WeissSat-1: A Student Developed Astrobiology Payload for Small Satellite Microgravity Research

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ABSTRACT

The WeissSat-1 is a novel student developed 1U CubeSat designed to support astrobiology payloads for microgravity research. WeissSat-1 is the premier project of the Weiss CubeSat Development Team (WCDT), which was established in August of 2015. The founding WeissSat-1 team consisted of nine students ranging between the ages of 10-12 years old. The mission was: to design, build, test, and fly a CubeSat into space within three years.

WeissSat-1, based on the NearSpace Launch Inc's 1U FastBus structure, was chosen by ELaNa 24 and manifested to fly in the fourth quarter of 2018. WeissSat-1 will carry a lab-on-a-chip system designed to test and validate the survivability of extremophile bacteria in orbit. WeissSat-1 demonstrates the benefit and the importance of engaging and involving students in space-based scientific research throughout the academic pipeline. This work will discuss in detail the technology of the WeissSat-1 mission, and will discuss its impacts on middle school students and their STEM interests. The WCDT contends that if the respective extremophile bacteria on WeissSat-1 are capable of surviving in space, this may have ramifications for the possibility that bacteria may have transferred between planetary bodies over the life of the solar system.

INTRODUCTION

CubeSats

CubeSats are a class of nanosatellites which have a specific size and form factor. They were originally conceived as a means to train university engineering students how to design, build, test, and fly a satellite during four years of college. Their small size, standardized dimensions and characteristics, and accompanying deployment hardware have contributed to their significant success over the past 15 years. CubeSats have developed into their own industry and are an emerging scientific tool with regular launch opportunities available from multiple launch providers.

The educational benefits of CubeSats are noteworthy, as are the number of universities, schools, companies, and nations that now build and fly them. Now capable of conducting communications, technology demonstrations, and a diverse range of scientific missions, CubeSats are an increasingly important tool for the development and training of aerospace professionals and engineers. The benefits and possibilities of CubeSats are now traversing down and impacting middle school students and younger.

The Weiss CubeSat Development Team

Upon arriving in July 2015, The Weiss School's new Science Educator, Mr. Kevin Simmons, initiated several Aerospace programs. At the beginning of the school year, the Weiss CubeSat Development Team (WCDT) was formed with nine students. The mission of the WCDT – with the tagline "Let's Go To Space" - was very simple: to design, build, test and fly a CubeSat into space, and to do so within three years.

Figure 1: WCDT Tethered Balloon Mission

The original plan for WCDT was multi-pronged and depended on early third party validation which included measurable early student successes. Additonally, the plan depended on building a strong sense of team and loyalty. The WCDT travelled significantly across the country to gain knowledge about small satellites from

universities. This included multiple trips to the University of Florida (UF) where students met with the UF Small Satellite Design Club and respective professors and experts. During the school year, middle school students had the option to take an aerospace class elective, which included elements of mission design for properties of space, rocket propulsion, and orbital mechanics. This course included Hohmann Transfers and Environmental Control & Life Support Systems. Addtionally, the WCDT met with university students after school to gain additional knowledge. An important aspect of this interaction was to allow the WCDT students to embrace inquiry based learning concepts and to "learn by doing". This allowed the students to take the initiative to perform difficult tasks with no penalty for failure. This included conducting bench work, captive carry flights, tethered balloons and high altitude balloon missions. The process will culminate with an orbital CubeSat launch. Using this "crawl, walk, run" methodology, students assembled and utilized BLUECUBE Aerospace (BCA) 1U CubeSat emulators. Students 3-D printed a 1U chassis, and assembled the Raspberry Pi-based BCA Emulators. The students also created Python-based code, which enabled remote access to the emulator data. This consisted of multiple types of sensor data and camera images via a Wi-Fi network which was connected to a student laptop graphic user interface. The WCDT's vision now includes developing and landing a lunar rover with the support of Astrobotic (a spin-out from Carnegie Mellon University).

KEY STUDENT EXPERIENCES

CubeSat Emulators

The WCDT began their journey by considering the CubeSat and its subsystems. In the fall of 2015, students assembled and tested Raspberry Pi based 1U CubeSat emulators from BLUECUBE Aerospace Inc. The emulator containing the BLUECUBE module shown in Figure 2 was the first major component designed and developed by the student team.

