EagleSat on HASP 2014:
Testing a CubeSat on a High-Altitude Balloon

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Abstract

In preparation for the delivery of their CubeSat in late 2015, the student engineers of the EagleSat project flew an engineering test article of EagleSat on the 2014 flight of the High Altitude Student Payload (HASP). These students, from the Prescott, Arizona campus of Embry-Riddle Aeronautical University (ERAU), were able to verify that systems would operate as planned in the near-space environment found at 127,000 feet, and that the onboard communications system could interface with the ground station at ERAU at ranges similar to those that would be experienced with the satellite on orbit. By testing EagleSat on a high altitude balloon, critical data was received that allowed the project to continue development in order to meet the delivery deadline.

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1 Payload Background and Development

High altitude balloons provide an efficient, reliable method of reaching high altitudes within Earth's atmosphere, at which the conditions are close to those experienced in Earth orbit. This near-space environment can subject payloads to temperatures between −50 °C and 50 °C, with pressures as low as 340 Pascal, or 0.335% of that at sea level. The High Altitude Student Platform (HASP) offers university students the chance to develop payloads for these conditions by providing space on a balloon flown by the Columbia Scientific Balloon Facility (CSBF), an organization within the National Aeronautics and Space Administration (NASA).

For the 2014 HASP flight, a team of student engineers from Embry-Riddle Aeronautical University (ERAU) developed a payload to test a CubeSat being developed at the Prescott, Arizona campus. The CubeSat, called EagleSat, is a 1U CubeSat that is currently scheduled for delivery to NASA in late 2015. As a 1U satellite, EagleSat is only 10 cm long on each side, leading to a small volume that presents a challenge for payload design. Subjecting EagleSat to the near-space environment experienced during a HASP flight allows for onboard systems to be verified in a way difficult to replicate in a laboratory environment, but also required the development of hardware to integrate EagleSat with HASP. The integration hardware was referred to as the Nest integration module, and was designed to contain the necessary electronics to provide power and HASP communications to EagleSat while also firmly attaching the satellite to the HASP structure.

The 2014 flight was the second time the ERAU team had flown an EagleSat test article on HASP, and marked a significant improvement over the first iteration. The 2014 EagleSat article was much closer to the payload to be launched into orbit, utilizing a different antenna and structure than had flown on the 2013 flight, as well as an upgraded onboard computer. The 2014 payload was able to take advantage of the lessons learned from the 2013 flight, as well as incorporate a year's worth of progress that the 2013 test article was unable to utilize.

1.1 EagleSat Development

The EagleSat Program began in the fall semester of 2012 with a small group of students dedicated to the task of designing and launching a CubeSat within four years. In that semester, the basic functions of the satellite, as well as a preliminary mission concept, were developed in order to allow the team to apply to the CubeSat Launch Initiative (CSLI), a program run by NASA that selects CubeSats for launch as an auxiliary payload on an already scheduled rocket. During the mission concept phase, EagleSat was designed to conduct two experiments:

- To study the effects of solar radiation on several types of commercially-available flash memory, with the specific goal of finding evidence of bit-flipping.
- To investigate the deorbit rate of a CubeSat by measuring orbital period with the aid of the Air Force Space Surveillance System, more often referred to as the Space Fence.

It was also decided that as many systems as possible would be student-designed, pending the completion of trade studies to evaluate all possible components for the mission. The trade study and design phase began during the spring semester of 2013, which led the student engineers to begin the development of antennas, an electric power system (EPS), payload experiment boards, solar panels, and a structure. The onboard computer (OBC) and radio systems were to be purchased due to the complexity present in their design and fabrication. An early EagleSat test article was flown on HASP 2013 to test the initial revision of the antennas, solar panels, and structure. The flight revealed several flaws in the student-designed structure, as well as severe directionality in the antenna. Both issues were central to the program during the fall 2013 semester as they were evaluated to find possible fixes for future revisions. While the antenna would undergo a redesign in anticipation of further testing, the student-built structure was abandoned in favor of a 1U CubeSat structure manufactured by Pumpkin, Inc. The August 2013 announcement of the decommissioning of the Space Fence forced the program to switch to a GPS-based method to measure the deorbit rate of EagleSat, which led to a series of trade studies to find the optimal GPS module for the mission. The design was solidified in November 2013 with the EagleSat Preliminary Design Review (PDR), during which ERAU faculty reviewed the design of EagleSat. The satellite had officially become a hybrid of student-designed, professor-designed, and purchased components, but in a combination that would allow the mission to succeed and meet all requirements.

