High Attitude Student Platform

Inter-American University, Bayamon

<u>Science Report</u>

Team Name: **ARIES-Dynamics Team. Payload #6**

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3 Mission goal, science and technical objectives.

3.1 Mission Goal

The SWIM CubeSat is a 3U satellite that uses several subsystems to maintain stability and a pointing accuracy of 0.1 degree due to the science payload, WINCS. The subsystem needed for this is an Attitude Determination and Control; however this system is required to be proven as a reliable subsystem. Therefore an initial testing can be achieved through the HASP platform in a near space environment. The development of this subsystem will also provide knowledge in aerospace engineering to students of the Puerto Rico SWIM CubeSat project.

3.2 Objectives

These objectives are the measureable, simple and practical steps that are needed and will contribute to the fulfillment of specific goals.

3.2.1 Science and Technical Objectives

The following are several science objectives related to this experiment:

1. Increase the understanding of aerospace sciences specialized in CubeSat technology.

2. Gain knowledge and experience in Attitude Determination such that it can be applied for a CubeSat prototype.

3. Learn, test, and calibrate different sensors to measure the Earth's gravitational, and magnetic fields, also the Sun intensity, and the angular momentum of the ARIES Dynamics payload.

4. Learn about flight characteristic such as angular rate rotation, and orientation with respect to different reference frame.

5. Measure the internal temperature during flight to determine the potential impact to the structure and the components of the structure.

6. Determine the position and the time of flight of the payload by using a global

positioning system.

7. Acquire knowledge of post flight data analysis.

8. Obtained an appropriate quaternion representation through the Kalman filter processing.

9. Study the Earth magnetic field to obtain orientation of the CubeSat body by using the Earth's magnetic field as a reference frame.

10. Study the Angular velocity vs. time of the CubeSat during the HASP flight.

11. Obtain knowledge of the acceleration of the CubeSat on the HASP platform during the flight, thus permitting through mathematical equations obtained the displacement and velocity by having an initial reference point.

12. Acquire information of internal temperature to obtain understanding of the thermal behavior of the cube throughout the flight.

13. Obtain knowledge of the position and time of flight of the payload by using a global positioning system.

14. Study the behavior of the Kalman filter with raw data of the HASP payload.

15. Use the obtained data to gather knowledge about the attitude motion of the payload and provide recommendations for future HASP and CubeSat projects.

16. Learn about the thermal characteristic of the payload through the environment that it will be exposed to through the flight.

17. Obtain knowledge of software implementation on a microcontroller.

3.2.2 **Specific objectives**

The specific objectives presented here are necessary to accomplish our mission goal. These objectives will be completed during the development of the prototype:

1. Apply astrodynamics, engineering, and programming concepts to design software that will be capable of interpreting and using the data from the Attitude Determination System, to stabilize the platform containing the scientific package.

2. Design and connect the sensors located in a PC/104 board inside the body frame of 10cm cube to determine the attitude motion of the payload. The PC/104 is a CubeSat standard PCB.

3. Implement different attitude determination algorithms such as the Kalman Filter and/or Newton Gauss method within the programming, to determine the motion and orientation of the payload. The Newton Gauss method is not

essential although can increase the accuracy of the determination while increase the computation complexity of the microprocessor.

4. Interpret the graphs obtained from the output of the different sensors as well as the attitude of the vehicle. This data can be inserted in a Kalman filter algorithm using MatLab to corroborate with the flight data a provide

5. Obtain the platform's orientation with respect to the inertial reference frame of the ARIES Dynamics project.

6. Reduce the attitude accuracy error of the payload to approximately 0.1 degrees. This can be performed with the Linear Covariance, which uses the sensors to determine the uncertainty of error.

7. Develop the source code that will be used to control the platform orientation in a closed loop system.

8. Implement a thermal system in the range of 0OC to 40oC to maintain the components in the nominal operating temperature range.

9. Maintain the dimensions of the package within 15x 15 x 30 cm area.

10. Reorient the cube to a desired position using PID control.

11. Design, connect and develop a board capable of having both a Global Positioning System and an Attitude Determination System while meeting the PC/104 standards.

12. Comply with the CubeSat PC/104 mechanical standards.

13. Utilize the PC/104 Pumpkin bus for the communication between different boards

14. Obtain internal temperature and pressure.

3.2.3 **Optional Objectives**

1. Determine the orientation of the payload with respect to the Sun using the data obtained VI characteristic board.

2. Test the CINEMA solar panel circuit that will be used to acquire the radiation measurements.

4. Thermal Payload Analysis

4.1 Thermal Payload Performance

The inside temperature of the payload is a very important parameter that has to be consider. If the inside temperatures reaches the critical temperatures the effects on the payload are:

- Damage on the circuit boards (possible shut down)
- Thermal expansion on the structure (could cause bending stress, structural failure)

The payload performance with respect to the thermal area was a success; the temperatures inside the payload didn't reach any critical conditions ($80℃\ to\ -20℃$), also no damage to the circuits board and structure was made with respect to the temperature. The payload in regards to thermal did what was expected.

4.2 Problems Encountered

No significant problems were encounter with regards to the thermal design and the inside temperature, although one of the thermostat did malfunction in flight reading $125℃$ and we know for a fact that this temperature reach is not possible (it could have been a possible reading error).

4.3 Lessons Learned

My personal experience with the HASP was a complete learning experience. For the thermal it is interesting to note how the thermal environment in space works. In example in space it is a complete vacuum so no convection is made, and much more.

4.4 Science Report

Some basic assumptions were made:

- Vacumm ambient
- Heat conduction inside
- Constante properties
- Steady State

Note that steady state will tell us about the maximum and minimum temperature the payload could reach.

Hot Case

Qemitted = 18.65 Watts and Tsur = 68.03°C.

Tin = 70.56°C.

Cold Case

Qemitted = 14.4 Watts and Tsur = 0.43°C.

Tin = 1.56°C.

These results are based on steady state analysis.

4.5 Technical Results

In the thermal design no used of "real" insulation was made because of the powerful heater provided by the electrical engineers. This heater provided us with an extreme internal heat load difference from 0W to 9W, that's a big advantage for the thermal design because when the temperature drop to 10 C the heater was turned on and when it passed 20 C it was turned on, so basically you'll have a temperature distribution oscillating around 10 C or 20 C. The only problem could had been caused by the sun, therefore we design for the surface to reflect most of the suns radiation. The thermal design for the HASP Dynamic was a success the proper amount of Kapton and a layer of mylar on the surface of the cube, gave a Temperature distribution with respect to time inside the cube of almost a perfect oscillation system.

