Even though there has been several studies performed on the structure of the CubeSat such as linear static structure, dynamic, flow, fatigue and dropping studies, the one relevant for this paper is the thermal study and the static structure study with external thermal loads. For the first thermal study, the most dangerous scenario was considerate, the one in where the CubeSat is located between the Sun and the Earth, creating a 0° angle for the albedo radiation. The next thermal loads have been applied:

- Solar radiation flux: 1371 W/m^2
- Earth albedo radiation flux: 480 W/m^2
- Earth radiation flux: 204 W/m^2
- Radiation from the CubeSat to the space: Variable.

The first important result is the temperature the CubeSat will reach when located between the Earth and the Sun. As it is seen in Fig. 4, the maximum temperature the CubeSat will reach round the 120 C°, and the minimum round the 110 C°. For the study configuration, the transient state response was employed, as the position of the CubeSat will not be hold at any time and the transient state response will be the one that provide us the information needed.

There is, although, a second position that is crucial to consider to have a proper panorama of the trajectory. In this second position, the CubeSat will be located “behind” the Earth and away from the radiation emitted by the Sun, with an albedo incident angle β of 180°.

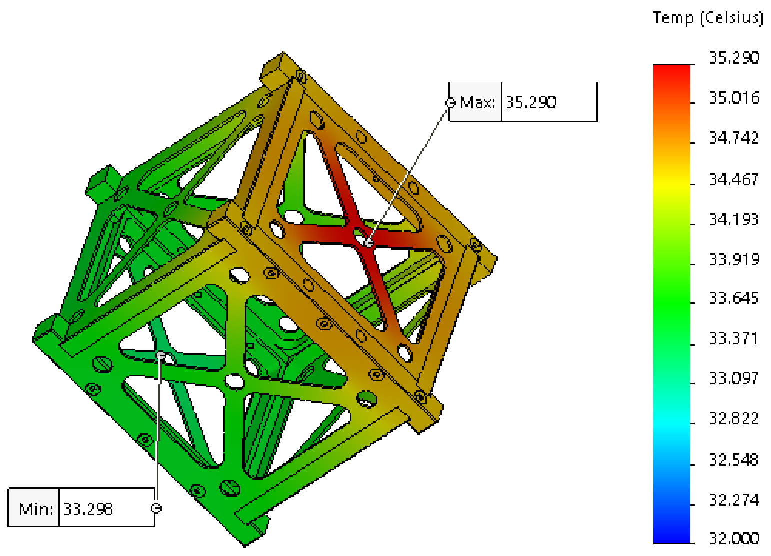

Figure 5. *Temperature of the CubeSat when β is 180°.*

The changes on the thermal loads are stated below.

- Earth albedo radiation flux: 0.048 W/m^2
- Earth radiation flux: 204 W/m^2
- Radiation from the CubeSat to the space: Variable

In Fig. 5 the resulted temperatures can be observed. It is important to notice that the maximum and minimum temperatures don't have a big change between each other, but in comparison with the result of the first study, there is a present change of 80 C°. This change is relatively fast if there is the consideration that the CubeSat will be surrounding the Earth approximately every 90 minutes, it means, from one point to the other there are 20-25 minutes, in which the satellite will be changing constantly its temperature.

As for the other important results, the static structure analysis with external thermal loads must be made. As in the last part, there will be taking in account 2 scenarios, the one with the maximum solar radiation, and the one with the minimum solar radiation. The results of these studies are stated below, in Figures 6 and 7.

In Fig. 6 and 7 it is important to realize that even though temperature only changes from 30 to 110 degrees; the stress caused by thermal changes makes a huge difference when translated to thermal stress. The difference from 968 MPa to 107 MPa is important in the way that contraction and expansion of material merged with stress from thermal loads can represent fatigue to the structure, and the fact that 6061 T6 aluminum alloy has an elastic module of 307 MPa brings a problem that must be solved by thermal control of the structure, since in every other way, the material is useful for the purposes of the small satellite.