The decisions made at the PDR led to the development of a more advanced test article for HASP 2014, which would include the new structure, a revised antenna, the GPS module, and a more robust solar power system. It was decided that the test article would not contain the memory experiment due to an inability to properly test it at the expected float altitude, as well as to allow the experiment more time for development. In addition to conducting a systems test in the near-space environment, the flight would provide a crucial opportunity to test interaction between the onboard communications system and the ground station at the Prescott campus prior to the anticipated launch date.

1.2 Nest Development

The Nest integration module is an evolution of Hatchling II, the payload ERAU developed for HASP 2013 alongside EagleSat. While Hatchling II contained equipment to test the stratosphere for traces of smoke from extremely energetic wildfires, the Nest module would utilize the Hatchling II structure to house the electronics needed to integrate EagleSat with HASP. Repurposing the structure required only minor changes, such as covering the inlet holes needed for the Hatchling II sensors, and creating slightly different mounting footprint to fit the Pumpkin structure. The Nest module would utilize an Arduino Uno to serve as the communications passthrough for EagleSat and HASP, allowing commands to be sent from HASP, and data from EagleSat to be logged on HASP. By linking the Arduino to the EagleSat transmitter, the HASP team would have the ability to disable the transmitter by sending a command, or if the transmitter did not respond to the command, by disabling the power to the Arduino. Nest would also contain the electronics necessary to step the 30 V provided by HASP to the 12 V required by EagleSat, while also preventing any current spikes the EagleSat capacitor array may have generated.

Further modifications were made to the Nest module to ensure the safety of payload components during the flight. A layer of foam was cut to provide the electronics insulation from the bottom of the module, as well as to provide thermal insulation during the colder phases of the flight. The method of sealing the payload was modified from the Hatchling II method, which had proved to be cumbersome and over-designed. New holes were drilled through the structure to allow it to bolt together easier, and to make accessing the internal components a less arduous task. Finally, the holes for the DB9 connectors that allowed the payload to communicate with HASP were enlarged to fit the DB25 connector required by the more advanced EagleSat article. Once both EagleSat and the Nest module were complete, testing was able to begin.

1.3 Issues Encountered During Payload Design

While designing the payload, one of the primary concerns was ensuring compatibility between EagleSat and HASP. Since EagleSat utilizes a capacitor array for energy storage and would periodically rely on HASP to recharge, an EPS had to be designed to prevent any sudden current spikes from blowing fuses on HASP. This EPS turned out to be quite a challenge to design, and the final revision utilized a pair of power resistors as a current limiting device. However, these resistors reached temperatures greater than 50 °C during operation, which caused the Arduino in the Nest module to overheat during tests. To alleviate this, the resistors were mounted the to the walls of the Nest module in an effort to use the structure as a radiator. This method proved to be effective at reducing the heat experienced by the Arduino, and led to more reliable operation during testing and flight.

In addition to the electrical concerns, the EagleSat antennas proved to be difficult to design. Conceived as a phase shifted circularly polarized antenna, an early iteration was tested on the 2013 HASP flight. Although transmissions could be received while at float altitude, this antenna proved to be very weak and extremely directional, and a redesign commenced immediately following the flight. This redesigned antenna seemed feasible through every stage of design, yet once testing arrived it was discovered that the SWR of the antenna was beyond the usable range, thus disqualifying the antenna from the 2014 flight. This decision lead to the use of a monopole antenna, which required adaptations to fit onto the EagleSat structure. The antenna was mounted to a PBC, which served as the ground plane, and was then mounted to a foam block to further insulate it from the structure. This arrangement performed well during testing, and was selected for the final flight configuration. However, the use of this antenna was expected to lead to an inaccurate picture of what to expect from the final EagleSat antenna, and will be studied closely through experimental validation once the final antenna has been selected.