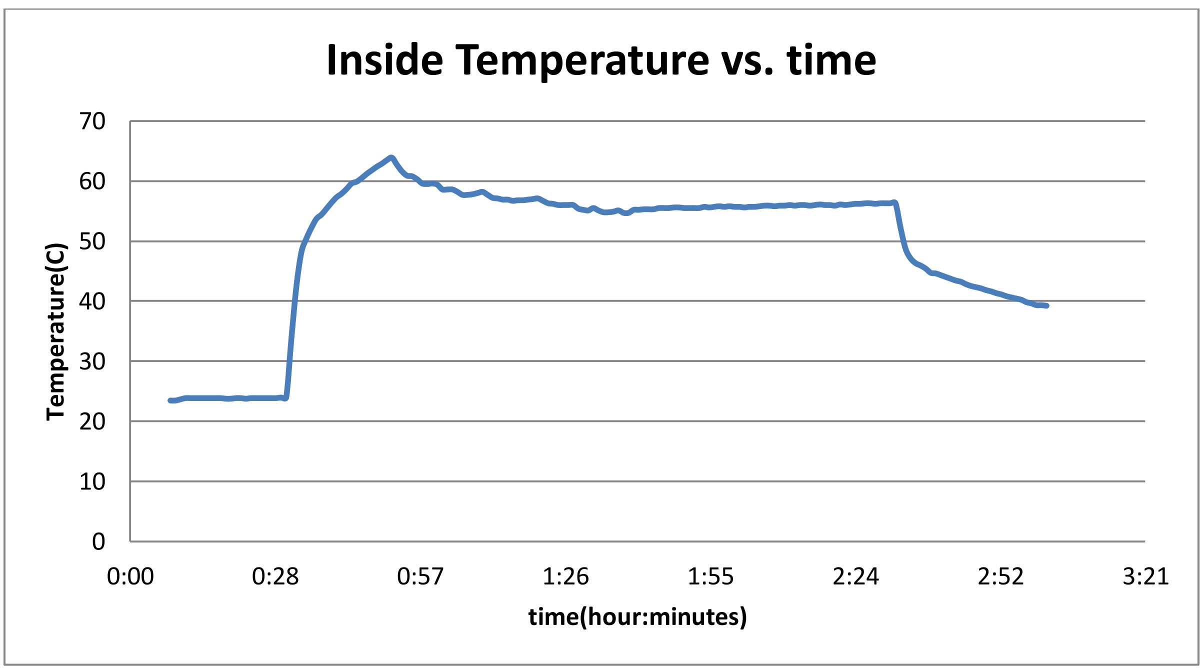

Figure 1 **Experimental Data from our vacuum chamber**

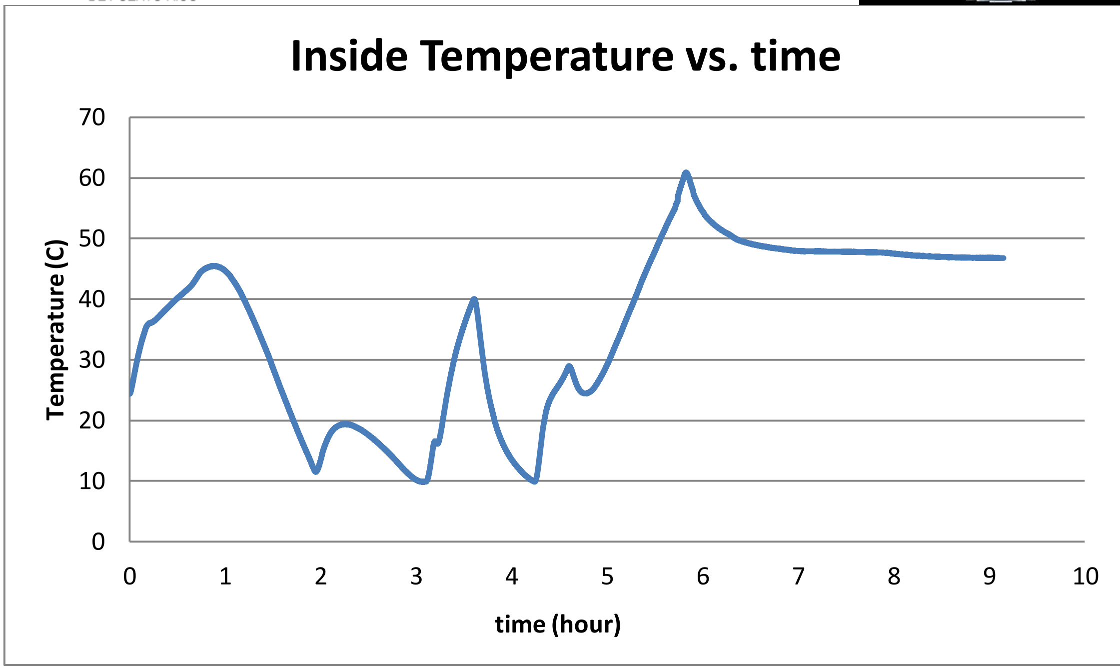

Figure 2 Flight temperature data

We can safely assume that the Hasp Dynamic could have another successful flight with regards the thermal.

5. Attitude Determination & Control System

5.1 System Performance

The attitude and determination control sub-system (ADCS) of the payload consisted of both electrical and mechanical components. As with most control systems, ours could be separated into two different parts: sensors, controller, and actuators. It's purpose was to perform real-time, two-axis (pitch, yaw) attitude control of the payload. Taking this into consideration we can classify the three system components into electrical and mechanical aspects. The sensors and other controller components are best considered from an electrical engineering point of view, while the motors and moving parts are left to be seen from a mechanical standpoint.

The attitude determination (sensors) part of our system relied on measurements taken from a magnetometer, accelerometer, and gyroscope.

Together these can be found in IMU's (inertial measurement units) as is the case for our system. The measurements taken from the IMU (Razor 9dof IMU) were filtered through Kalman and other complimentary filters to calculate the angular velocity, near magnetic fields, and acceleration of the system.

These filters were implemented taking into account the limitations and performance of the separate IMU components and were of paramount importance when trying to minimize gyro drifting and fusing separate sensor signals. To further reduce measurement uncertainty, calculations were performed in the form of quaternions and only given rotation angle format when stored for user processing.

