CANSAT Competition 2020: Best technical development by OrbiSat team

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Abstract

OrbiSat is a high school educational project that was part of the CANSAT SPAIN 2020 student competition organized by ESERO. This project has ranked first in the Catalonia Championship and second at the National Championship, winning the prize for the best technical development. OrbiSat has successfully fulfilled the objective of creating a mini satellite with the size of a soda can that was later launched by a rocket of the COSMIC Research UPC Students Association to analyze physical aspects of the air such as pressure, temperature, humidity, or the amount of UV solar radiation of a territory.

Thanks to the CanSat presented by this team, during the launch we were able to know the presence of up to 15 chemical elements in the air. Elements ranging from hydrogen and oxygen can indicate water in the atmosphere or other greenhouse gases such as CO2 or methane.

The launched rocket reached an approximate height of 532.7 ± 1.5 meters, with the sensors we were able to determine the apogee of the rocket and the subsequent release of the minisatellite and deployment of the parachute. We were also able to interrelate the altitude data with parameters such as humidity, UV radiation, presence of hydrogen, among others.

The CanSat presented by the OrbiSat team had a unique design never seen before in other CanSat competitions, solving problems such as high weight and overheating. This design made by AutoCAD was an open concept where the air can refrigerate the CPU and also the 3D printed concept saved 125 grams over a third of the maximum allowed. In addition, all the data collected was broadcast in real-time and received by a ground station every 0.25 seconds.

Before the launch, a simulation was completed estimating a 61 seconds flight, finally, the real flight was 59 seconds. The vast majority of the project was done during the COVID-19 pandemic, the consequence was new methodologies to carry on the project with a minimum time for the workshop and test phase that were supplied with simulations having a better performance than expected.

Keywords
CanSat, Educational Project, ESERO

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1. Introduction

CanSat is an initiative of the European Space Agency [1] that challenges students from all over Europe to build and launch a mini satellite the size of a "soda can" to a height of no more than one kilometer. The challenge for participants is to fit all the major subsystems found in a satellite: electric power, sensors, and the communications system. Everything must fit into the volume and shape of a soda can.

Subsequently, the CanSat will be launched, in our case by a rocket, to a height of no more than one kilometer. Although on other occasions, it is dropped from a platform, a drone, or a balloon. Once the CanSat parachute [2][3] deploys, the mission begins, and the satellite starts to perform scientific experiments as it descends and lands safely. After the flight, the teams must process the data and draw conclusions about the flight.

The experiments that the CanSat will perform while descending are divided into two parts firstly, the Primary Mission, mandatory for all teams and consisting of the constant emission from the satellite and reception from a ground station [4][5] of temperature and atmospheric pressure data at least once per second.

The Secondary Mission is free and is the one that differentiates CanSat from the other teams. However, the implementation of both in a different way led the OrbiSat team to win the technical achievement for the complexity and originality of the design, implementation, and integration.

In the case of the OrbiSat team, the Primary Mission mentioned above communicated with the ground station four times per second, allowing us that if one of the temperatures and atmospheric pressure data did not arrive or arrived damaged, it could be discarded without affecting the overall results. We also decided to extend it a little more by obtaining the humidity data and sending the satellite's GPS position through the antenna, which helped to locate it once it had fallen.

The OrbiSat team's secondary mission was to recreate a kind of probe satellite that would be launched on a planetary mission. As it descended through the atmosphere, it would collect data on gases that might be in the atmosphere of the hypothetical planet. It also collected information on UV radiation, and all were stored on two SD cards that served as a backup if one was damaged during the impact.

2. Prototype

2.1. *Version 1*

The CanSat structure presented here shows an open concept that has been entirely designed in AutoCAD, allowing us to save many resources since we were able to perform tests and simulations of practical space for the placement of the various experiments without the need for further printing.

2.1.1. *Materials*

The material used for the structure was Polylactic Acid, commonly known by its abbreviation (PLA). The properties of PLA [6] are interesting; the one we highlight is its melting temperature as it is relatively low, between 130 - 180 ºC making it an ideal material for 3D printing. In addition to the properties that this plastic has that perfectly adapt to our needs, it is a plastic obtained from fermented vegetable starch. In other words, it is a plastic that does not come from petroleum.

