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ME476C-001, 21Spr01-GA
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From: 21Spr01-GA

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Re: Individual Analysis Topics Memo

The following memo will discuss each of the 4 primary topics of analysis decided upon for the project. Additional analysis will be done as the project progresses, but this will serve as a starting point for further decisions and considerations as the group begins the prototyping process.

Worm Gear Setup (Travis Harrison)

In order to accurately relocated the center of gravity along the x and z directions, we intend to shift the CubeSat along the top of the stand. The current plan is based on a similar concept to how a 3D printer moves the bed which is held in place along the axis with small wheels along an aluminum extrusion. The two primary concerns for this are accuracy and guaranteed self-locking properties. After consultation with Dr. Penado, a worm gear setup was suggested as it can be self-locking, even under significant forces. With the gear reduction possible through a worm gear setup, high locational precision can be achieved as a single revolution of the worm pinion may move the setup by as little as 0.1 mm. This system will consist of a worm pinion driven by a motor, a worm gear that mates with the pinion, and a rack mounted along the bottom of the section that needs to be relocated. For the analysis of this concept, a MATLAB code will be constructed to analyze available gearing setups for the level of precision offered, checking the self-locking properties, running the standard AGMA worm gear tests to ensure that the system will not fail under the required conditions that will be present, and the cost associated with such a setup. As the other consideration to achieve this goal is a system that operates using lead screws, the precision and price of both systems will be compared directly to assist us in deciding which route to pursue. If we decide to go down this path, some additional analysis will be done for the shafts in which we will mount the worm gear to.

Lead Screw Setup (Sean McGee)

As mentioned previously, a lead screw system is being considered as an alternative to a worm gear system. In this system, motors will drive trapezoidal profile threaded rods. The carriage is mounted on these lead screws by using compatible lead screw nuts. A second, similar assembly will be used in tandem to provide translation perpendicular to the first screw axis. This may afford similar performance to a worm gear system at a reduced weight, but the self-locking properties of lead screws varies depending on their specific design. This analysis will quantify design constraints for such a system. The chief concern will be identifying circumstances under which such a system exhibits self-locking behavior. These requirements will impose the initial constraints for further design analysis, including screw diameter, lead angle, tooth profile, and material. Frictional losses and required power input will be quantified and compared across various design options. Additionally, the performance of multiple parallel lead screws will be compared to the performance of a single lead screw combined with simple linear rods and bearings to support the carriage. Finally, a detailed initial design will be generated using the best-performing combination(s) of these elements.

Should it be identified early in this process that no lead screws perform adequately, the analysis will alternatively focus on the design of a simple, robust braking system to keep the carriages stationary. This may either alleviate the self-locking requirement of the satellite relocation system or can provide an additional level of safety in the event of a failure in self-locking behavior. Required braking force, mechanism, design, and materials will be identified which provide a reliable and safe mechanism to prevent unintended movement of the satellite.

Motor Comparison and Analysis (Scott Mesoyedz)

Considering all iterations of this project require a motor, one individual analysis topics is a trade study on different types of motors. The three types of motors that will be evaluated are direct current motors, inductive motors, and pneumatic motors. This will include a comparison of the torque speed characteristics for each motor. Torque speed characteristics is the relationship between the mechanical torque and the angular velocity of the motor. Then there will be a work analysis to determine how much work will be necessary to accomplish the goals of the design. The next point of comparison will be power output to find which motors have enough power to perform the work required. If the power is too little, the motor will not be able to move the mass needed. However, too much power could result in damage or injury. A last criterion being analyzed is the magnetic field production for each motor. The client specifically requested that the magnetic field production be minimized so it will not interfere in their experiment. Another piece of information that will be included is a breakdown on magnetic field shielding cloths and faraday cages. If a motor performs better than the others, but produces a significant magnetic field, it may still be a viable option if it can be properly shielded.

Identifying Location of Fixture Center of Gravity

The purpose of this project is to collocate the center of gravity of the bearing-fixture-satellite assembly with the center of rotation of the spherical air bearing. In order to complete this task, the center of gravity location must be identified. The location of the center of rotation will be known within the system as it is the center of the spherical bearing. Locating the center of gravity can be accomplished with force sensors. The idea for the use of force sensors was utilized by the previous year's team. Other potential ideas for the identification of the center of gravity location include accelerometers, gyroscopes, tilt sensors, or a combination of these. Accelerometers and gyroscopes measure linear acceleration and angular velocity respectively, which might only make them useful if there is a pendulum type system that is incorporated that allows a known mass to move in a constant cycle. Tilt sensors measure the orientation or tilt of a plane relative to gravity which could easily be utilized to help identify the center of gravity location. Once the center of gravity is identified to a specific location a controller must be incorporated that converts the data of the location to a signal to the motors. This controller incorporation will be included but will not be the center of this analysis. This topic will be thoroughly analyzed to ensure that the location of the center of gravity will be accurately identified and converted into mechanical movement.