Though all members involved with design and fabrication were dedicated to the project, as students, their time was prioritized for school before work on the payload. This often lead to delays in the development of the payload, especially with staggered midterm exam schedules, which mean that final fabrication deadlines slipped over the course of the semester. An unfortunate consequence of this was that final fabrication was during the summer break, when most of the team was gone. Having to rely on the smaller team available for the summer meant work progressed at a slower pace, and the work load for those members was higher than it normally would have been. However, this is not unexpected for a student project, but is something to be addressed in the future. It may be possible that similar delays can be prevented by recruiting more members to the project in hopes that work can progress during the slower periods of development.

2 Goals for Flight Operation

2.1 Goals for Flight

By flying EagleSat on HASP, the team hoped to collect long-duration, near-space performance data in order to test systems prior to on orbit operations. Given the similarities between conditions at the float altitude of 40 km and at the International Space Station (ISS) altitude of 430 km, allowing EagleSat to operate on HASP would be a better analog of flight operations than a lab-based setup. The 2014 HASP flight would be the most complete model of EagleSat to date, allowing the team to gather data on how the system operated as a whole. One component that was important to gather data on were the solar panels; though a single panel had flown on the 2013 flight, the EagleSat test article had relied on HASP for power. By flying a more complete solar array on the flight, the team would be able to get a better idea of how much power the panels could realistically produce during flight operations. However, flying the panels on HASP would lead to a power production case that wouldn't be seen on orbit due to testing in the Earth's atmosphere. On orbit, the satellite would experience a rapid succession of day/night cycles, spending roughly 70% of each orbit in sunlight. The time spent in the sun would not be long enough to charge the capacitor array to power the satellite through the entirety of the shadow of the Earth. Because of this, systems had been developed to expect to power down least once during a 90 minute period, however, while on HASP, the system would be constantly powered from either sunlight or HASP. To address the power being delivered by HASP, a switch was devised to disconnect EagleSat from the power line. This switch could be triggered by sending a command through HASP to the Nest Arduino, and would leave EagleSat to rely on solely on solar power. However, it still did not address the issue of constant exposure to the sun during the daytime, but it was decided that that exposure was unavoidable and would provide longer data on power performance.

Another area of interest to the team was testing the transmitter, which had also flown on the 2013 flight. However, the transmitter had been coupled to the earlier, flawed antenna, and while the selected antenna for the 2014 flight was not the final flight model, it would provide stronger, more realistic performance than the previous year's had. By including the transmitter on HASP, it would test both EagleSat and the ERAU ground station and prepare them for on orbit operations. The launch location in Ft. Sumner, New Mexico is 755 km from the ERAU campus in Prescott; when the flight altitude of 40 km is reached, the transmissions has to cover 760 km to communicate with the ground.

2.2 Ideal Flight Operation

Given the differences between balloon and orbital operations, an ideal flight of the EagleSat test article would be separated into several stages, with different objectives for each sage. The ideal flight operation of EagleSat would be as follows:

- Pre-launch operations would see the capacitor bank on EagleSat charge up when power was supplied from HASP. This would allow EagleSat to begin transmitting data over the HASP serial line, allowing the team to verify all systems were functioning normally, as well as receive for environmental and location data to establish initial conditions for the flight.
- The launch stage would test the accuracy of the GPS as the balloon began its ascent to flight altitude. As the balloon ascended at a rate of approximately 1000 feet per minute, this phase would cover nearly two hours and yield a large number of data points to map the ascent.

- Upon reaching float stage, a command would be sent through the HASP serial connection to isolate EagleSat from the HASP power, allowing the team to acquire data on the EagleSat solar cells. Given the constant operation of the GPS, it would be an area of interest to see how long EagleSat could transmit data and receive GPS data before exhausting the capacitor bank.
- As the sun passed overhead at noon, the Nest module would be commanded to provide EagleSat with HASP power once more. Due to the placement of the communications antenna, the EagleSat article lacked a solar panel on top of the payload, making power generation impossible at this stage. Also, it is anticipated that the payload would reach its hottest temperatures during this phase, allowing the team to gather data on how well the article handles thermal loads.
- Once the sun begins to set in the west, EagleSat would be disconnected from HASP power once more, and remain on solar power until the sun began to set, or just prior to HASP beginning to descend.
- During descent, EagleSat would be constantly relaying GPS coordinates through HASP and over the radio to allow the team to track it, and hopefully find it after landing.