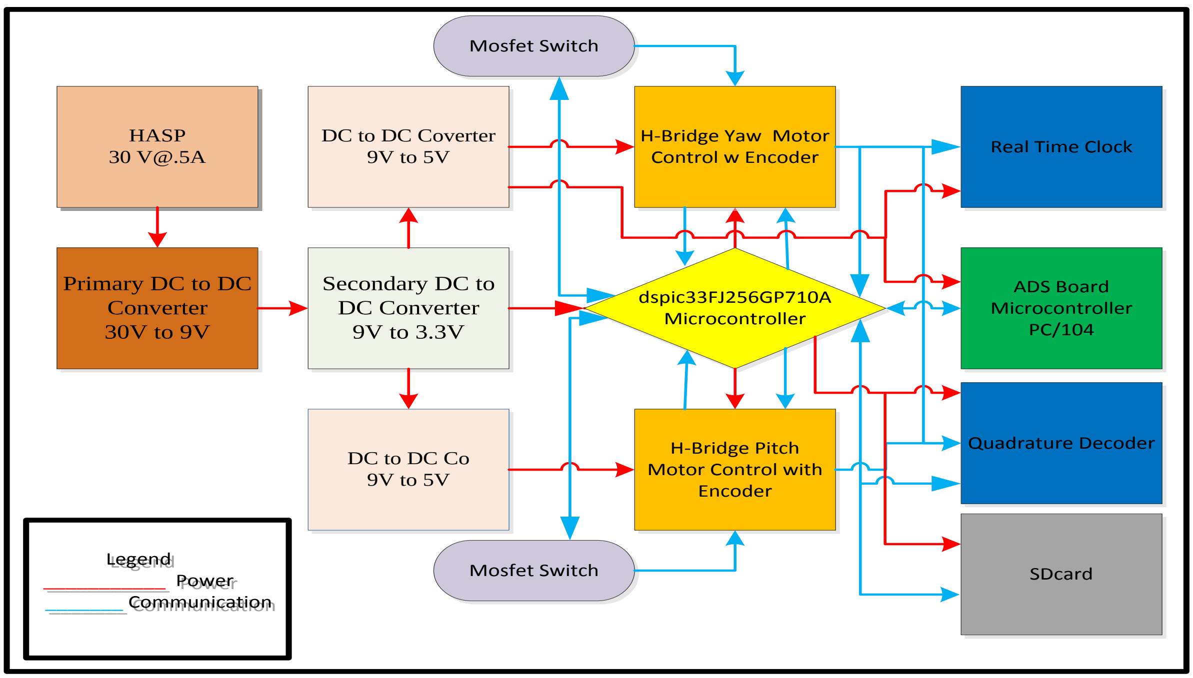

Figure 3, Detailed component diagram of Attitude Control System

The attitude control (actuator) part of our system was simpler in that it relies only on two inputs: the desired pitch and yaw angles. The actuators were simply two custom Maxon DC motors connected via timing belts to separate gears fixed to the structure. Each motor was responsible for a single rotation direction. This configuration has the advantage that the timing belts were of such length so that the structure remained rigid when the motors were stationary. That is to say, we only had to worry about HASP platform attitude since the satellite would be stationary with respect to it.

The final part of the system is of course, the controller itself. While this does not strictly fall into a mechanical or electronic classification as suggested above, it needs to be so seamlessly a part of both that it would be harder to describe is as anything else. For simplicity, the controller of choice was a PID controller. The corresponding gains of the system (proportional, integral, and differential) were determined after analyzing the dynamics of the system using methods such as pole placement and Zeigler-Nichols tuning. Armed with measurements such as motor constants, rotational moments of inertia, and others it was also possible to determine the system's transfer functions:

$$G(s)_p = \frac{\theta(s)}{V_m(s)} = \frac{K_{eq}}{s[J_{eqs}+B_{eq}]} = \frac{0.1587}{0.02668\, s^2 + 1.092\, s}$$

$$G(s)_y = \frac{\theta(s)}{V_m(s)} = \frac{K_{eq}}{s[J_{eqs}+B_{eq}]} = \frac{0.1533}{0.02712\, s^2 + 1.02\, s}$$

Where subscripts p and y indicate pitch and yaw respectively. The basic equation and diagram for the chosen standard PID controller are shown below.

$$u(t) = k_p e(t) + k_i \int_0^t e(\tau) d\tau + k_d \frac{de}{dt}$$

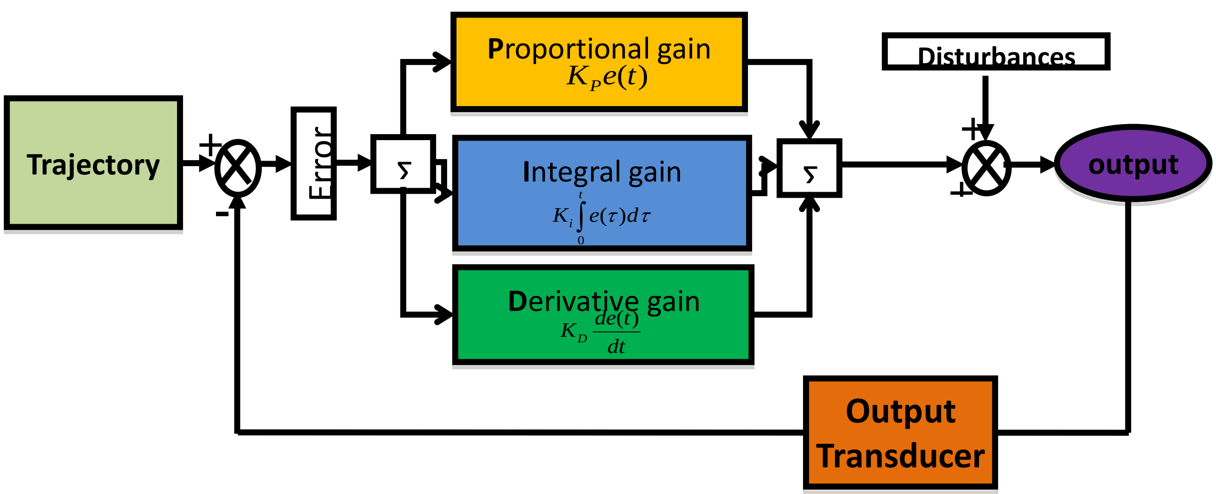

Figure 4, Block diagram of the PID control system located in the dspic microcontroller.

Using SIMULINK's PID design tools it was possible to determine (using the system's EOM (equations of motions)) the ideal values for the PID were determined and then compared to the calculated ones. As expected the results were similar but some discrepancies existed. These were resolved by simply testing the system and then tweaking the gain values back and forth between the expected values until the desired response was achieved.

The resulting controller gave an output with a steady state error of approximately +/- 1° which is remarkable performance. While theoretically there should be no error as long there is integral gain present it should be considered that no sensor or filter is perfect, therefore there is bound to be some error.

5.2 Problems Encountered

While the performance described above was indeed achieved, thus meeting the set accuracy requirements (+/- 5°). Some unforeseen complications occurred between this time and the time of flight.

As is often the case with these situations, the exact cause of mistakes and shortcomings is not completely certain. For this reason, this section will be outlined such as to state what went wrong, the effects of this mistake, and then possible causes. In order of occurrence:

- **H-bridges Stopped Working:**

The h-bridge is an electrical component which main purpose in our system is to allow a DC motor to rotate in either direction using logic voltages. That is, it reverses the current flow through the motor. At different points both h-bridges malfunctioned rendering the control system unusable as the system could only compensate for disturbances in a single direction. The reason for this mishap is not clear but is most likely due to carelessness while handling the payload. Although since both components failed, it is possible there was a flaw in the soldering or circuit design. It should be noted that the yaw h-bridge failed two months before the pitch h-bridge did.

- **Payload Stalled or did not Rotate:**

The second problem occurred after the first h-bridge failed. This time the payload rotated but chose an arbitrary 0° position every time it was started and while it did respond to external disturbances and changes in position it did so erratically. After some analysis it was determined that a new Kalman filter had to be implemented and that the PID controller gains had to be recalculated. Several attempts were made to fix this but though the attitude correction did improve it did not regain the same accuracy as before. Furthermore after a few trials the problem started to repeat itself.

