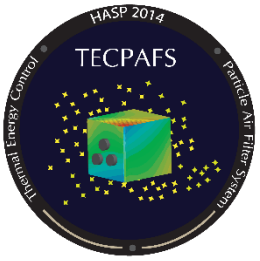

Hasp 2014

Large Payload # 9

Inter-American University of Puerto Rico

Thermal Energy Control and Particle Air Filter System (TECPAFS)

Student Leader:

Emmanuel M. Torres Oquendo

Faculty Advisors:

Prof. Amilcar Rincon-Charris (PI)

Dr. Rafael Salgado

Dr. Othoniel Díaz

Dr. Nedim Vardar (Consultant)

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Introduction

This year for the HASP 2014 the Inter-American University of Puerto Rico submitted the proposal for a payload on the HASP platform which consisted as a two experiment payload. The experiments consisted on two phases, the first phase is address as an experiment in environmental sciences for analyzing Persistent Organic Pollutants (POPs) in the Earth's atmosphere. The analysis consists of two separate mechanisms, one uses PTFE membrane filters to collect atmospheric particles, the other uses a polyurethane foam (PUF) to collect samples in gas phase as well. As for the second phase consists of testing several types of Phase Change Materials (PCMs) at high and low temperatures (-20°C - 80°C) to study the energy storage capacity of certain PCMs for future CubeSat applications. The second phase is composed of three different phase change materials for comparing as they are solid paraffin, granulated and a powdered version of paraffin, since the high temperatures on the past HASP flights has not been so high, part of the mechanism for this phase was to enclose the material in a thermal conductive material with a heating resistance to achieve the desired temperature.

Figure 1 Phase Exchange Materials

Figure 2 PTFE filter

Payload

The final design of the payload had the mechanism to expose the PUF at the maximum altitude at the HASP launch and a set of solenoid valves with a vacuum pump for the arranging of the PTFE filters for the collection of air particles. Also, four small boxes for the PCMs and one as a reference (benchmark) to compare results with a structure without the materials. This was the final design for the TECPAFS team on the HASP 2014:

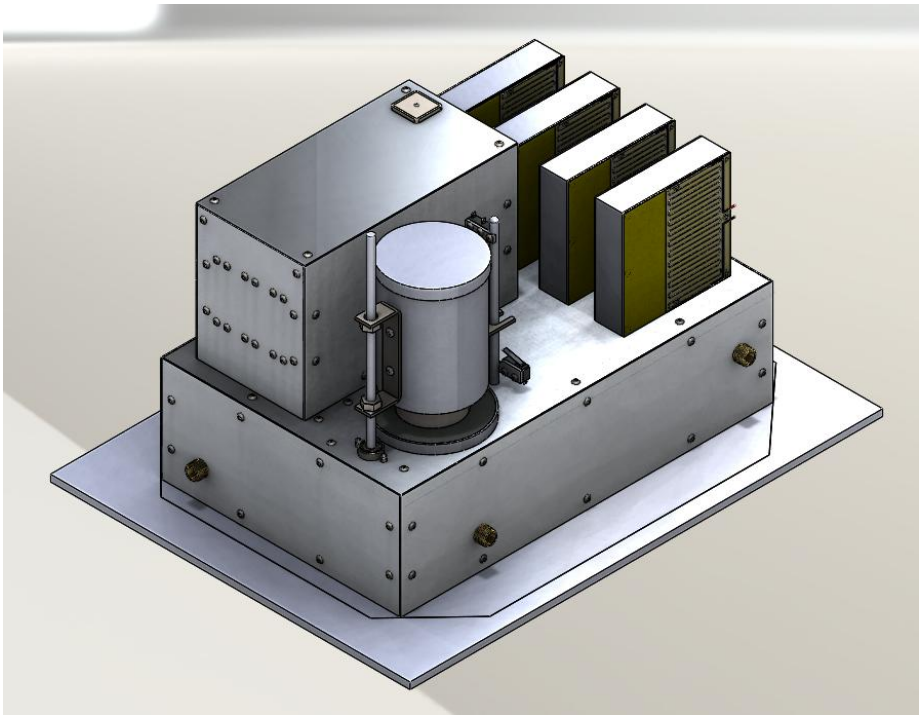

Figure 3 TECPAFS final design

Figure 2 Payload Structure Part Machining.