The ideal operation outline was developed by considering the critical data the team wished to receive from the payload, as well as the best ways to test the performance of the EagleSat article. The ideal operation outline would also allow for opportunities to try to command the payload over the radio in order to verify system responses to the commands. This verification would be critical in ensuring that EagleSat could have two-way communication with the ERAU ground station, and even reset systems if needed.

2.3 Test Performance

Testing the payload consisted of thermal testing in AXFAB at ERAU, and thermal vacuum testing at the CSBF facilities in Palestine, TX. The thermal testing at ERAU focused on motoring performance at colder temperatures, a test that both EagleSat and the Nest module excelled at. The cold temperatures were a concern for the EagleSat OBC and the Nest Arduino, and though such temperatures would only be experienced during the accent and descent stages (or at float if the flight continued into the night), ensuring that the payload could handle them was a critical concern for the team. Passing these tests allowed the payload to proceed to HASP integration with few concerns.

The thermal vacuum tests at CSBF proved to be more rigorous than the thermal tests conducted on campus, as they allowed the payload to experience variations in both temperature and pressure. The tests required EagleSat to rely on HASP for power, as the chamber prevented any sunlight from reaching the solar panels, which was a deviation from the ideal operation outline. However, testing EagleSat in this manner alerted the team to a critical issue: When operating at high temperatures, especially in a low pressure environment, the resistors in the Nest module would cause the Arduino to overheat and report errors over the HASP serial line. This issue prompted the team to relocate the resistors, as well as to consider more robust thermal engineering for future payloads. Outside of that issue, the payload excelled in its tests, and proved to be ready for flight operations.

3 Data Analysis

During flight operations, data was not stored onboard in either the Nest module or in EagleSat; rather, it was transmitted through the Nest module to HASP, and a simpler copy was radioed out through EagleSat. Not having a copy stored onboard meant that the transmitted data needed to be kept in a easily interpreted format for later analysis. This format was not made into an easily readable format in an effort to keep the transmissions as simple as possible, as such, a typical transmission looked like the following string:

GPGGA 150727.934 3436.4864 N 10417.0880 W 1 10 0.9 30381.3M -20.4 M

In this string, the GPGGA refers to the encoding from the GPS constellation, while 150727.934 can be interpreted to be the time at the Prime Meridian, or 15:07:27 hours. 3436.4864 N is the latitude, or 34° 36.4864' N, and 10417.0880 W is the longitude, or 104° 17.0880' W. Further, the number 10 refers to the number of GPS satellites in view, while 30381.3 M is the altitude - just over 30 km. Using this interpretation of the data, all of the flight data was patched together into one contiguous Microsoft Excel file, which would allow easy dismissal of any corrupted data, and even easier interpretation of all complete data. By importing the data into Excel, it could be sorted into a much more intelligible format, an example of which is below:

CPU TIME	VOLTS	ZTIME	LAT	LONG	ALT	SATS	T1	T2
13:14:00	11.928						-5.5	-12.6
13:15:00	12.044	13:57:23	3434.0915	10405.2325	11344.2	9		
		13:57:25	3434.0915	10405.1985	11350.1	9		
		13:57:27	3434.1161	10405.1348	11371.1	8		

Table 1: RSSI voltage between EagleSat and ERAU ground station.

