VULCAN II

Recovery Failure Analysis and Prevention

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The Recovery Team identified several major places where failure could occur and implemented design choices into the recovery system to minimize the probability of catastrophic failure. Places where failure was most prominent: electronics to deploy the parachutes, nose cone attachment, drogue attachment, and deployment of the primary parachute. Loading of structures during deployment was seen as a possible form of failure, so collaboration with the structures team to certify that the rocket would not fail from the parachute load.

Avionic Redundancy

Avionics has many different points of failure that have to be prepared for. Examples include; power loss, sensor damage/inaccurate readings, GPS connection, and ematch board/main computer failure. Careful software design like filters to notice inaccurate data from sensors, and the ability to read multiple sensors to determine recovery activation, will help to reduce the chance of failure but do not solve the issue of major electronics failure. Vulcan-II will make use of a redundant avionics system that will be nearly identical to each other and will be entirely isolated (seperate power supply, sensors, e-match charge deployment).

Pyrotechnics

To find the black powder amount needed to pressurize the chamber and release the drogue. Rigorous testing will be conducted to find the amount of black powder needed and how it should be packed in the container. The amount of powder used should be able to easily break all three shear pins and eject the nose-cone.

To ignite the black powder and release the quick releases, 2 e-matches are redundancies so there is always a second igniter. The quick releases are also redundant to ensure minimize failure of the system.

Nomex blankets are used to cover the drogue chute to prevent damage from occurring when the charge explodes. During deployment of the drogue, the blanket will eject along with the chute and fall away.

Primary Deployment

The greatest force that the rocket will experience during the duration of its flight is the shock load during the opening of the parachute lines. The load could compromise the structures and rip apart the internal structures of the rocket. To minimize the shock load, a sliding ring is being used. A sliding ring slows down the line open velocity so the parachute unfurls and catches the air slower. It is wrapped around the upper harness lines. It “slides” down the lines. Slowing their deployment. The calculation of the force went from about 3000 lbf to 1000 lbf. All load bearing structures have been chosen with high loads in mind with these parts having a load rating of over 4000 lbs.

Harnesses

The harness is composed of several components, all of which are designed to withstand high amounts of tension force caused from the parachute opening force. The components are arranged where a nylon cord runs from the main chute to a quick-link; then two nylon cords run from that quick-link to two other quick-links that mount the harness to the tanks in the rocket. The parachute opening force is expected to be roughly 1000 lbf. The nylon chords are rated over 4000 lbf and the quick-links connecting the chords are rated to 5000 lbf in shock and 2100 lbf in loading. This gives a safety factor of 5. The harness will be directly mounted to the tanks in order to transfer the entire load on the full structure of the rocket to maximize structural integrity and minimize failure. Structures also confirmed that their mounts should be able to withstand this force.

Nose Cone Attachment

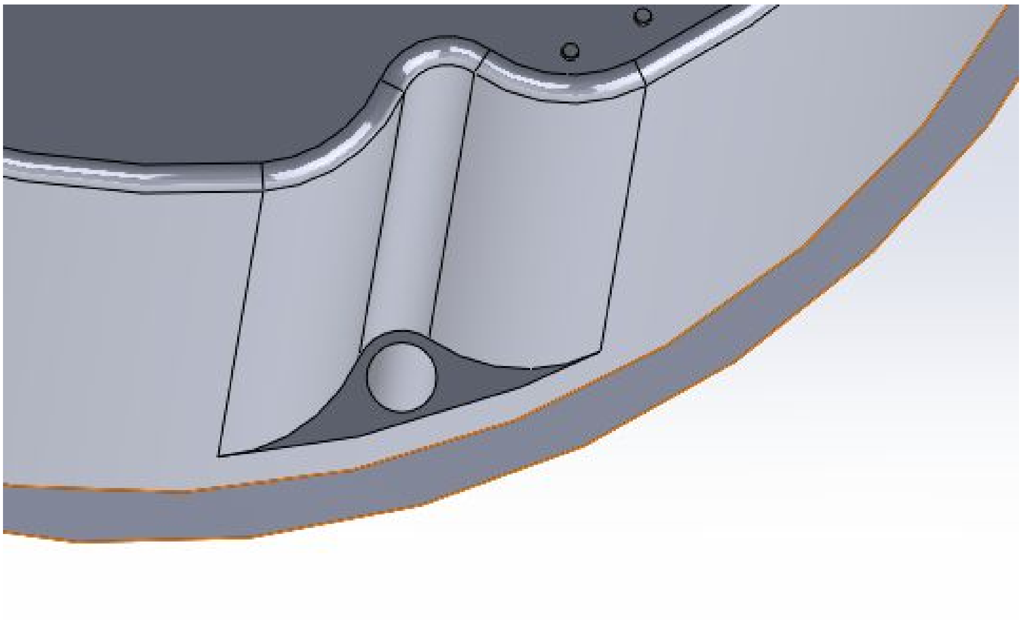

Figure 1: Close-up of the bypass tube. Rounded surface is for smoothness

The nose cone is where the most important payload of the rocket is being held, the competition payload which ultimately will give the final score. This is being attached to a shackle on top of the helium tank. A kevlar rope serves as the linkage and is rated to 2000 lbs minimum breaking strength, which is many times the max load the nose cone is able to exert. The kevlar rope runs through an aluminum tube on the inside wall of the recovery chamber that serves as a bypass through the chamber so the rope will not tangle any other components of the recovery system. And the max force expected to be exerted on the nose-cone itself is 685 lbf, but that is during deployment of the drogue when the tether is not in tension.