2.1.2. *Prototype parts*

This prototype CanSat (Figure 1), was divided into three parts. The lower part was where the battery and two SD cards would be housed. The middle part, a circular piece 3 millimeters thick, served as the lid of the lower part and the base of the upper part. Finally, the upper part was the structure that would house all the sensors, the Arduino UNO board, and the GPS antenna.

The lower part (Figure 2) has three protected areas; the first two on the starboard and port side of the CanSat are symmetrical and one more in the aft area. In addition to protecting batteries and SD memory cards, this is the place where this part connects to the rest of the CanSat's parts.

The upper part has three columns located at 120º and whose thickness is 10.6 millimeters. These columns allow having an interior space where all the sensors were located. Moreover, we would find another circular cover attached to the columns in the upper part. This cover has two holes, the first and central one where the eyebolt that would join the parachute with the CanSat would be located. The second hole was used to pass the cables from the lower part to the upper part.

The pieces of this first CanSat prototype were joined with polymer glue.

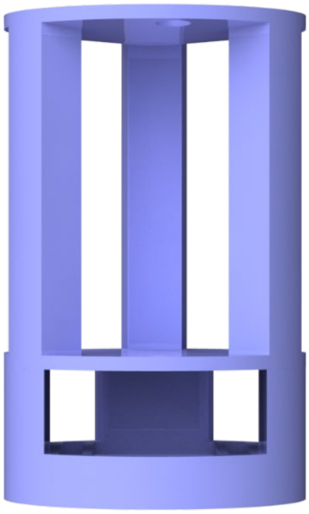

Figure 1. CanSat Prototype Version 1.

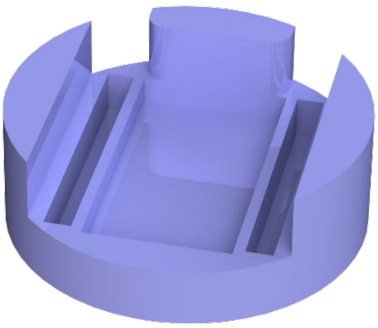

Figure 2. Lower part section CanSat Prototype Version 1.

2.1.3. 3D Printing

The 3D printing was carried out, leaving a square mesh inside the structure, which allowed saving weight, counting both the mesh and the outer layer, which was solid. As a result, we only used 30% of the material compared to making the whole figure solid.

2.2. Version 2

We did not have the opportunity to print this second prototype, although it would have allowed us to correct errors that we had detected after submitting the first prototype to some tests.

2.2.1. Materials

The materials used were the same as the first prototype: PLA plastic and polymeric glue.

2.2.2. Prototype parts

This second prototype (Figure 3) had two pieces, the first lower part formed by the lower part mentioned above and the circular piece that acted as a lid. The second part was very similar to the upper part mentioned before.

The lower part (Figure 4) in this prototype was going to be the sum of the lower part of the first prototype and the intermediate part, and it also includes three holes where the upper part would fit. It also contains four holes that have the sole purpose of being places to pass cables from the lower part to the upper part of the other way around. Unlike the previous prototype, the rear area is covered, allowing access to the interior area only through the front part protecting more components.

The upper area would be very similar to the one mentioned in the first prototype. The main changes would be some bars in the lower area of the three columns that would be inserted in the other piece of this prototype. In addition, we implemented changes to reduce the width of the columns and round off their inner edges. It would also include four holes in the upper part to allow different accesses, thus reducing the number of cables needed.

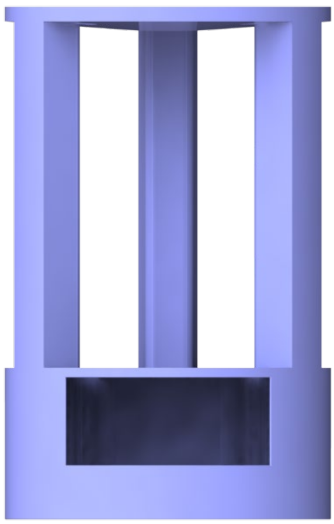

Figure 3. CanSat Prototype Version 2.

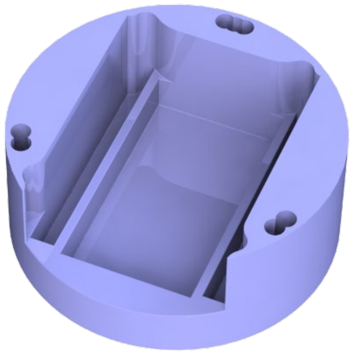

Figure 4. Lower part section CanSat Prototype Version 2.