The reason behind this problem was never clear. Since the student who designed the initial control system was not available during the summer period there was little the current team could do other than to implement a different control system. The result was a simple circumstantial feedback loop system with several nested conditions. The idea was simple and effective but limited. The system was able to compensate for disturbances in noticeably larger steps depending in the magnitude of the offset from its zero point, however, these steps were marked by noticeable pauses instead of a fluid motion as with the PID controller. On the other hand, with this system there was zero overshoot.

- **Payload Rotated Continuously and was Irresponsive:**

During the thermal testing at the Balloon Facility in Texas the payload began to exhibit some unusual behavior after it had spent more than an hour inside the vacuum chamber. In these occasions the payload would begin to spin continuously in one direction and become unresponsive. At the time it was thought to be a problem with the IMU board but later it became clear that the implemented control code did not account for cumulative gyroscope drift. This caused this error to build up and eventually the system became unable to compensate and exhibited the discussed reaction. Later, the pitch control h-bridge was determined to be functioning intermittently.

- **No Live HASP Communications:**

During the HASP flight no live data was received. There is no way of verifying the cause of this but it could range anywhere from an electrical subsystem failure to damage acquired during shipment and handling. For more details see below.

- **Corrupted Attitude Data:**

The biggest problem of all was none other than data corruption. Upon the return of our payload we attempted to retrieve the flight data stored in the system SD card but upon further analysis (shown in the next section) we discovered that all data except for the temperature reading storage was corrupt and completely unreadable in places. In addition, it appears that the attitude determination system stopped working (or at least the data storage process) and restarted several time during flight.

The evidence above suggests that the problem lies not in the control software but rather in the control system board. Particularly the DC to DC 9V to 5V regulator. In Figure 1 this it can be seen that this component powers not only the ADS microcontroller but also the yaw rotation h-bridge and the real time clock. All of which were parts that experienced problems. In fact, a faulty power regulator could have been responsible for damaging both the h-bridge IC and the attitude data by continuously cycling power to the ADS microcontroller (which the data shows happened at least 30 times during flight).

5.3 Lessons Learned

Of the many lessons learned, perhaps the most important from a controls system perspective is to know your sensors. Many of the problems could have been properly diagnosed if not for the fact that many a times we did not know in which system in particular the problem lay. The issue with the gyroscope drift clearly shows how ignorance or lack of information on a small matter can jeopardize the entire project.

Furthermore, another thing of great importance when working on a team containing multiple members of different concentrations and specialties is communication. What may be perfectly obvious to one person could be confusing or completely unknown to another. This weighs even more when considering that some members of the group were forced to leave and were replaced with others that while skillful were completely new to the project.

It is no doubt hard to find a person, much more a student, who is knowledgeable in enough areas to do an entire task unassisted by peers with different knowledge and skills, however, it should be a goal while a member of a team to become familiar with as many areas as possible. This way, while carrying out your own assignment it will be possible for you to understand when your decisions affect other areas of a project and whether those decision are correct. In our particular case, if those working on control had been more familiar with the basics of microcontroller programming and sensor integrated circuits and electronics, the previous section may have been much shorter than it is.

That being said, it should be noted that as a student project the experience was by no means a failure. Despite the mission's shortcomings some data was retrieved safely and other subsystems worked correctly and successfully. It has been an invaluable opportunity that will undoubtedly yield fruitful experience for all involved.

5.4 Technical and Science Results

As stated above, since the attitude data was corrupted there is very little in terms of results in the attitude control area. The following figures show how the recorded data compares with the same type of data collected in a laboratory test of the same system. As can be see, the collected data does not even measure in the same order of magnitude as the lab data. In addition the sampling time labels were also corrupted, giving the data the ‘blank’ appearance displayed in the Figure 5.

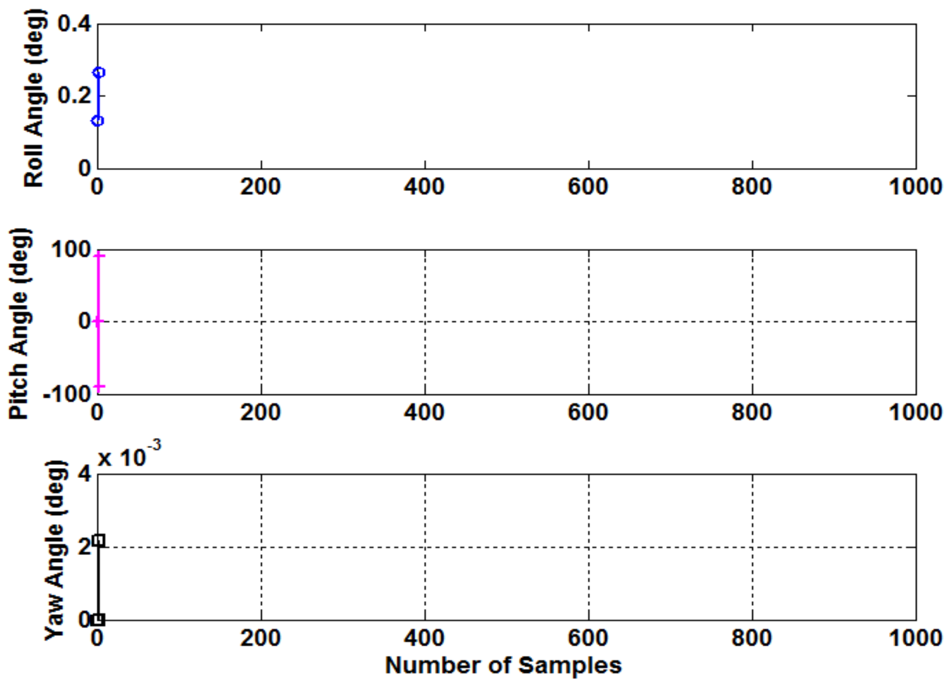

Figure 5, HASP 2012 recorded attitude determination data in the form of angular rotations.

