Mechanical Design of Coronagraph CubeSat

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Abstract

A coronagraph telescope is designed to fit inside of a CubeSat, thus creating a CubeSat satellite-based coronagraph. The objective of this research is to modify the mechanical design of various components of the Coronagraph CubeSat. The CubeSat will be mounted inside of a spacecraft. Once the CubeSat reaches space, it will then be released from the spacecraft into orbit. A coronagraph is a telescope that can see objects very close to the sun. It consists of optics and a filter lens, a sun-shield, a camera, and an aperture or disk. This instrument that is installed in the CubeSat will allow the scientist to study the corona and various volcanoes on the sun. In addition to the sun, this instrument will also study objects around the sun, such as stars. The instrument will record various images of the sun's corona from different lens perspectives. Once all the weight and space restrictions are known, commercial Computer Aided Design (CAD) software is used to redesign various mechanical components of the CubeSat in order to meet the desired operations and to reduce the structure's weight. These restriction parameters included a mass restriction of 1.33 kilograms and a volume restriction of 1000 cubic centimeters.

Introduction

A CubeSat is a type of research satellite called a nanosatellite. It is used for science, exploration, education, and operations. The slight weight and size distinguish a CubeSat from a traditional satellite since the CubeSat is only 1000 cm^3 and has a mass of 1.33kg (3 lbs). This small volume and weight allow the CubeSat to be mounted on the unoccupied space of a spacecraft.

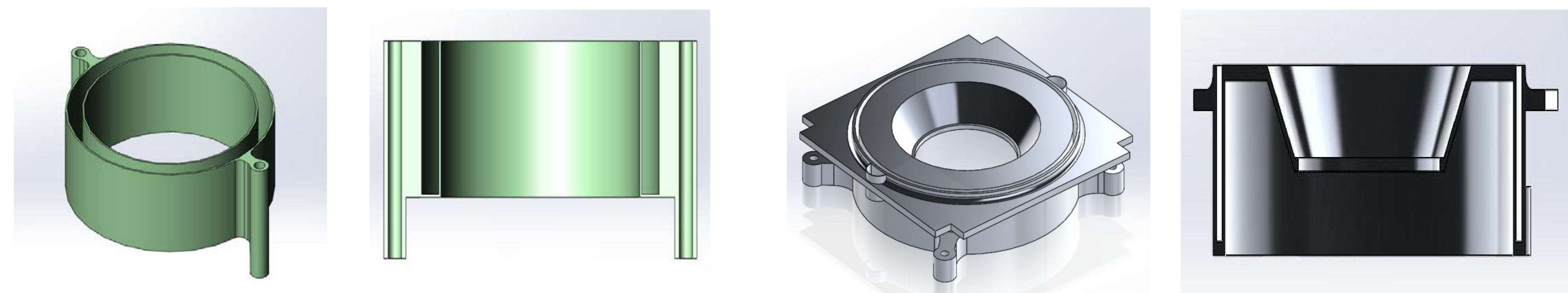
A coronagraph is a telescopic attachment designed to block out the direct light from the sun so that nearby objects such as plasma or corona can be observed. This telescope not only allows for the study of plasma and it behaviors on surface of the sun, but it also views objects around the sun.

This project is in the early stage of design. The mechanical characteristics and reliability of the parts for desired operation will be studied so that eventually the parts can be manufactured. The SolidWorks software is used to create the CAD models and perform structural analysis prior to manufacturing of the parts.

The overall objectives of the project are:

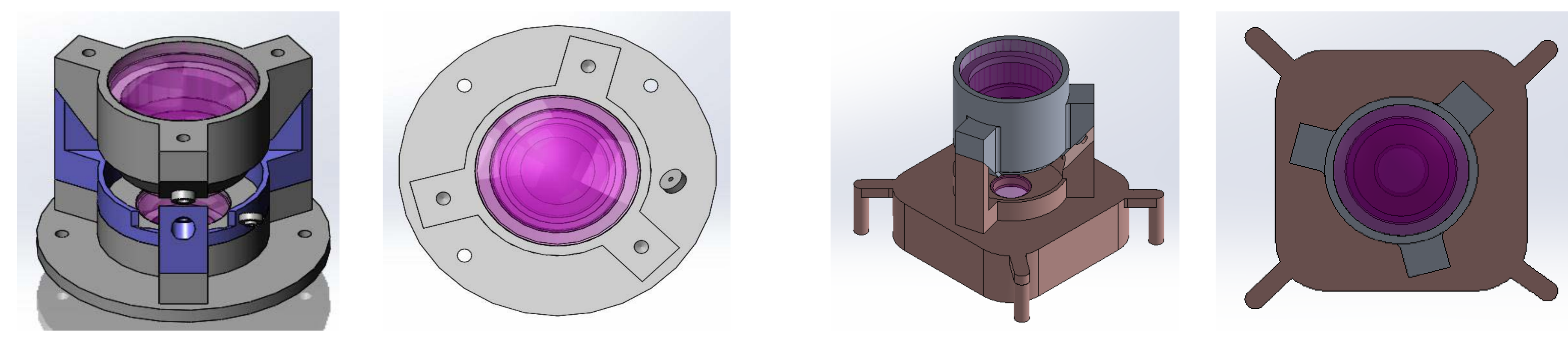
a. Design a CubeSat coronagraph with a volume of 1000 cm^3 and mass of 1.33 kg or less.
b. Create a mechanism to release a compressed spring and sunshade of 50 cm.
c. Assign material to each part that will keep the structural health and integrity of the part and will stay within the mass limit.
d. Perform mechanical property calculations including Torque and Thermal Expansion.
e. Redesign parts to meet the new specifications.

New Design verses Original Design



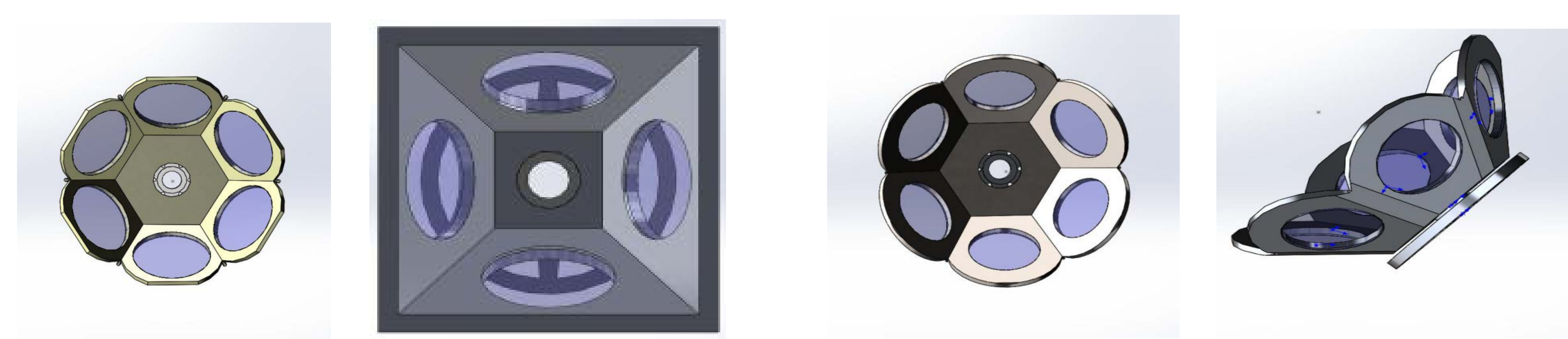
Original Design Spring Canister New Design

The application of the spring canister is to hold a loaded cylindrical spring along with a sunshield inside itself.



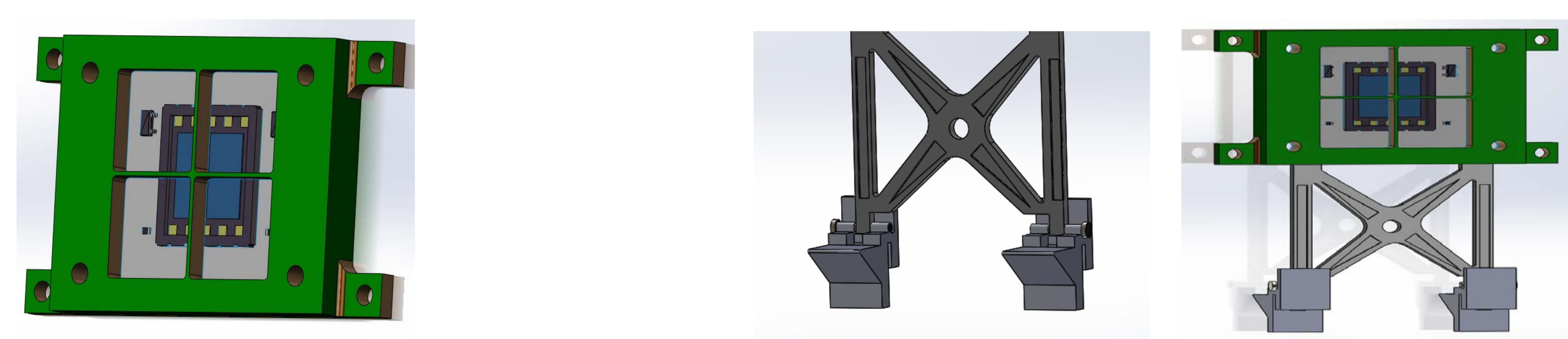
Original Design Optical Structure New Design

