectors, and many other various tests. We have also completely redesigned our injector system, replacing a complex series of plumbing valves and fixtures with a much more elegant shower head and ball bearing design. This design has been tested with pressures up to 2000psi, much higher than anticipated during the launch.

The Fuel

The fuel that will be used in this year's hybrid rocket is 90% HTPB and 10% aluminum powder for the solid fuel, and liquid nitrous oxide as the oxidizer. The liquid nitrous oxide is held in the oxidizer tank at roughly 700psi, and will be continuously vented to maintain the desired pressure to keep it a liquid. The solid fuel is cast into a 6 spoke star pattern within a 0.25" thick, 3.5" OD ABS pipe. This six spoke star pattern was chosen in order to give the rocket a relatively neutral thrust profile, by keeping the instantaneous burning area relatively even at all points of the burn. The fuel is bonded to the PVC pipe in order to provide insulation to the combustion chamber, and also inhibit any inward burning of the fuel structure.

The Avionics

This year's rocket incorporates two commercial Ravens as its flight computer, and also a student built system for data logging and tracking. The Ravens will flight critical avionics and altitude sensing, and the student built computer will operate separate and non-critical functions such as data logging. The rocket will also house two onboard cameras, independent of the flight computer systems. These cameras include a sideways shot of the horizon, with the camera mounted behind the fiberglass shell of the avionics bay, and a downwards shot, with the camera being mounted slightly outside the rocket's cylindrical profile and having a 3D printed plastic aero-shroud to protect it.

The Launch Tower

Our launch tower is a repurposed radio tower, measuring 40ft in height once fully erected. The main structure of the tower has been used by the team for many years, though the based has been redesigned this year on order to allow for easier erection. In the past we would pour a concrete form around the base of the tower and submerge it a set depth into the desert floor. This year we have a completely new system at the base of the tower, one that allows us to build and assemble the tower in a horizontal state and rotate it into position before the scheduled launch time. The launch rail is 32 feet long and made of 1515 extruded aluminum rails. Two launch lugs on the rocket will guide the rocket smoothly up the launch rail.