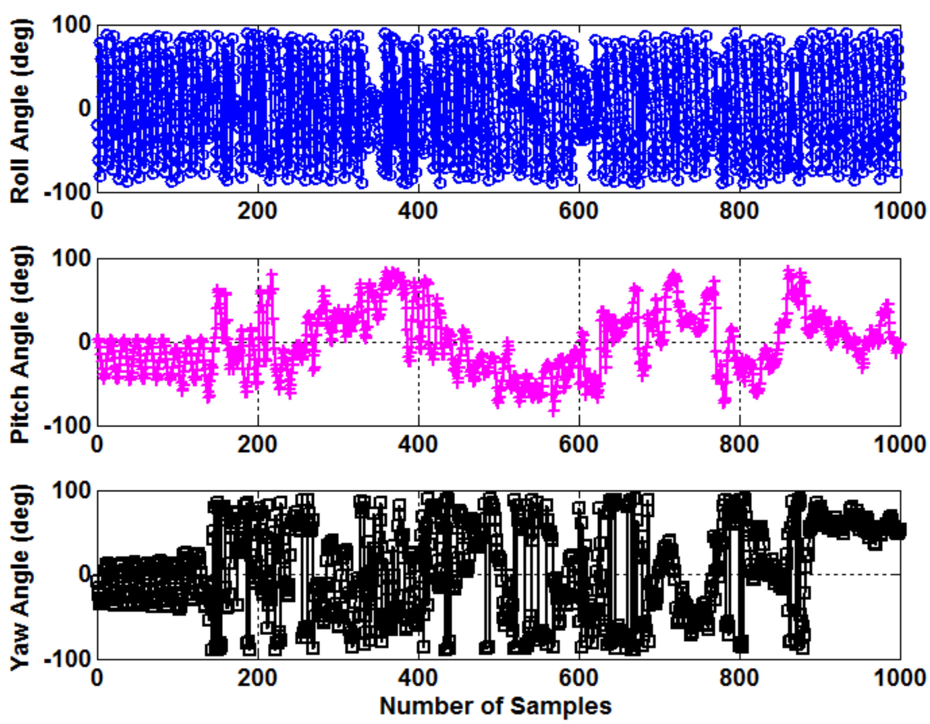

Figure 6, HASP 2012 recorded attitude determination data in the form of angular rotations.

6.0 Mechanical Payload Analysis:

6.1 Payload Performance:

In terms of performance the CubeSat (structurally speaking) performed almost perfectly. There were no major flaws in the design and it suffered no cracks or serious deflections (the only one being a small twist in the shaft which did not cause the system to fail).

The small cube rotated without crashing into any of the other parts like it did before, the motors didn't stop working nor did the rest of the components freeze over and break. Speaking in terms of functionality, the project was a success.

6.2 Problems Encountered:

The biggest problems encountered that dealt with the mechanical part of the design were in the manufacturing part of the project. The university did not have the tools necessary to build the CubeSat so we found ourselves in need to employ outside resources, which resulted in many inconveniences. These inconveniences were of economical and temporal nature. We had to find a machine shop, either industrial or from another university, which would do the labor cheaply and quickly.

At first we thought we were in the clear when we got some students from the same university who were working on their capstone project to do the work for us for free but the machines they were using broke down and half of the payload's parts were incomplete. With the little time we had we searched desperately for a machine shop that would get the things done before we ran out of time. We enlisted the help of a student from the University of Florida to get the job done.

6.3 Lessons Learned:

Throughout the entire project our team acquired and mastered many new skills. Many of our members were new to designing and manufacturing so taking part in all the processes that involved applying their knowledge to the building of the CubeSat's mechanisms proved to be both a challenge and a good experience.

Improving upon the previous design of the CubeSat was not very difficult since it only amounted to fixing a few minor details like the cube not being able to turn completely. The real challenge lied with the manufacturing part of the project as described in the previous section. Thanks to that experience our team gained valuable knowledge and experience that will serve us well in future projects of the same nature.

It can be said that the team learned how to use CAD software better than before and learned how to run structural and thermal simulations through them. Also, we put our interpersonal skills to the test since, again, most of us haven't worked in projects such as this before and haven't really seen the limits of our skills. All in all our members grew, not only as a team, but also as individuals seeking to become better professionals in the fields of science and engineering.

6.4 Science and Technical Results:

In a static analysis the best method to determine if the structure is going to fail by yield is applying the Distortional Energy Theory best known as the Von-Misses theory or the Maximum Shear Stress Theory. To be less conservative we used the Von-Misses theory (have in mind that this is the most used in common practice). This theory is based on the idea that yielding occurs when the distortion strain energy reaches or exceeds the distortion strain energy for yield in simple tension or compression, that's why it is only used for ductile materials. The ABS+ and Aluminum 6061 T6 have $\varepsilon_f \geq 0.05$ so they are considered ductile materials ergo the Von-Misses theory is applicable.

$$\sigma' = \frac{1}{\sqrt{2}}\left[\left(\sigma_x - \sigma_y\right)^2 + \left(\sigma_y - \sigma_z\right)^2 + (\sigma_z - \sigma_x)^2 + 6\left({\tau_{xy}}^2 + {\tau_{yz}}^2 + {\tau_{zx}}^2\right)\right]^{1/2}$$

The previous equation is the Von-Misses equation for a 3-dimension analysis, for simplification the analysis is made in a 2 dimension so the equation boils down to:

$$\sigma' = \left({\sigma_x}^2 - \sigma_x\sigma_y + {\sigma_y}^2 + 3{\tau_{xy}}^2\right)^{1/2}$$

Where σ' is the Von-Mises Stress, σ_x is the stress in the x component, σ_y is the stress in the y component and τ_{xy} is the shear stress applied in the y component where the stress in x takes place.

After applying the above equation for a simple analytical approach and later corroborating the results by performing numerical solutions with a CAD program (NX) we were certain that the structural integrity of the payload wasn't an issue. But as the flight proved, you cannot always rely completely in software simulations. During the flight, the payload suffered a minor deflection in one of its shafts and, although it resulted in no problems, it showed that more serious tests than the ones performed are needed to make sure everything will go as planned.

The following figures are some examples of our simulations using the CAD program NX:

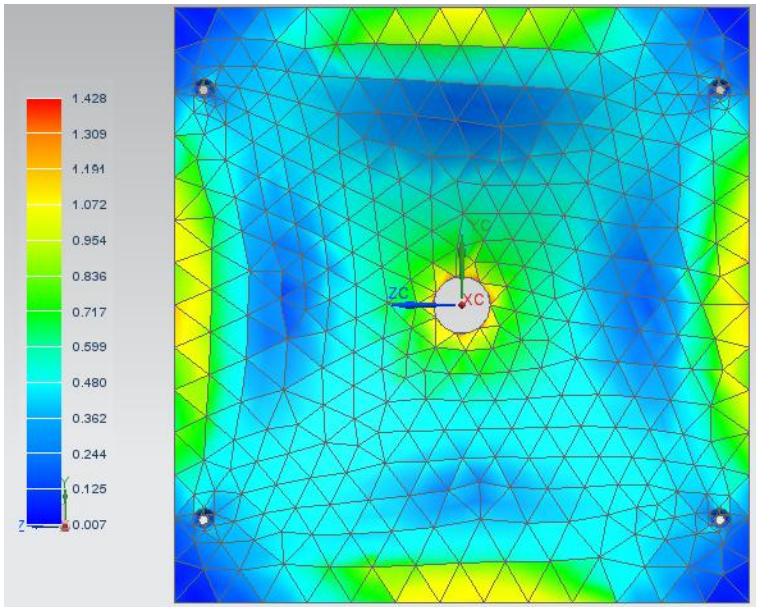

Figure 7: Example of NX's structural simulation performed on one of the faces of the small cube.

