**ME 756 Senior Design**

**Spring 2018**

**Testing Plan**

**Team 13**

**Project Name:** SEDS Student Rocketry Competition

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**Testing Plan:** The engine of our rocket needs to be tested to ensure that it will meet the required specifications. The engine is limited by a maximum total impulse of 640 N-s. The thrust must be experimentally measured to ensure the engine falls within the limit of 640 N-s. This will be done through the use of a static test fire rig (STFR). The rig will be comprised of a load cell and a tube casing to hold the engine. The rig will be oriented such that the thrust from the engine will be applied downward, exerting a variable force onto the load cell underneath. Ideally, the rig should be adjustable so multiple iterations can be performed with different engine sizes. This will be achieved by employing adjustable set screws along the circumference of the tube. It is important to consider different engine heights as the engine exhaust should be exposed to the atmosphere so that there is no pressure build up in the tube or contact between the flame and fixture. The different engine heights will be accounted for by inserting an aluminum rod spacer into the casing to account for shorter engines.

The maximum expected thrust is around 100 lb, therefore a 150 lb load cell will be utilized. The STFR and load cell configuration will be wired to an external power source (12V battery) and an amplifier and connected to a laptop for data acquisition. Data will be acquired using VirtualBench software and downloaded and imported into Matlab for further analysis and clear visualization of the results. The force data will be converted to impulse and both thrust and impulse measurements will be compared to the experimental characteristics of the rocket engine. Verifying that the engine does not exceed the maximum required thrust will not only make the team eligible for competition but the data will also prove useful in future calculations involving the aerodynamics of the rocket and fuel rate consumption.

Apogee height is one of the deciding factors in selecting a winning team for the competition. Once the carbon fiber rocket body is laminated and manufactured, the team will test the rocket nose cone and fins in the UNH wind tunnel and calculate the coefficients of drag. Such information will be helpful in optimizing the rocket characteristics and maximizing launch height. We will need to design a fixture with a rod and clamp to securely hold the nose cone inside of the wind tunnel so that it cannot move or spin in place. A solid setup will provide for accurate force readings, and ultimately a more accurate measurement of the drag coefficient.

With rocketry, one of the most important tests is the actual launching of the rocket. Our first (and possibly first few) launches will be test flights. We will ultimately iterate upon and improve our design before our final competition launch. We have calculated various aerodynamics of the rocket, estimated the launch height, and are working on modeling the rocket trajectory. By finding the drag coefficient of the rocket profile, we are able to more accurately measure the effects of drag on the rocket and better estimate the apogee height. Further investigation will be done into testing the full-size rocket in the wind tunnel as well.

The altimeter that will be secured inside of the rocket nose cone will record the change in height of the rocket over a measured period of time. With such measurements, we can calculate the falling speed of the rocket during recovery. The rocket, by competition criteria, cannot fall faster than five meters per second. Careful consideration will be taken to ensure the electronics within the rocket deploy the parachute as close to apogee as possible. Doing so will ensure that the rocket does not exceed the maximum falling speed before parachute deployment. Additionally, the size of the parachute will determine the recovery speed of the rocket. Ahead of the test launch, we will estimate the speed at which the rocket and parachute unit will fall by treating the rocket as a hanging mass and modeling the system. By doing so, the team can then decide what size parachute to use.

We want to be sure that the rocket does not fall too fast but we also don’t want the parachute to be too large and create too much air resistance. Unless we are launching in pristine conditions (which are rather rare for our location), even slight winds could cause the rocket to drift far away if the falling speed is too slow; making it difficult to retrieve. The calculations will require some simplifying assumptions, however, and a test flight of the rocket will allow us to make sure we are satisfying competition criteria. The results from the altimeter data will allow the team to measure the speed of recovery and test the accuracy of our calculations. If the falling speed exceeds five meters per second, the team can then consider a larger parachute design that will decrease the descending speed of the rocket.