As seen with this table, not every line was complete. This was due to issues with the EagleSat OBC logging data from the GPS and internal sensors. The lack of data on the line that recorded the temperatures reflects a line recorded by the EagleSat OBC, essentially a status check for conditions within the test article. The temperature was logged every ten minutes, and looking through the data records can verify that at that interval, only temperature data was recorded - not a one strand of GPS data was logged at the tenth minute. When looking at the lines with GPS data, the CPU TIME category reflects the time the OBC had when it began the record, which is why the time was not repeated for every instance of the three-string series. ZTIME is the time from the GPS, and as seen in the table it logged three instances, each two seconds apart. The voltage was measured by the OBC, which is why it is on both GPS and non-GPS strings - it was a critical value to be measured throughout the flight, and the plethora of logged data supports that. Not shown in this sample table is the Received Signal Strength Indication (RSSI) voltage, or the measurement of signal strength between the ground station and the test article. The RSSI voltages could only be generated by a command from the ERAU ground station, and thus we recorded relatively infrequently over the duration of the flight. The RSSI voltages recorded during the flight are listed below.

ZTIME	RSSI VOLTAGE
19:09:01	2.097
19:09:03	2.11
19:09:05	2.106
19:20:05	2.006
19:20:07	2.039
19:58:12	2.103
19:58:14	2.094
19:58:16	2.084
19:58:18	2.094
19:58:20	2.106
19:58:22	2.09
19:58:24	2.113
19:58:26	2.1
19:58:28	2.097
19:58:30	2.1
19:58:32	2.116
19:58:34	2.087
19:58:36	2.09
19:58:38	2.1
19:58:40	2.094
19:58:42	2.097
19:58:44	2.087
21:51:09	2.435
21:51:11	2.452

Table 2: RSSI voltage between EagleSat and ERAU ground station.

RSSI values can range between 0 and 3.7 V, and as seen in this table, the values experienced between EagleSat and the ERAU ground station ranged from nearly 2 to almost 2.5. Given the distance between the two, those are fairly strong values, and the data recorded over the ground station link reflects that. A strong RSSI value will be critical for successful on orbit operations - if the ground station cannot successfully receive data from the satellite, the mission isn't serving a useful purpose.

Of use for the satellite is knowing the internal temperatures during operations. EagleSat has sensors mounted inside to measure the temperature throughout operations; on HASP, these were put to the test to monitor the wildly fluctuating conditions of the six hour flight. The figure below shows the temperatures and how they varied throughout the flight.

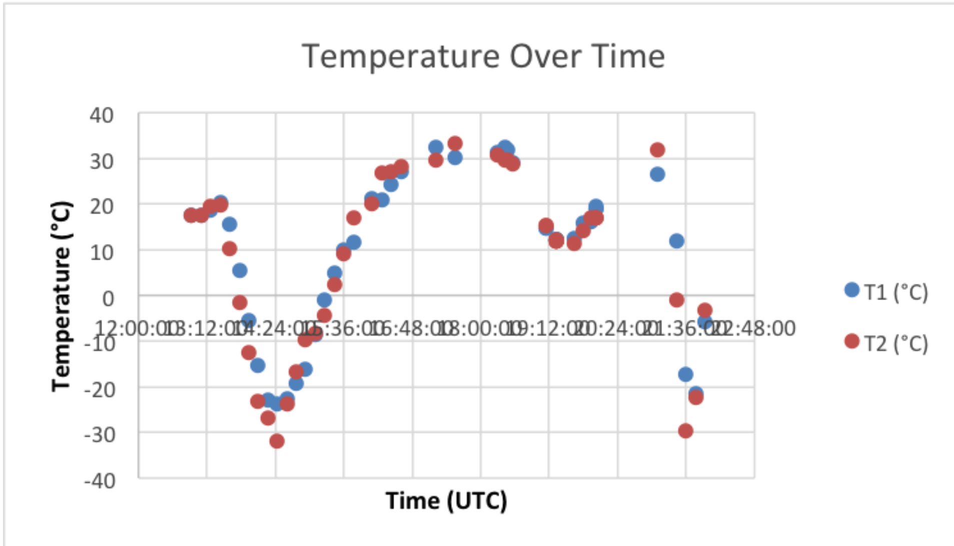

Figure 1: Temperatures recorded by EagleSat over time.

