VDR 3 Report

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EML 4551: Senior Design 1

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***Current State***  
 Our current design is in its early stages - we are creating CAD and cardboard models to develop the structure of the testing apparatus. The design involves using a knife edge to split the airflow, allowing half of a crater formation to be measured by a camera. This assumes that the crater and jet plume will be symmetric, which is a valid assumption based on previous tests done by NASA.

We have obtained a tank to be filled with air and the pressure regulator, along with some extra piping that can be used. Our preliminary tests will be completed with a converging nozzle where the flow characteristics can be determined through the area ratio and regulator pressure. Additionally, the appropriate tubing (likely polyethylene) must withstand the required pressure. To restrain the nozzle, we are considering placing plates behind the nozzle to absorb the thrust in conjunction with straps or clamps to ensure the nozzle remains stationary.

The data NASA is most interested in is the scaling effects of a hypersonic nozzle on the crater formation and depth. Since the relative elevation (height/diameter) of the nozzle must remain the same, the height of the jet must change as the diameter changes. To accomplish the change in height, an adjustable arm with pegs at the desired locations will be used. Extra care will be taken to ensure that the arm is stable and has minimal play between the pieces.

***Forecast***

We have created a tentative spring project plan that includes a schedule of our future work. There are many specific tasks to complete but most can be categorized into creating our rig, quality assurance, and data acquisition. While we have a baseline for the main goals that must be accomplished over the spring semester, these goals can be broken down into sub-goals, which need to be delegated to different members of the group to ensure success. The most immediate forecast includes several more iterations of our design with CAD and an eventual physical prototype. From that point more improvements may be made depending upon performance – the goal is to fail many times at the start to get a quicker understanding of what works and what needs to be improved upon.

***Problem Areas***

The first issue that our group encountered was the small nozzle diameters (0.1-1 cm). Our team is still deciding the manufacturing procedure to achieve these dimensions, but machining is likely. The small size will also make characterizing the jet with a pitot probe to be much more difficult, requiring very fine movements (potentially we will use micrometer screws).

Triggering the camera and nozzle to run at the same time is another problem; we are currently using an iPhone for slow motion, and while the framerate is more than enough, the triggering system may cause some issues. The video format is also of some concern, as the video may have some compression artifacts depending on the encoder that would affect detailed image comparisons. It will likely be possible to get a slow-motion camera from the FCAAP labs – if a non-iPhone camera is needed, we will be able to adapt our design with hopefully little difficulty.

The depth of the sand bed is another issue that will need some preliminary testing for. To determine a rough depth of the sand required, we plan to run a test with just a supersonic nozzle pointed at a bed of sand. The test will be a bit rough but should give a good enough estimate to inform the rest of the tests.

The stability of the knife edge will likely require some iteration to obtain a level of stiffness that is sufficient, especially at supersonic flow velocities. Vibrations would have a drastic effect on our results and so must be nearly non-existent to measure accurately.