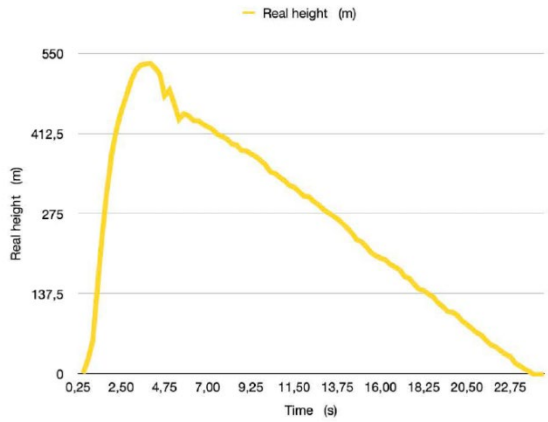

Figure 5. Height graph OrbiSat launch July 2020.

2.2.3. 3D Printing

The 3D printing would have been carried out following the method previously mentioned in the first prototype, although slight changes would have. The lower and upper parts would have a different mesh at this prototype. The lower part would have been printed with a mesh of 90%, while the upper part would have a mesh of 45%.

As a result, in addition to increasing the weight, we would not have had to insert ballast, thus occupying space, which would have allowed us to lower the center of gravity, thus improving stability during the descent. In addition, the CanSat would be positioned in the optimal way to open the parachute in a shorter time.

3. Results and discussion

The Primary Mission that the OrbiSat team planned worked perfectly, fulfilling all the requirements requested by ESERO Spain. The maximum height that the rocket reached was 532.7 ± 1.5 meters, which was later checked correctly by the organization.

In the height graph (Figure 5), it is possible to observe two peaks after the maximum point of the graph. The rocket itself created the first one when the warhead deployment. The rocket made a small charge explode to deploy the warhead, and since the satellite was still inside the rocket, it could detect that pressure spike. The parachute's opening caused the second one since it took 2 seconds to open from being fully folded.

On the other hand, the Secondary Mission was not so brilliant since we had the failure of the CO_2 sensor, and even having checked its correct operation the day before, it gave completely erroneous and meaningless data. Therefore, after analyzing the sensor data, we had no choice but to dismiss it and not take its information as relevant.

The rest of the sensors of the Secondary Mission worked perfectly and without problems.

As we had predicted, the structure ended up yielding at the weakest point. Once the competition was over and analyzing the debris, we could see that because we had to load ballast the day before the launch and that this ballast exceeded the allowed dimensions, we had to break a joint. Unfortunately, when we reassembled that joint, we did not clean well the surface of the old adhesive, and we added new adhesive on top of it, creating tiny air chambers as we feared that resulted in the breakage of the lower part of the CanSat.

As we thought that a slight possibility of break could occur at the lower part of the CanSat, we attached the battery to the main body of the CanSat. If the situation of that breakage occurred, the operation of the satellite would not be compromised, and it could continue operating without problems. So that contingency plan worked perfectly.

CanSat regulations require a minimum weight of 300 grams, but thanks to the 3D printing used and the design, our casing had such a low mass that we initially lacked 125 grams. This problem would have been solved with the second version. However, in a case closer to the reality of launching a satellite into orbit, every gram saved is money.

4. Conclusions

After the various arguments exposed previously, we conclude that the first design we made was outstanding since it demonstrated its capabilities in the competition to achieve the second position. Moreover, it was a first test prototype of several that were expected to be manufactured but the pandemic forced to modify the plans with little time to act.

The second prototype would have solved the biggest problem we had during the competition, the breakage of part of our CanSat. However, it would have also helped to improve the aesthetics and possibly would have allowed us to be in the first position.

The open concept design avoided many problems and gave us many options in the days before the final. For example, after having some severe failures in the control boards, it allowed us to introduce an Arduino Uno board in the CanSat, something that other teams did not understand how to fit. Consequently, it has advantages when transferring it to other types of secondary missions other than ours. Also, this design has allowed us to have more accurate data, especially in temperature, since no heat produced by the CPU and gas sensors alter the measures.

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