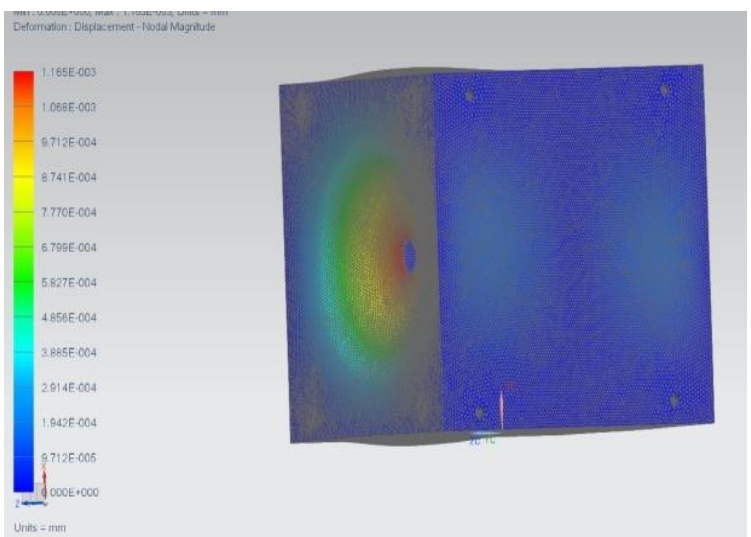

Figure 8: Example of NX's structural simulation performed on the entire small cube.

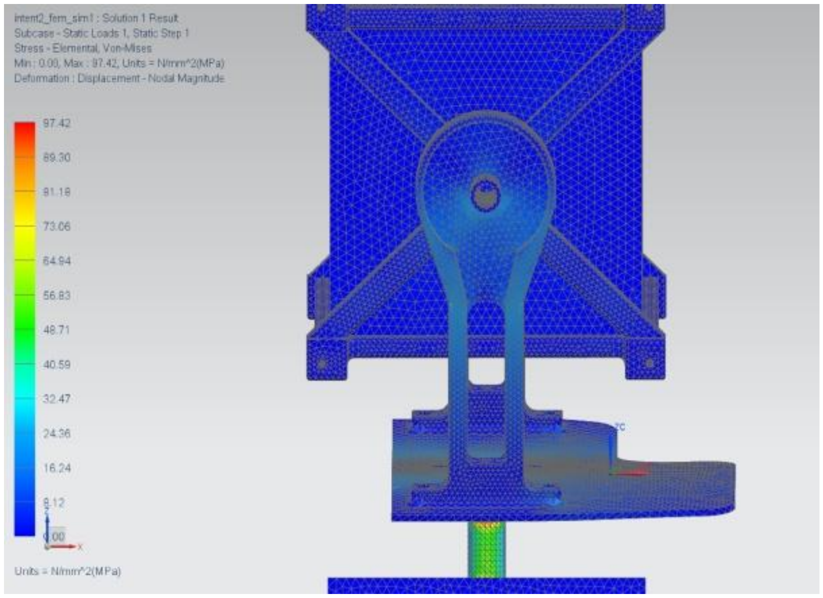

Figure 9: Example of NX's structural simulation performed on the entire payload.

7 Electrical Payload Analysis

7.1 Electrical System

The electrical system is divided in three main parts; ADS board, Heater board and ACS board. In the ADS board is where the principal power conditioning components are located. The primary DC/DC converter converts the 30VDC from the HASP platform to 9V. Then the secondary converters convert those 9V into 5V and 3.3V. These voltages are distributed into the different components and boards in the payload. For example, the H-Bridge Yaw motor control, Real Time Clock and ADS microcontroller are been fed by one of these converters. The other two secondary converters supply voltage to the H-bridge Pitch control and dspic microcontroller. Figure x shows in more detail the power conditioning and distribution in the ADS board.

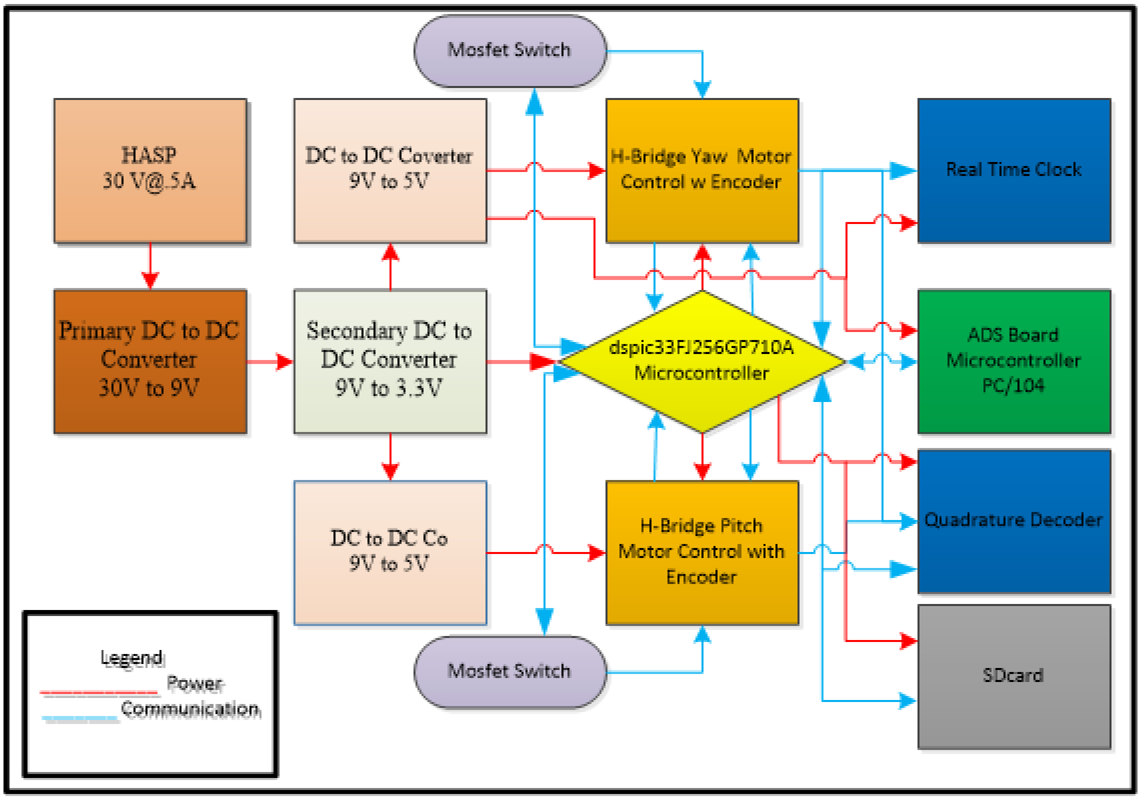

Figure 10 Attitude control system and Flight Board system diagram

The components used on the heater board are two 2F7455 MOSFET, one dspic microcontroller and three hi-power resistor, which work as the component in charge of transforming the electrical power into heat. The temperature on the payload is controlled on this board and start with the microcontroller which is programmed to send a signal (high) to the MOSFETs, we named this time interval as the "ON period" of the heater. The MOSFETs are used as a simple switch which allows the pass of current whenever the dspic send the signal. This dspic is programmed to be in the "ON period" when the internal temperature on the payload reaches 0 °C or below. Figure x shows the schematic design created in Eagle of the heater board.