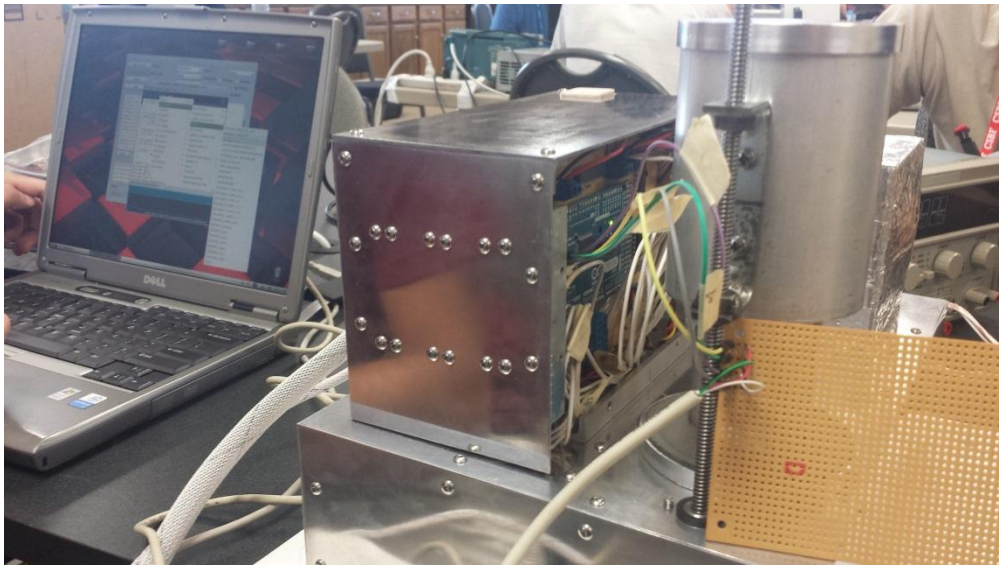

Figure 3 Payload Communication Interface.

Figure 4 Vacuum and Temperature Test Chamber.

Figure 5 New Mexico Weather Report Presentation for Payload Flight Launch.

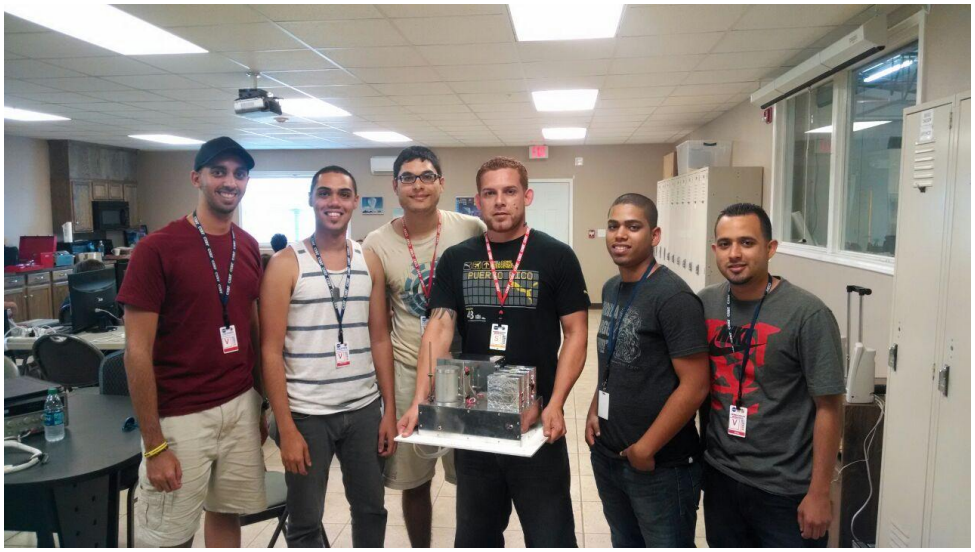

Figure 6 Team at Texas, Palestine TECPAFS Integration.

Figure 7 Payload Balloon Deployed.

