SENIOR DESIGN ORGANIZATION SYNOPSIS – SPRING 2013

Design, Analysis, and Construction of a Reaction Control System for an Orbital Launch Vehicle

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In recent years, university research has been expanding to include experiments in space. Universities seeking to launch their projects into orbit have to wait for a launch, which not only allows for the desired mass allocation, orbit altitude, and inclination, but also the deployment mechanism for their experiments. The most common orbital experiment run by universities involves the use of a 3U cubesat. This is a standardized 10cm x 10cm x 30cm frame that houses instrumentation.

To facilitate these orbital experiments for universities, NASA has created the Nanolaunch program. The program's purpose is to design and build a $1.2 million orbital launch vehicle, to be followed by a $250 thousand version once more research is done to reduce costs. This will allow more universities to gain access to orbital experiments through a large reduction in cost. It also grants the university more control over launch time. The 33-foot tall rocket needs to be able to place a 3U cubesat into a 6 hour to 6 month orbit.

In order for an orbital launch vehicle to achieve its intended orbital altitude and inclination, the desired trajectory requires several corrections that pitch the vehicle over from the initial launch attitude to a tangential pitch (relative to Earth). This allows the vehicle to accelerate to orbital velocity. The separation of stages and other unknowns can also cause the vehicle to steer slightly off its intended path. While most of these effects are counteracted through spin-stabilization, some additional active correction is still needed. In order to correct the pitch of the orbital launch vehicle and steer it onto its intended inclination, a reaction control system (RCS) using thrusters is needed. The Nanolaunch program is looking for the most financially viable RCS that will meet the mission requirements.

The goal of our project is to design a reaction control system that reduces cost, mass, volume, and complexity. NASA's current RCS prototype for Nanolaunch uses four on/off solenoid switches with various pipe adapters to control four cold gas (CO_2) thrusters. Our concept revolves around one selector valve and one solenoid switch. The selector valve will be controlled by a stepper motor which will align the ports needed for proper RCS operation. Pitch, yaw, and bi-directional rotation is possible with the port combination. The RCS has been designed with Solidworks and will be analyzed with Solidworks Flow simulator, ANSYS, and other software as resources become available. A prototype made of delrin (acetal) and acrylic is currently being built and will be tested with compressed air. NASA will 3D print the final version in titanium to be used with a carbon fiber 4500 PSI tank regulated down to 1100 PSI. The required force per RCS activation is currently set at 10-15 newtons. Our design will produce 106 newtons at maximum pressure using 1/8" tubing. This allows for leeway in requirement changes, flow losses, and other unknown effects.

Our concept eliminates heavy pipe adapter fittings, reduces the failure points due to the elimination of pipe connection points and solenoid switches, and reduces the cost of parts. The incorporation of our design into the Nanolaunch250 will enable NASA to meet their budget requirements in offering universities more control and affordable access for their orbital experiments.