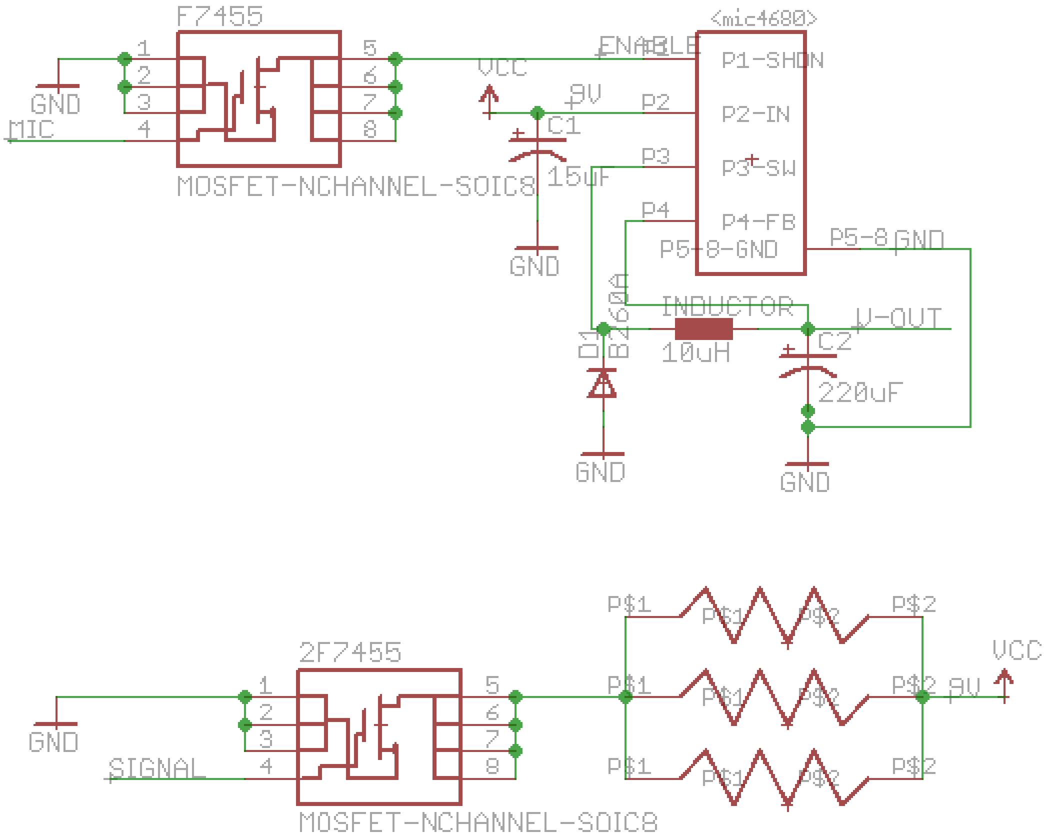

Figure x:

Figure 11 Heater Schematic Design

7.2 Data Measurement

The measurement of the voltage supply by the HASP platform was taken. This is important to our team because the selection of the Integrated Circuits is based on those voltage values. **Figure x** shows the voltage supply during the complete flight. This graphs shows that the average voltage supply remains in 29V, not getting higher that 31V or lower than 28V. Also the data shows approximately a dozen times in where the power was reset. This can lead to a problem if the interval of time is too long, because the heater could not turn on in case of any extreme temperature.

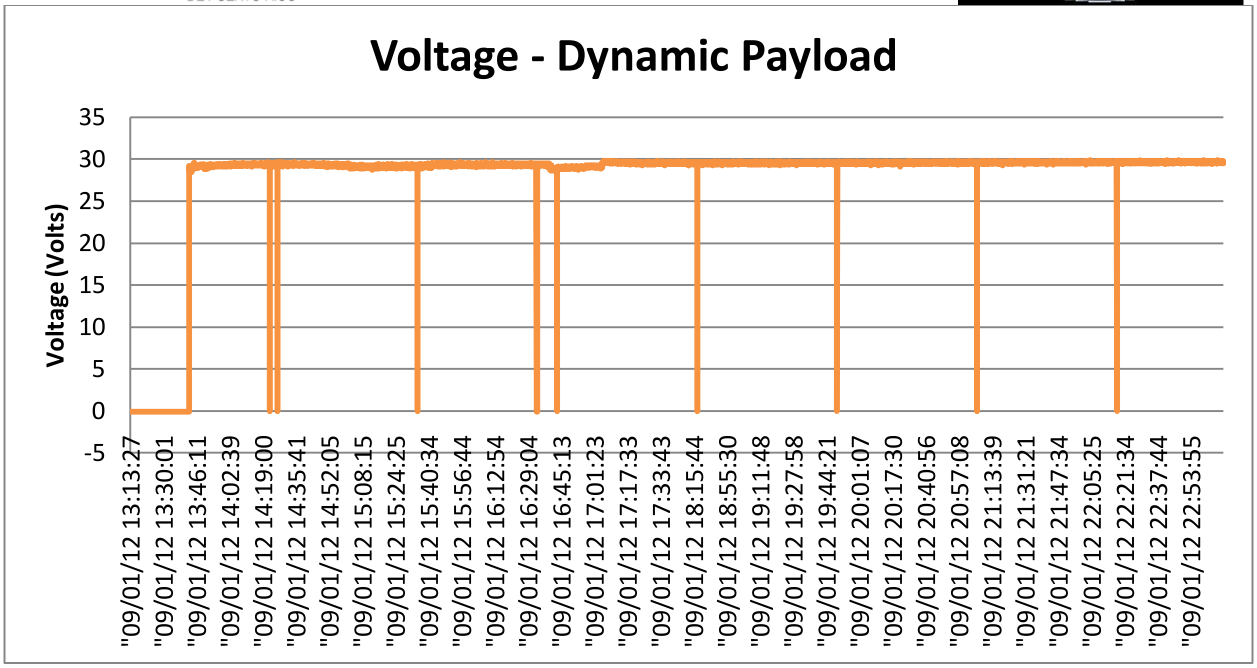

Figure x

Figure 12: Voltage supply during flight

The HASP Platform provides different amount of power consumption depending on the payload size (big or small). In our case (small payload) the platform provides us with 30VDC @ 0.5A, this means that we cannot exceed 15W of power consumption. In the graph shown in **Figure x** the data related to the power draw was taken. The power draws state most of the time at ~4W, with a high peak of 12.2W for a short interval of time. This peak happened when the heater turn on (low temperature). This data demonstrate that the electrical part regarding the heater was successful.

