**Designing a Small-scale Satellite for Habitable Exoplanet Research.**

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**Introduction:** This project was completed as part of the requirements for graduation at STAR Academy at The Arecibo Observatory as a high school level investigation with the purpose of exposing students to real scientific research. The main goal for this project was to explore the possibility and design a small-scale satellite for habitable exoplanet research. Technology has played an important role in the development of quicker and more effective methods of research in all fields of science. In the case of exoplanet research, The Transiting Exoplanet Survey Satellite (TESS) has been one of the most important technological developments in the field. However, this technology comes with a hefty investment in development, materials, and operational costs. This project approaches idea of creating a small-scale satellite that will be used for the study of habitable exoplanet research, minimizing costs so that more productive missions can be made.

**Design:** As part of the project, sketches were made to better visualize a well-structured satellite during the design process. While designing the instrument some factors related to habitability were taken into consideration and understood as what we would like our instrument to evaluate to determine the habitability of an exoplanet, such as temperature, presence of water, atmosphere composition, energy distribution, and nutrient availability [1]. The final sketch was then transferred into a 3D design application. This helped us create a 3D scale model of the satellite.

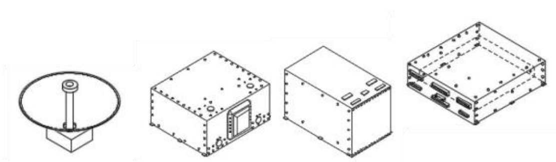

*Figure 1: Example Sketches of the Instruments*

The satellite that was designed with the goal of having as destination the exoplanet Kepler 705b. Different sections such as a power system, a communication system, a propulsion system, an outer protection layer, a thermal control system and its main instruments to gather data. Some of the instruments will study the exoplanet itself, and some infrared-based instruments will study the exoplanet's star.

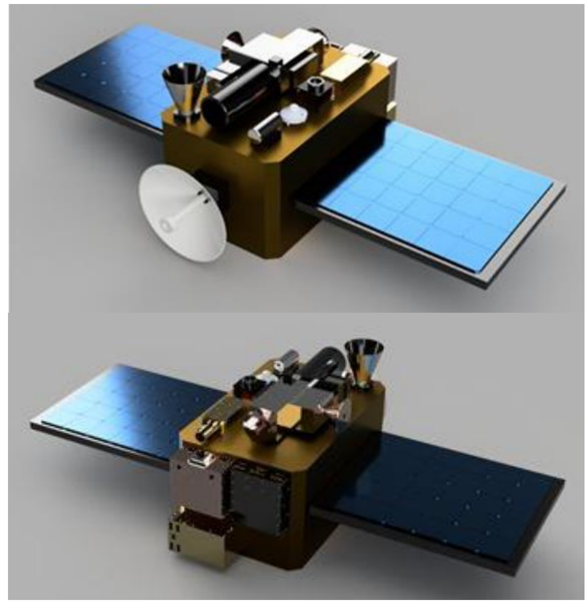

*Figure 2: Final Design of the Small-Scale Satellite*

A mass and power budget analysis were also completed as part of the project. This is a system that is used to calculate the total power and total mass of the satellite, to then evaluate whether the satellite can be considered a small-scale satellite, or not. Table 1 shows the mass and power of all components of the satellite. The analysis yielded that the total mass of the satellite is 152.92 kg and the total power transmitted by the satellite is 222.89 W, taking into consideration that the power of the solar panel was not added to the total power measurement. Since the mass of the satellite is less than 500kg the satellite can be considered a small-scale satellite. The benefit of this type of satellite is mainly in the heavily lowered production and assembly costs, but not necessarily in the deployment cost.

| INSTRUMENT | MASS | POWER |
|---|---|---|
| Composite Infrared Spectrometer | 39.24kg | 32.89W |
| Photometer | 2.17kg | 2.4W |
| Ka-Band Antenna | 2.1kg | undefined |
| Near Infrared Imager | 2.5kg | 5.0W |
| Pyranometer | 0.9kg | $2.6x10^{-9}$W |
| Infrared Sounder | 45kg | 50W |
| Digital Barometer | 0.2kg | 1.6W |
| SEM-2 TED | 4.7kg | $2.8x10^{-8}$W |
| SEM-2 MEPED | 8.7kg | $3.7x10^{-8}$W |
| SEM-2 DPU | 4.6kg | $1.1x10^{-8}$W |
| Nickel Cadmium Battery(24voltage) | 19.1kg | 96W |
| Solar Panel | 22.68kg | 320W |
| Bae Rad 5545 | 1.0kg | 35W |
| Passive Thermal Control System | undefined | undefined |
| Multilayer Insulation | undefined | undefined |

*Table 1: Mass and Power Budget Chart*

**Conclusion:** The market for small-scale satellites has been increasing in demand over the past few years [2]. Satellites that stay near Earth's orbit are usually more affordable in terms of deployment and operation when compared to greater sized satellites. However, costs are expected to increase for instruments that operate outside LEO, but due to the affordability of the instrument itself, the overall cost for a mission that uses this type of instrument will be greatly minimized. In this project we have shown that it is possible to design a small-scale satellite with the purpose of studying exoplanet habitability. In 1992, A. Wolszczan and D.A. Frail discovered the first ever exoplanet around the millisecond pulsar PSR1257 + 12 using The Arecibo Observatory's radio telescope [3]. Today, more than 4,000 exoplanets have been discovered. This elevates the practicality of this type of instrument and increases the possibility of a great discovery to be made in the near future regarding exoplanet habitability, as well as the prospects of extraterrestrial life in the cosmos.

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**References:** [1] *"Factors that Contribute to Making a Planet Habitable."* Lunar and Planetary Institute. Accessed January 9, 2021. https://www.lpi.usra.edu/education/explore/our_place/hab_ref_table.pdf. [2] E. Buchen (2015). "*Small Satellite Market Observations"* Small Satellite Conference. [3] Wolszczan, A., and D. A. Frail, (1992). *"A planetary system around the millisecond pulsar PSR1257 + 12."* Nature 355, no. 6356. doi:10.1038/355145a0.