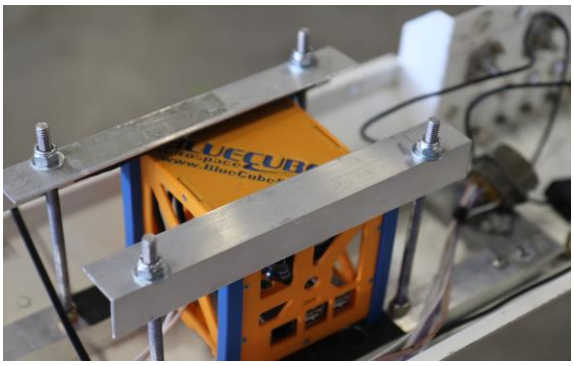

Figure 2: WCDT BCA Emulator in Captive Carry Flight Pod

Later WCDT students traveled to Cartersville, Georgia, where they completed their first Final Flight Review (FFR) prior to an emulator captive-carry flight. The CubeSat emulator was flown inside an electronics jammer pod under the wing of a modified Leer jet. The emulator collected sensor data while the jet flew numerous high 'g' flight profiles.

University of Florida Working Trips

In November of 2015, the WCDT travelled to the University of Florida (UF). The purpose of this trip was to gain more experience with satellites, such as the CubeSat and aerospace antennas. The trip comprised of discussing SwampSat, UF's current satellite at the time, and visiting the UF satellite high bay. The WCDT gained their first experiences working in a clean room and wearing "slippers" over their shoes in an effort to not contaminate the area. They observed and discussed the use of a thermal vacuum chamber, which generates similar conditions to those the CubeSats will experience in space. Students learned about this testing chamber, and later toured the control room. On day two, the students learned about directional antennas and communication through the task of assembling Yagi antennas. They experimented communicating with the antennas on various hills located around the UF campus.

On the second UF trip, WCDT students observed the execution of tethered balloon launches by the UF students. They engaged in meanigful discussion; comparing and contrasting the differences in their CubeSats compared to their classmates. For the remainder of the trip, students listened to presentations, and later were able to visit the clean room once more.

High Altitude BalloonSat

Since fall of 2015, the nine initial members of the WCDT grew to over 20 regular participating student members. After two successful working trips to the University of Florida, the students completed several tethered balloon flights with Raspberry Pi CubeSat emulators in the spring of 2016.

Figure 3: Image by WCDT's HAB Mission

Figure 4: Students at SmallSat Conference with UF

The WCDT's first high altitude BalloonSat (HAB) mission occurred in April 2017, and the second mission in March 2018. A major part in the launch process was the running of simulations and predictions of the flight path of the balloon. In the first and second launches, students, ranging from ten to fourteen years old, ran these simulations to determine the best launch site and date based on weather and external factors. In the second mission, student simulations aided in determining the recovery plan. These simulations were generally accurate and provided a good estimate of the trajectory and landing site of the balloon. After culminating their simulations, students successfully launched a developed CubeSat emulator, and gained valuable experience with a transmitter similar to the flight hardware and in using the data downlink provided by the GlobalStar network of satellites. Launched from the school, live video transmission and over 250 data points were collected during the four hour mission, which ended in the Atlantic north of the Bahama Islands.

Both HAB missions allowed WCDT students to gain knowledge in several areas that would contribute to the future WCDT's WeissSat-1 mission. The missions allowed for a hands-on experience for aerospace and WCDT students. Not only did this mission familiarize the students with the general aerospace mission planning and creation, but it familiarized the team with working with the WeissSat-1 radio systems. Additionally, these early missions allowed The Weiss School to stand out against other middle schools, and even most high schools across the nation. These missions were a huge part of our success in partnering with numerous corporations. To continue WCDT's HAB missions, another launch is planned for July of 2018, with the goal of reaching at least 30,500 meters (>100,000 ft).