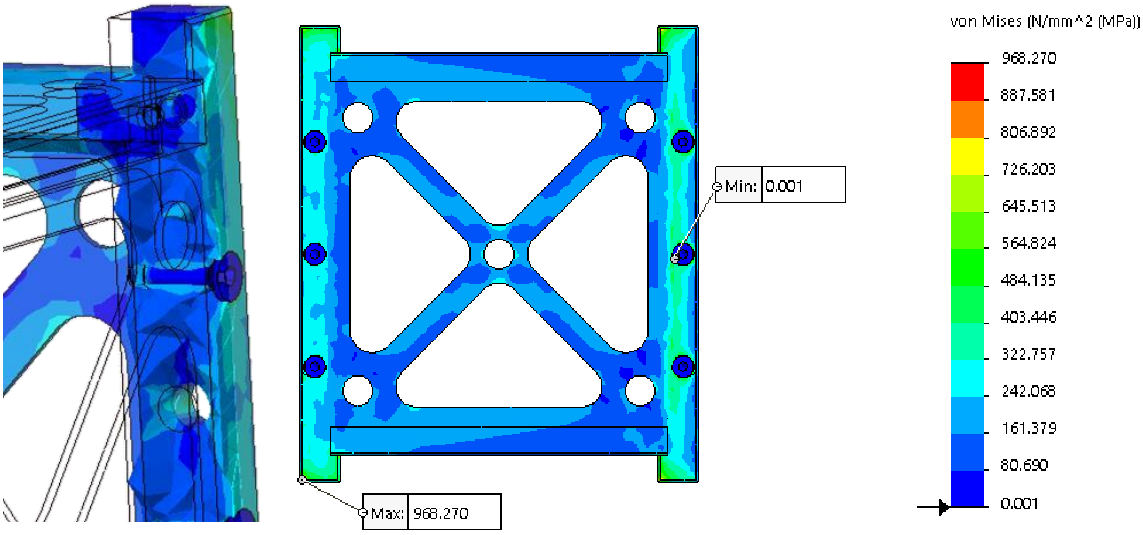

Figure 6. *Result of the static structure study when β is 0°.*

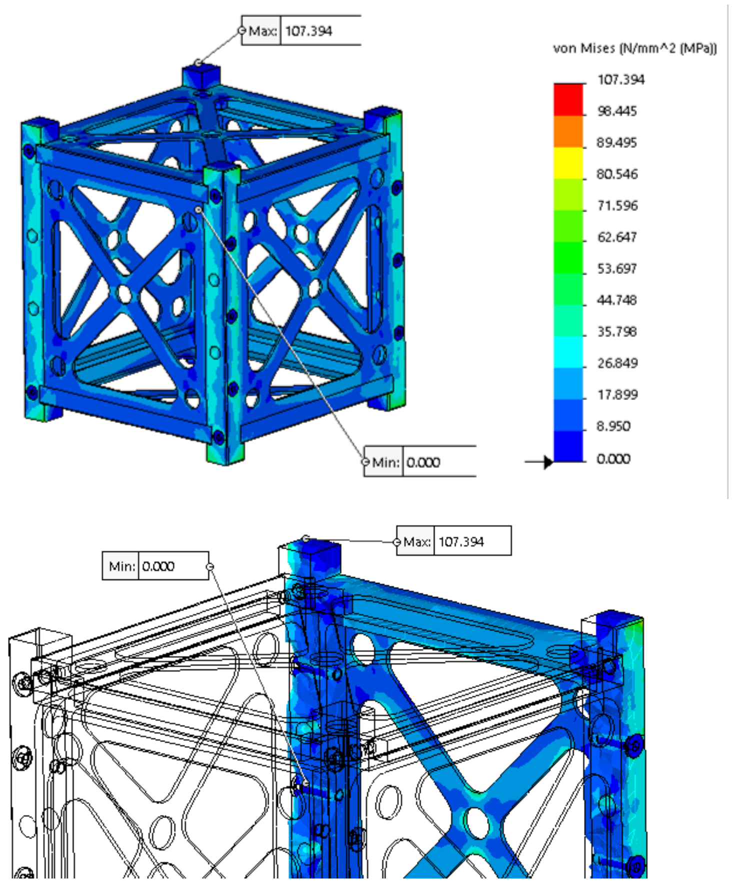

Figure 7. *Result of the static structure study when β is 180°.*

5. CONCLUSIONS AND FUTURE WORK

One of the first steps for further development, is to support the studies already made. Current work is being done with COMSOL so that the results obtained with SolidWorks 2016 could be sustained. After that, laboratory tests must be made in order to back up the results from the software and merge the lab tests results with the CAE results.

Finally, from this research one conclusion emerge rapidly. Thermal analysis is one of the most important analysis that can be made to a spacecraft. The 6061 T6 aluminum alloy has been chosen due to its mechanic characteristics, and after several static and dynamic studies without the consideration of thermal loads it seems to be a perfect choice. After the thermal study it can be seen that it has a slight deficiency; fortunately, it can be regulated with the help of active thermal control electronics and other adjuncts, from thermal clothes to opaque surfaces that can deviate the effect of absorb radiation.

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