The optical structure houses the lenses that will be used for the coronagraph. It will also hold the filter wheel that will rotate different filter lenses for various studies.



Original Design Filter Well New Design

The filter wheel, which has six filter lenses, will rotate 360 degrees through the optical structure. All the sharp corners on the petals were removed and were replaced by round edges. The petals' geometry changed from sharp corners to flattened ones.

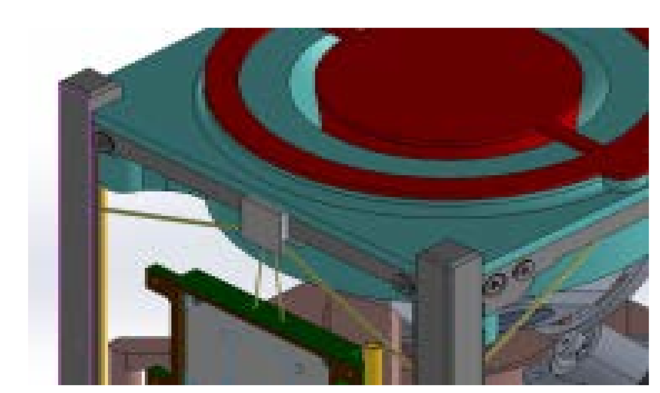


Original Design Sun Tracker New Design

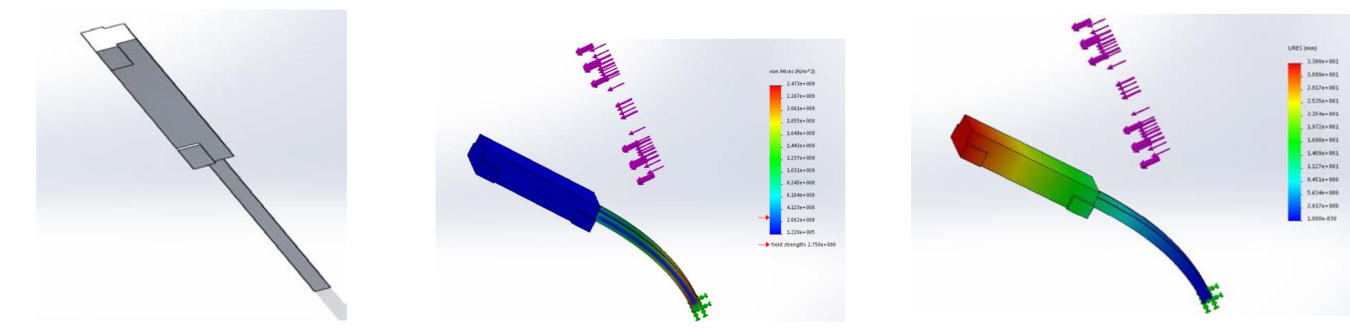
The sun tracker, as its name implies, will track the motion of the sun when it is deployed from the CubeSat.

Release Mechanism Design

After various ideas, a released mechanism was chosen to deploy the spring with the sunshield and the sun tracker with the required length for the coronagraph.