The Conference on Small Satellites

In August of 2017, 11 members of the WCDT attended the 31st annual AIAA/USU Conference on Small Satellites at Utah State University for the first time. They were well received and were interviewed by Utah Public Radio, the story airing on August 29, 2017. Attending SmallSat better prepared the educator and students to author a proposal in response to NASA's annual CubeSat Launch Initiative and to design the satellite itself.

WeissSat-1

WeissSat-1, the current premier project of the WCDT, is a 1.3kg 1U CubeSat, a platform based on the NearSpace Launch Inc. 1U FastBus Structure. WeissSat-1 will validate the NYRAD lab-on-a-chip system that will demonstrate a live/dead fluorescent dye staining approach and microfluidics to assess the viability of aerobic and anaerobic bacteria that have been thawed after being entrapped in water ice.

In the Fall of 2016, Mr. Simmons submitted the WeissSat-1 proposal in response to NASA's CubeSat Launch Initiative. In February 2017, NASA selected WeissSat-1 for flight out of Vandenberg Air Force Base on September 30th, 2018.

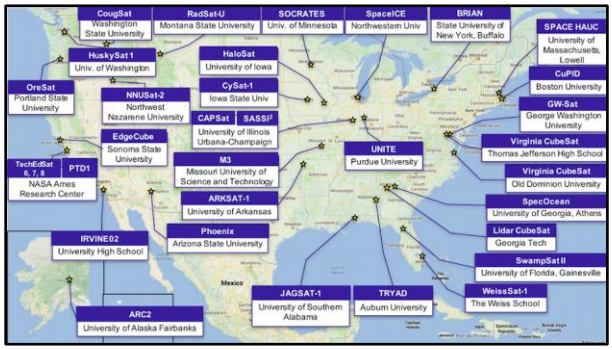

Figure 5: NASA CubeSat Launch Initiative 2017 Selections

The desired orbit for WeissSat-1 is at an altitude of 325km and at an inclination of 61.6 degrees, with a mission life of about 1-12 months. WeissSat-1 will test

the survivability of extremophile bacteria, and it is designed to collect and transmit sensor data, and to analyze the bacteria viability using the NYRAD lab-on-a-chip system.

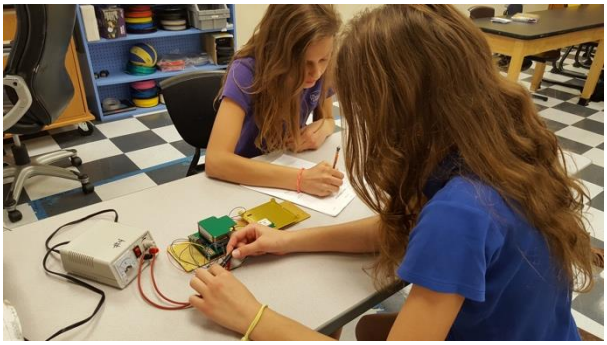

Figure 6: WCDT Students Testing WeissSat-1 Hardware

This mission has been developed with the philosophy of of incrementally accomplishing numerous intermediate goals and to fly a Low Earth Orbit 1U CubeSat within three years. The mission will maximize student involvement while constraining project complexity and containing costs. This initial 1U CubeSat is called WeissSat-1. The WeissSat-1 mission is the culmination of a multilayer process of educating gifted middle school students in three specific threads: aerospace, biotechnology, and mission management/planning.

Applications

The mission statement for The Weiss School's Science, Mathematics, and Engineering Center of Excellence (SME-COE) is "…To establish a robust STEM program featuring a hands-on research-focused approach, to foster natural student curiosity, and to facilitate excellence via individual and team competitions." As part of the STEM (Science, Technology, Engineering, Mathematics) program at The Weiss School, a successful launch of WeissSat-1 will promote CubeSat education and exploration as an important aspect of the future of Weiss' SME-COE and the Weiss CubeSat Development Team. The aim is not only to contribute to Weiss' exceptional educational program, but also to inspire other schools and individuals to embark on the journey, as well.

The Weiss School has many missions and projects planned for the future, such as developing and landing a lunar rover with the support of Astrobotic (a spin-out from Carnegie Mellon University). WeissSat-1 is only the beginning of the many undertakings that will take place, all of which will enable excellence at a new level.