As seen in the figure, the temperature varied between 40 ℃ and −40℃, but never varied beyond those bounds. The extreme cold temperatures come from the ascent and descent stages of the flight, where the payload was exposed to the extreme cold at the upper bounds of the troposphere. The highest temperatures were experienced by the payload during solar noon, when the harsh sun had nothing to prevent it from beating down on the payload. It was during these conditions that errors occurred on the Arduino - the temperature in the Nest module elevated to the point where the data downlink grew to be unreliable. However, during that stage EagleSat continued to operate, as data was received over the ground station radio link far more reliably than through the Arduino.

The altitude experienced by the payload over time was recorded through the onboard GPS receiver. The data included the number of satellites in view, and whenever the number of satellites dropped beneath 3, the data was essentially unverifiable, and thus was discounted from the final analysis. A plot of the altitude versus time can be seen below.

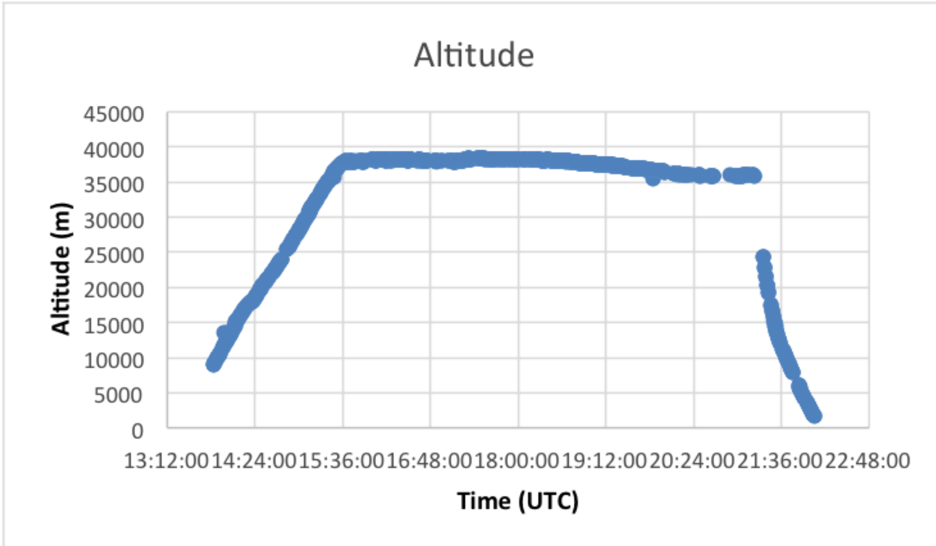

Figure 2: HASP altitude vs. time.

As seen from the plot, HASP reached a maximum altitude of nearly 40 km, a respectably high altitude for such a flight. The GPS data managed to come through reliably enough that the entire flight profile could be logged, including the fact that the launch location in Ft. Sumner was at a high altitude than the landing location in Northern Arizona. What is interesting to note, however, is just how violent and hot the beginning of the descent stage was - at that point, the payload dropped quickly enough to leave a large gap in the data, creating the impression that the payload dropped 10 km in a matter of minutes. Another interesting aspect revealed from the data is how early in the flight the balloon reached its maximum altitude - for almost two thirds of the flight, the entire payload was descending in altitude.

The final aspect of the payload to be analyzed were the voltages produced by the EagleSat solar power system. The max voltage the capacitor bank could reach on HASP power was 11 V, so any instance over that is indicative of the solar cells producing quite impressive amounts of current, as seen in the figure below.