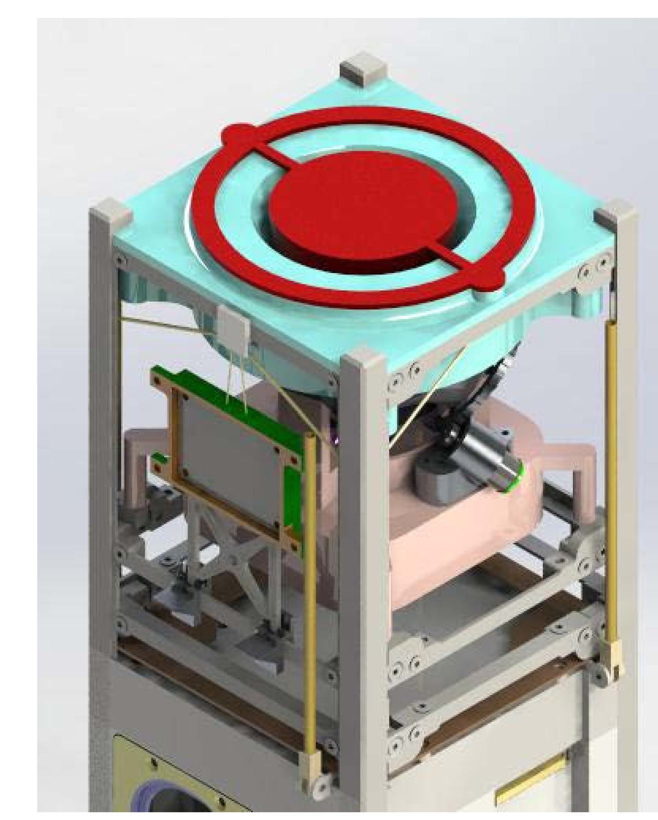


Simulation Result

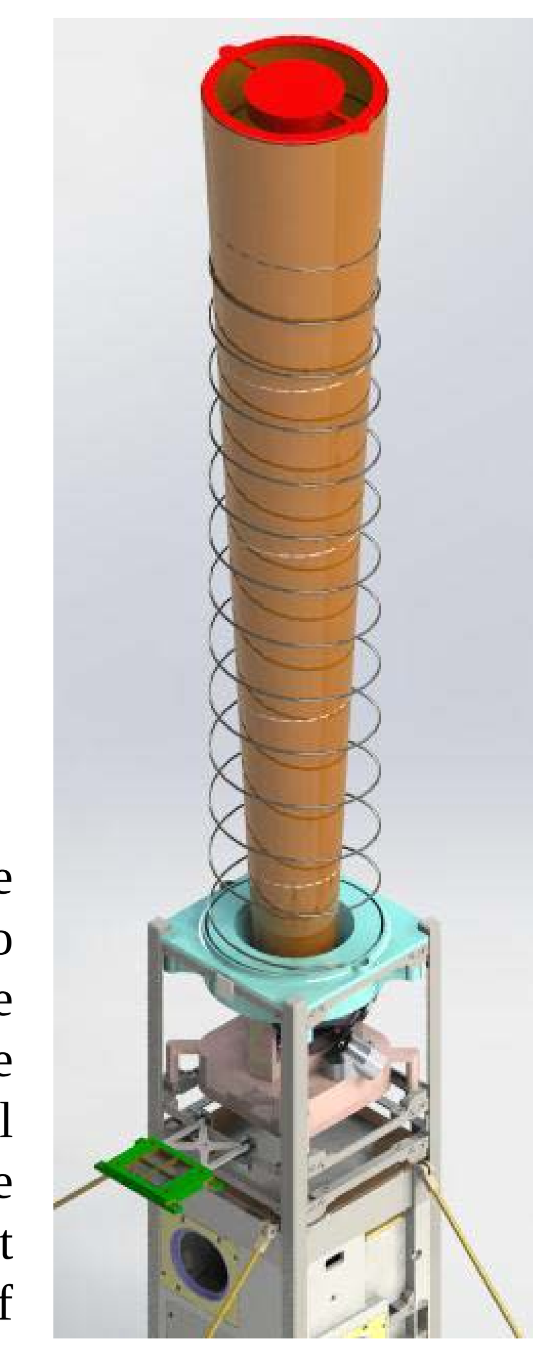


The SolidWorks simulation software is used to analyze and simulate the stress on the sun tracker structure when a force of 45 N is applied. The maximum stress is yielded 2.473 e + 009 N/m^2, which is much higher than yield strength 2.750 e + 008 N/m^2. This means that the legs of the sun tracker will eventually reach their ultimate strength and break according to the Stress vs. Strain graph. In the displacement simulation of the sun tracker, the deviation can be seen by comparing the results with the original model.

Model Result



The above picture shows the CubeSat, which will be carried into space. Once it reaches the designated distance in space, the sunshield and the sun tracker will deploy (picture on right). These are the tentative designs of the first unit of the CubeSat. The final mass of all the components, including the frame of the satellite is currently at 923.7 g, which is a 30% reduced from its maximum allowable mass of 1.33 kg. This model is within the budget.



Future Work:
Work on second and third units which include power source, reaction wheels, star trackers and deployable solar arrays.