STUDENT PERSPECTIVES

The WCDT project demonstrates the benefit and the importance of engaging and involving students in space-based scientific research within the academic pipeline. Elementary and middle school students can offer new perspectives and can develop innovative solutions. This project also shows that even relatively young students can accomplish amazing things if given the right environment, proper exposure, guidance, and challenge.

WeissSat-1

This educational CubeSat is primarily intended to train students. Its secondary purpose is to collect data regarding the viability of extremophile bacteria in melting ice while in LEO; creating a significant contribution to the scientific community. As one of 34 proposals selected, and the only middle school, the WCDT was further honored when shuttle astronaut and current United States Senator, Bill Nelson, visited The Weiss School to announce the selection.

The possibility of extremophile bacteria living in space is also of great interest to the WCDT students. If the hypothesis of this experiment were to be proven correct, then there would be major advancements towards answering the question of whether or not there is other life throughout the universe. If the extremophile bacteria on the WeissSat-1 were to survive, this would allow for the possibility of bacteria living on comets that transit through the solar system. Bacteria such as these could subsequently seed planets with life throughout the universe.

Not only has the WeissSat-1 project encouraged students to engage in satellite and aerospace-related research, it has also taught the students how to be productive members of an engineering team, how to better manage projects and time, and to realize that 'blue-sky' research is well within their reach.

Spinoff Benefits

At The Weiss School, spinoff benefits of the WCDT are numerous. Through the school's Distinguished Speaker Series, astronauts Story Musgrave, who repaired the Hubble Space Telescope, and Apollo 16 moonwalker, Charlie Duke, have visited and presented at the school which inspired students.

The students' passion and energy has proved to be contagious across the industry resulting in frequent invitations across domains and across the county. The middle school students have been invited to attend and present at Aerospace conferences and banquets, including the American Institute of Aeronautics and Astronautics (AIAA), the Missileers and Space Range

Pioneers, the Business Development Board National Engineering Week Banquet, and the Humans2Mars Summit.

Additional Student Opportunities

The Weiss School annually conducts highly successful aerospace summer camps, and leads a NASA-sponsored Space Settlement Contest working with students from several nations to form a single team. In 2018 Weiss students partnered with students from Chile, China, Germany, and Peru to earn a second place finish and recently attended and presented at the 2018 International Space Settlement Conference in Los Angeles. For three years, WCDT members have called on Congress with the Space Exploration Alliance. Weiss faculty and students are AIAA members and/or officers in the Palm Beach Section and call on the Congress annually with the AIAA Congressional Visits Day. Weiss faculty and students recently helped to write the WeissSat-1 resolution, which was introduced by Congressman Mast on the floor of the United States House of Representatives. Students staffed a booth at the 2018 USA Science and Engineering Festival, where they presented and discussed their CubeSat work and upcoming missions.

In the near future, students will present at the International Space Development Conference. They will travel to Indiana with the WeissSat-1 engineering unit to work with NSL, and to Kennedy Space Center to work with NYRAD to conduct the rigorous certification testing.

Upcoming Missions

The WCDT is excited to begin the development of the Amaris Lunar Rover with the goal of deploying it on the moon in 2020 - 2021. The rover is based on NSL CubeSat technology, while the rover delivery, and enroute and post-landing telemetry will be from Astrobotic's Peregrine Lander. The landing site for our rover will be on Lacus Mortis, the Lake of Death on the Moon. The payload consists of a radio astronomy antenna and a transmitter. Students are currently considering the size and frequency of the antenna, and they are partnering with various universities and companies for the payload development. The goal is to apply as much knowledge as possible from the students' WeissSat-1 experience to the lunar rover project.

CONCLUSION

Students attest to the fact that the ultimate teaching frontier is at the intersection of aerospace, biotechnology, and entrepreneurship. Having an opportunity to unleash a 'blue-sky' vision that encompasses all three in the form of a satellite carrying a biotechnology payload represents the ultimate real-world student challenge. During the WeissSat-1 mission, students will at times fail, and will learn from it. Students will gain academic confidence through this experience and will gain valuble experinces from collaboring with industry. Getting to space requires them to "work hard, work smart." Why do something so risky and so difficult? Why not? "Let's Go To Space".

Acknowledgments

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