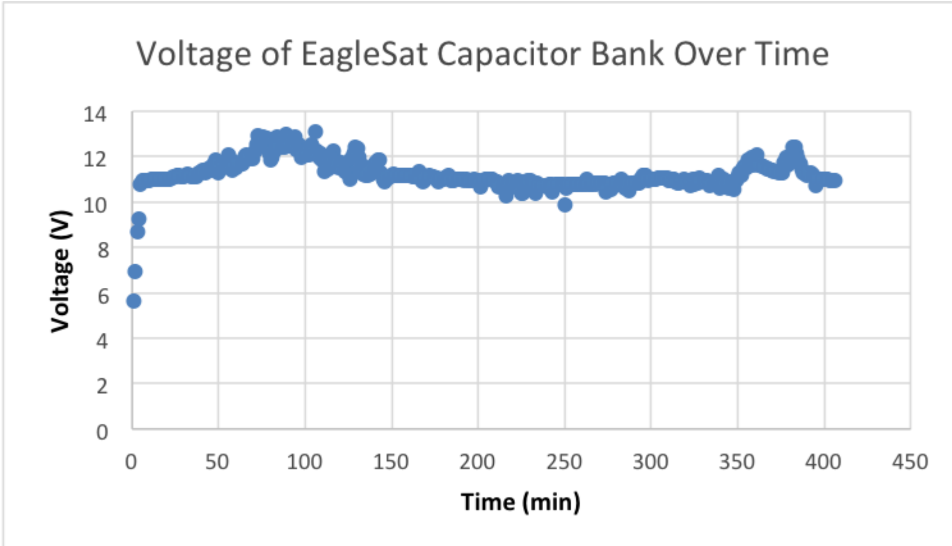

Figure 3: EagleSat capacitor voltages over time.

The plot shows that EagleSat had two major spikes in voltage, which appear to indicate time periods when the sun was shining favorably on the solar panels. Knowing that panels and capacitors can reach these voltages is promising for orbital operations, as they give the impression that the satellite can charge its capacitors quite efficiently. Also of note is the sharp curve when the capacitors began to charge - this was a major worry when designing the Nest EPS, as the capacitors will draw whatever energy they can. By limiting the amount of current the capacitors could draw, the Nest EPS was deemed to be safe to use on HASP, but the charge curve is still quite a sight to see.

4 System Review

4.1 Payload Performance

As verified by the data received from the payload, the EagleSat system operated outside of the ideal operational outline, but still performed as expected, setting the stage for successful operations on orbit. Even with the short flight time, the team was able to gather useful data on system operations, and even learn about potential issues the system may face on orbit. Thermal protection has not been as much of a concern for the EagleSat team as ensuring the satellite can generate enough power to sustain operations, but with the errors associated with the OBC at extreme temperatures, more work is being devoted to thermal protection. Also, having EagleSat constantly rely on HASP for power showed that the system is able to operate outside of the expected orbit operations, and that the solar panels are powerful enough to charge the system to a point beyond what HASP could. However, with the lack of several systems, including the final communications antenna, GPS, and payload board, future work is required to verify the entire system for successful operations.

4.2 Lessons Learned

The development of EagleSat and the Nest module exposed a critical flaw in the composition of the ERAU HASP team: a lack of computer and electrical engineers. Since a successful payload relies so heavily on electronics, both the lack of students to represent those fields is troubling, and often lead to setbacks in payload development prior to finding team members to fill the needed areas. Moving forward, recruiting more team members from these fields is an action item for both the EagleSat and HASP teams, as a lack of knowledgeable individuals always seems to become an issue as payload development proceeds.

By participating in HASP, the EagleSat team have learned what will and what won't work for the final model of the satellite, a valuable part of the design process. Being able to test the antennas on a long-duration flight showed their weaknesses, while testing them in the lab had previously shown them to function within requirements. The practical applications of flight testing on a high altitude balloon flight are undeniable, as there are some conditions that simply cannot be replicated in a lab environment. Through the experience gained from participating in HASP, flight testing on high altitude balloons has solidified itself as a critical element of payload design at ERAU.

4.3 Future work

Prior to delivering EagleSat in the fall of 2015, the final stage of fabrication need to be completed. Work is underway to identify a replacement antenna for the student-designed antenna, which includes the third iteration of that design. However, since the antenna will be such a critical element of on orbit operations, the most reliable option will be selected, which may rule out all student-designed options. Work is underway to have the antenna selected prior to the EagleSat Critical Design Review (CDR) in January 2015. The GPS that will be used on orbit is undergoing testing in the Aerospace Experimentation and Fabrication Building (AXFAB) at the ERAU campus to verify that it will properly interface with the OBC, an operation critical to secondary mission success. These tests have allowed the OBC, Payloads, and Flight Operations subsystems to all verify that their systems will be compatible with the final flight configuration, and to proceed to prepare for the CDR. The flash memory experiment, the main payload for EagleSat, has been an element missing from the test articles that have flown on HASP in 2013 and 2014. However, development has proceeded through to the early fabrication and testing phase, allowing the Payload subsystem to experimentally verify that the primary mission objective will work on orbit.