Flight

The flight started successfully, our payload was designed to work autonomously, the GPS worked for the first stage of our experiment, and the GPS stopped working since it was not space qualified. The group prepared for our payload a “plan b” or a backup, all processes of our payload besides being autonomous it could control externally. The first part consisted of the three filters opening from the ground up to 5,000 feet and the second one from 5,000 feet to 10,000 feet. The second part of our experiment was controlled by commands and we know that everything was running smoothly as they could observe that our expected payload power consumptions. The end of our experiment was also controlled right through external commands, and the observations by Cosmo Cam video of our last stage, HASP worked properly. At the end of everything we had no mechanical problem, electric or programming that would make our payload malfunction, our only drawback flight was the GPS but as mentioned above, there was a plan to control the processes of our payload externally.

Figure 8 CosmoCam picture of HASP

Results & Problems

Particle Air Filter System (PAFS)

The particle air filter system experiment integrated inside HASP structure was not achieved as expected. The system of filters used to collect the particles consists of three PTFE filters of different microns. The filters were observed by using a TESCAN scanning electron microscope (SEM) Model VEGA 3 XMU, the examination of particle was negative since the photos taken illustrated below at figure 1 were the filter composition does not reveal any trace of pollution or microorganism. The problem that causes the undesirable result of filters is under investigation since during flight the vacuum and the solenoids power consumption were monitored to assure the activation of each component at corresponding stage. The analysis performed for the selection of vacuum critical stage at 20 km is approximately 0.18 Litters/min of vacuum flow. The vacuum starting point of 0.5 km altitude was supposed to collect at least a minimum of particles through filters.

The second experiment performed using polyurethane foam (PUF) housed in an aluminum cylinder by deployable mechanism to open at highest altitude reached of approximately 35 km to collect the gas stage persistent organic pollutants. The PUF sample was Soxhlet extracted with a 20:80 dichloromethane (DCM): petroleum ether (PE) solution for 24 h. The sample was spiked with POPs surrogate standards prior to extraction. The extract was concentrated by K-D evaporation to approximately 5 mL. Solvent was exchanged for hexane by adding 15 mL hexane and the extract was reduced to 2 mL with stream of UHT nitrogen. After volume reduction the samples were cleaned up on an alumina-silicic acid column containing 3 g of silicic acid (3% water), 2 g of alumina (6% water) and about 1 cm anhydrous Na_2SO_4. Unfortunately, the sample could not be analyzed because of the instrument malfunction. The analysis of the samples will be performed using a Varian 450-GC coupled to an ion trap mass spectrometer Varian 240 MS once it is fixed.

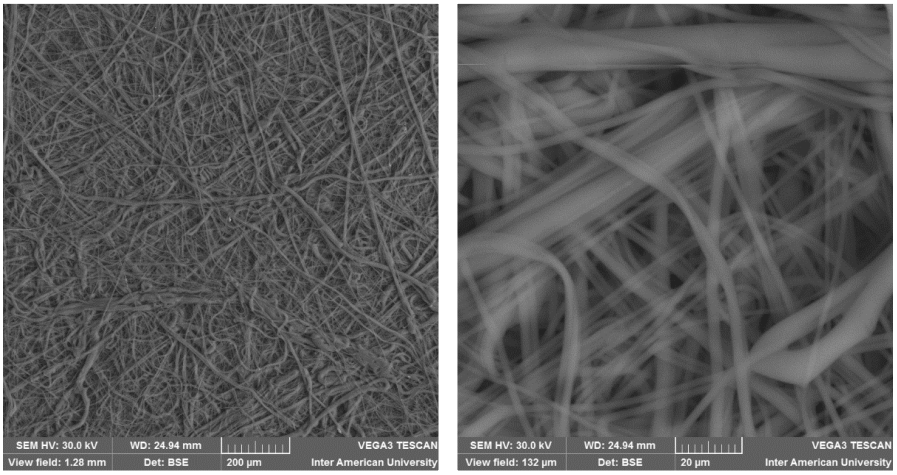

Figure 9 SEM images of PTFE filters

Phase Change Material Experiment

During the flight all temperatures where gathered as expected. Behavior in terms of temperatures also was as expected, although a thorough energy analysis could not be done because of other variables like voltage and current of the electrical heating resistance where not gathered.

Little change in temperature (2 ^{o}C) was observed in the box with the paraffin wax. This is due to the small thickness of the volume containing the material. This thickness was selected because of the maximum dimensions allowed for the CubeSat project. Another interesting experiment would be to add some fiber glass particles or another aggregate to modify the heat conduction properties of the phase change material.