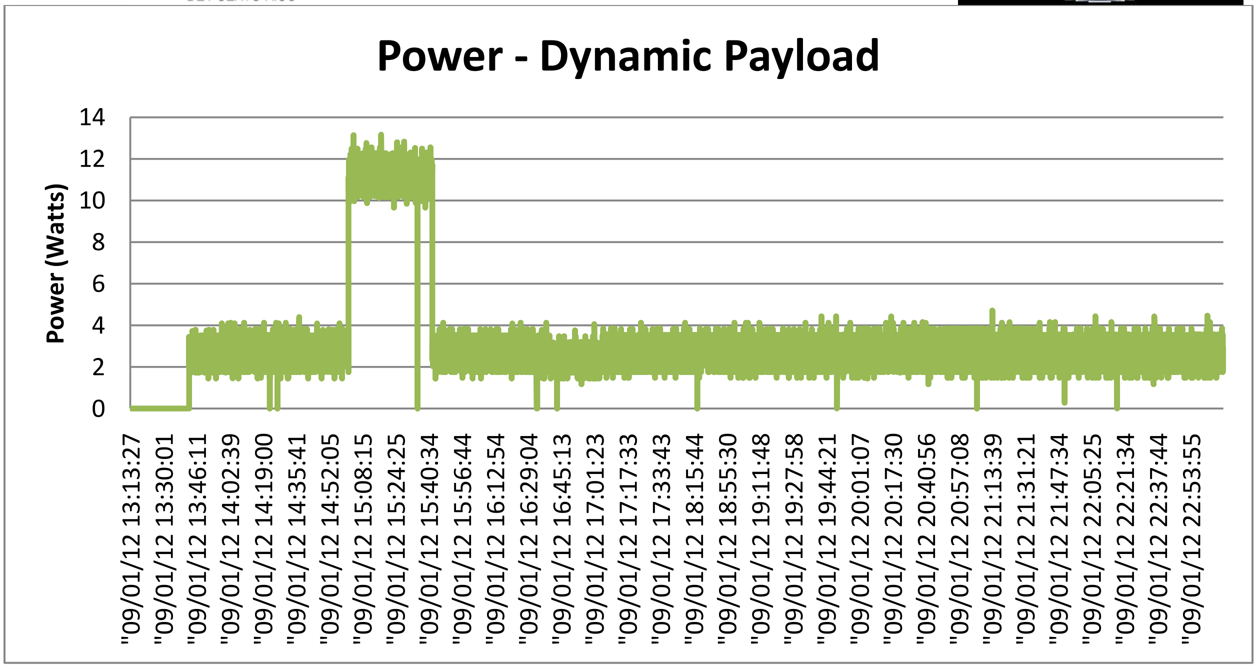

Figure 13: Power consumption during flight

7.3 **Electrical Issues**

As soon as the payload arrives to Puerto Rico after flight, electrical tests were performed to all the boards in the payload. In those tests we found that the heater, ADS and ACS board worked as expected, with the exception of one DC/DC converter on the ADS board. This converter fed the H-bridge Yaw motor and the ADS microcontroller. At first we thought that the failure in this converter was not a big issue, but after analyzing the SD card data we found that it was corrupted (with the exception of the temperature data) due to this problem. A single component like this cause major data loss of the experiment, e.g. the yaw, rolls and pitch data.

The cause of this failure was because the external capacitor of the dc/dc converter blew up. Several reasons could be the cause of this problem like; Electromagnetic Interference (EMI), short circuit and/or vibration problems. We do not had enough understanding on the EMI field and that's why we do not perform any simulation nor implementation regarding the EMI control. Some vibration tests were performed on the payload before the flight (which were success), but maybe more deeply vibrations tests were needed to discard any possibility.

The work ahead is mainly oriented to understand and perform all the necessary tests and simulations to ensure a proper performance during flight. At least electromagnetic interference simulations have to be under our consideration for the next payload project.

8 Software Payload Analysis

8.1 Problems Encountered

After the integration process at Palestine, TX the payload suffered several problems and we take it back home for fixing it and to let it ready for the flight in New Mexico. During the process of reviewing the payload the serial communication line TX and RX was inverted disabling the possibility of establishing the serial communication channel with the payload. That error limited our possibility of any kind of troubleshooting with the device since the payload did not sent the housekeeping data.

In addition when the data analysis was produced we manage to see that there were not any force reset state with the software, since all the data logging was continuous and was only interrupted when the payload was powered on and off. This was checked using the data logging of the HASP platform, specially on the files that showed the current and voltage of the payload.

Even though the software was running as expected we did notice that our ADCS data was in part corrupted so our team believe that the IMU was damaged during the flight but its data logging was performed as expected.

8.2 Lessons Learned

The most important lesson learned was that space environment is really hostile and that it is never enough all the little details that could help to prevent a malfunction. For that reason our team considered that for future flights we could create a more self intelligent system capable of performing self-corrections if it is flown without serial communications. So ,let say that our MCU detects that the IMU data is being normally received and logged but that its content is corrupted. So our system could consider that kind of event as a malfunction and perform a reset in order to see if the problem was properly fixed.

In addition we learned that we have to double check all the steps that we do until we are sure it is properly working. This previous statement is more focused to our serial communications mistake and the consequences of the action.

9 Payload Member List

No.	Name	Sex	Hispanic	Race	Student status	Disability	Graduation date	Employed
1	Javier Espinosa	Male	Yes	Caucasian	Graduate	No	5/1/2012	Honeywell Aerospace of PR – System engineer
2	Jose Almonte	Male	Yes	Caucasian	Graduate	No	5/1/2012	Honeywell Aerospace of PR - Software engineer
3	Jorge Quinones	Male	Yes	Caucasian	Graduate	No	5/1/2012	Honeywell Aerospace of PR – Testing engineer
4	Francisco Franquiz	Male	Yes	Caucasian	Graduate	No	5/1/2012	Doing graduate school at ERAU – Daytona beach
5	Fernando Ferrer	Male	Yes	Caucasian	Undergraduate	No	5/1/2013	N/A
6	Nelson Nieves	Male	Yes	Caucasian	Undergraduate	No	5/1/2013	N/A
7	Victor Roman	Male	Yes	Caucasian	Undergraduate	No	8/1/2012	Industrial reliable service as a mechanical engineer
8	Carlos Javier	Male	Yes	Caucasian	Undergraduate	No	8/1/2013	N/A
9	Luis Sanchez	Male	Yes	Caucasian	Undergraduate	No	8/1/2012	N/A
10	Abdiani Rivera	Male	Yes	Caucasian	Undergraduate	No	8/1/2013	N/A
11	Alex Santiago	Male	Yes	Caucasian	Undergraduate	No	8/1/2015	N/A
12	Damian Miralles	Male	Yes	Caucasian	Undergraduate	No	8/1/2014	N/A
13	Jean Ojeda	Male	Yes	Caucasian	Undergraduate	No	8/1/2013	N/A
14	Juan G. Rosado	Male	Yes	Caucasian	Undergraduate	No	8/1/2013	N/A

Figure 14 List of the Personnel involved in the AIES-Dynamics payload.

The previous table show all the member that take action in the creation of this payload. As listed some of the member who hardly work on the project are already employed thanks to the training an the experience that platform like HASP offered to our group.