Looking to the future, it is anticipated that a third EagleSat test article will fly on HASP 2015. This model will be nearly identical to the final iteration, however, it will use components that have flown on HASP before and have been disqualified from on orbit use. This test article will be as compete as the one to be delivered for on orbit use, including the memory experiment for the first time since EagleSat began flying on HASP. A third flight will allow for further verification of the EagleSat ground station, from the use of the final antenna to testing of the ground station software still under development. in addition, given the proximity between the anticipated HASP launch and the delivery of EagleSat, it will allow the EagleSat team to drum up interest in the project ahead of orbital operations, and help to inspire more students to join the EagleSat Program for the development of a second CubeSat.

5 The Embry-Riddle Aeronautical University Team

5.1 An ERAU NASA Space Grant Program

The HASP Program at ERAU is run through the campus chapter of the Arizona Space Grant Consortium, and is run under the guidance of faculty mentors Dr. Gary Yale, Dr. Ed Post, and Professor Jack Crabtree. As a Space Grant project, Clayton Jacobs and Zachary Henney, the project managers for both the EagleSat and HASP, are both student research interns through Embry-Riddle NASA Space Grant. Additionally, several of the subsystem team leads within the EagleSat project are interns as well, reflective of the amount work required to design a satellite. As a requirement for maintaining Space Grant support, all research interns must present on their work at the Arizona Space Grant Symposium, held annually in April. The ERAU HASP program has been a subject of two presentations by Mr. Henney, detailing the work completed for the 2013 and 2014 HASP flights. In addition to these two, Mr. Henney will be presenting at the 2015 Symposium to present on the results of the 2014 HASP flight, as well as the ongoing work for the 2015 flight. Outside of Space Grant presentations, HASP was also introduced to the ERAU campus during presentations at the 2013 Discovery Day event, a day in which Embry-Riddle students can present on their research. HASP was mentioned in presentations by several of the EagleSat team, mostly to explain the benefits of testing a CubeSat on a high altitude balloon, but also to raise awareness for high altitude ballooning. In addition to HASP, interns from ERAU Space Grant are involved in several balloon program of a lesser scale. However, these interns are all engineering students, so raising awareness within the physics or meteorology departments could lead to more diverse payloads for future flights.

5.2 ERAU Team Demographics

The EagleSat program has attracted a wide variety of students since its inception; however, most students involved in the project today tend to be Aerospace Engineering majors, with a handful of Electrical and Computer Engineering students as well. The team that developed the payload for HASP 2014 are largely reflective of that dynamic, as seen in the table below.

Marcus Bever	Male	Hispanic	Asian, Caucasian/White	No	Undergrad	Senior
Mo Sabliny	Male	Hispanic	Other	No	Undergrad	Senior
Aaron Taylor	Male	Non-Hispanic	Caucasian/White	No	Undergrad	Senior
Zach Henney	Male	Non-Hispanic	Caucasian/White, Native American	No	Undergrad	Senior
Aaron Petrek	Male	Non-Hispanic	Caucasian/White	No	Undergrad	Senior
Robert Layton	Male	Non-Hispanic	Caucasian/White	No	Undergrad	Senior
Clayton Jacobs	Male	Non-Hispanic	Caucasian/White	No	Undergrad	Senior
Shawn Thompson	Male	Non-Hispanic	Caucasian/White	No	Undergrad	Sophomore
David Gomez-Herrera	Male	Hispanic	Other	No	Undergrad	Junior
Dadija Bluidzius	Female	Non-Hispanic	Caucasian/White	No	Undergrad	Senior
Kevin Jordan	Male	Non-Hispanic	Caucasian/White	No	Undergraduate	Senior
Eric Giler	Male	Hispanic	Other	No	Graduate	

Table 3: ERAU HASP Team Demographics.