Considerable change (15 ^{o}C) was observed with the encapsulated material. Although there were two different (one powder, one granulated), behavior was similar. We have to keep in mind that there was more volume of these materials than that of paraffin, so a complete assessment can't be done right now. The time rate of change of material temperature would permit this comparison and enable to select between the materials.

In perspective, a new experiment should be design in order to achieve more precise results about the phase change materials and their inclusion within the CubeSat mission of the Inter-American University of Puerto Rico.

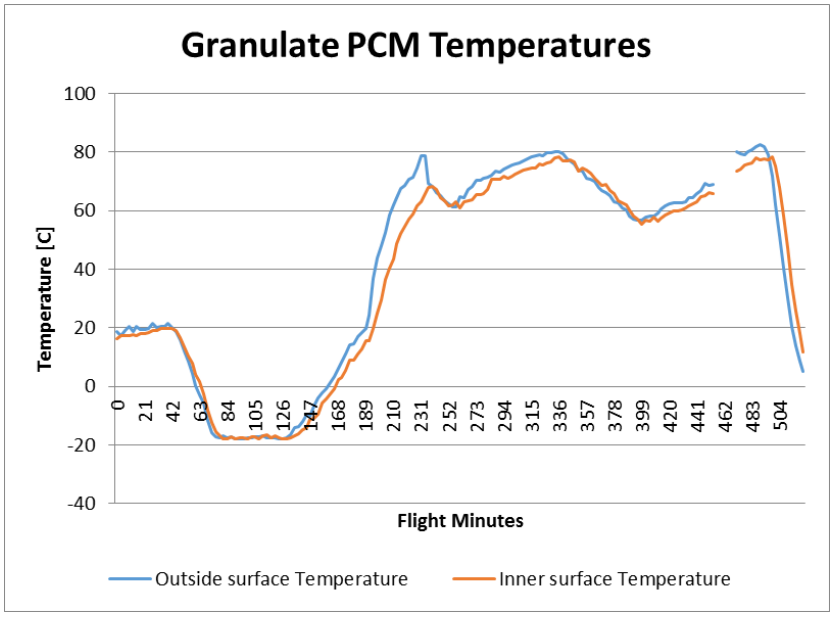

Figure 10 Granulate PCM Material Temperatures.

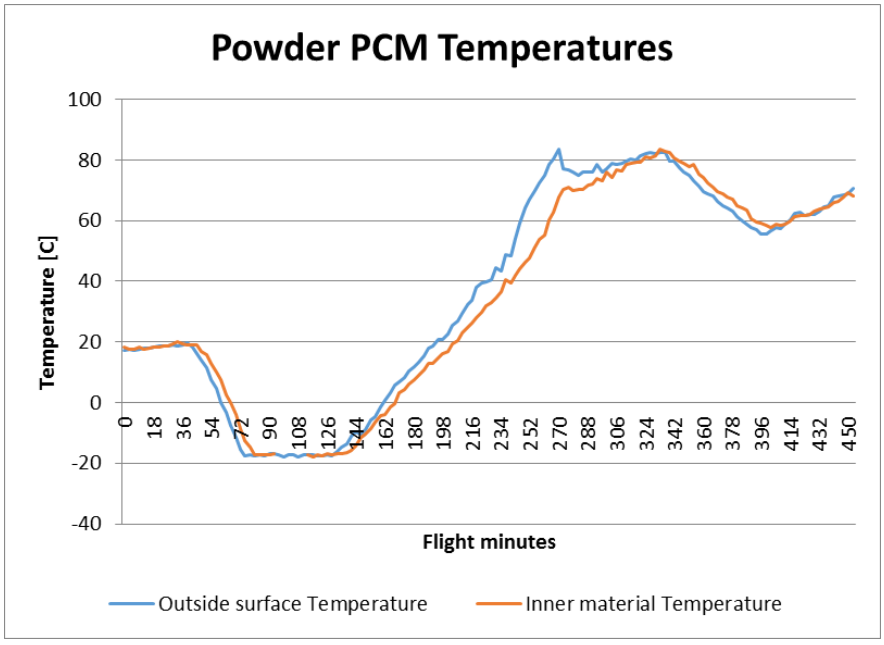

Figure 11 Powder PCM Material Temperatures.

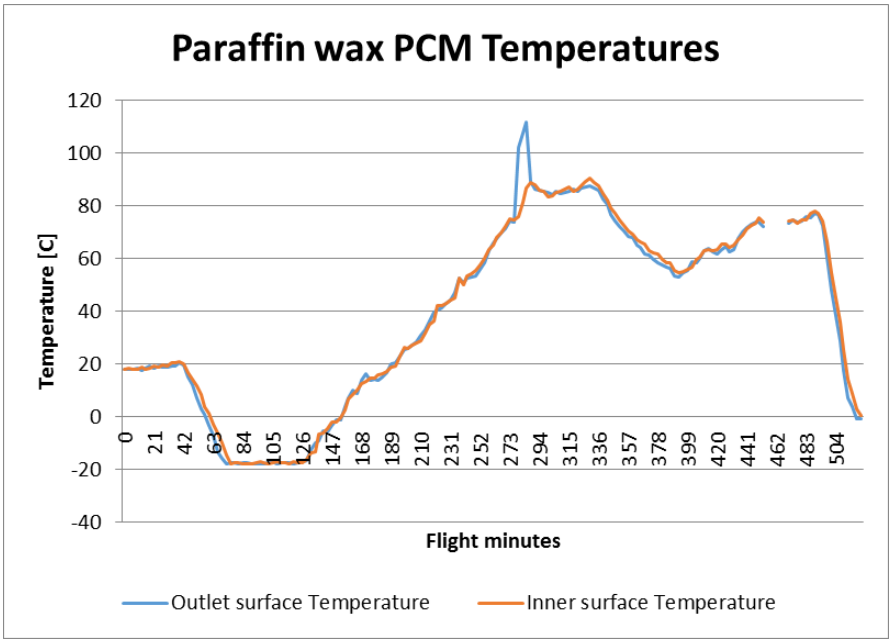

Figure 12 Paraffin wax PCM Material Temperatures.

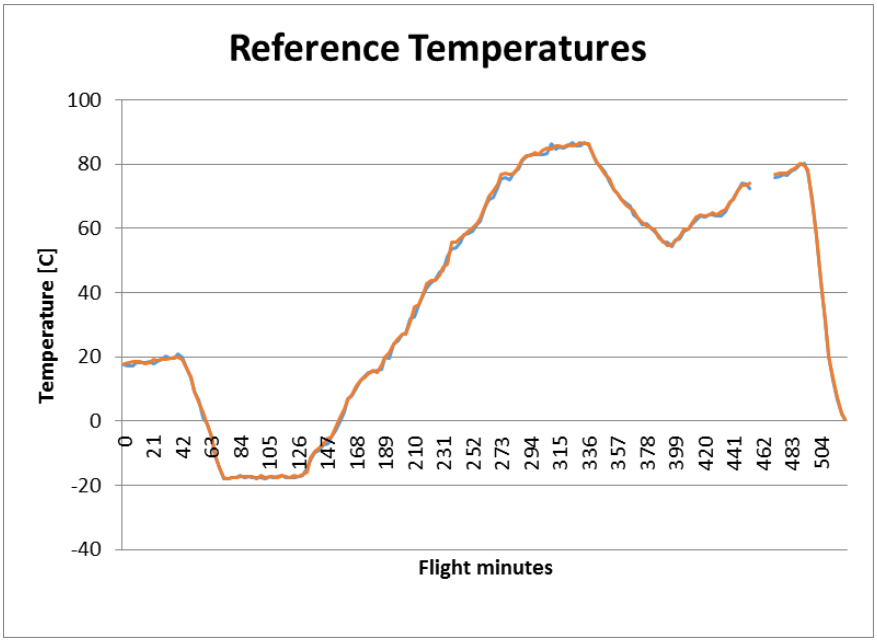

Figure 13 Reference Temperatures.

Next summer considering the previous problems gives us the opportunity to understand the procedures to follow and with ideas gathered for structure design constraints for a suitable space to organize the components of each system integrated at HASP payload. Since it was our first experience building the payload for summer 2014 we expect better results for the next summer considering problems encountered during test and flight process to accomplished objectives.

Demographics

Table 1 - Demographics of TECPAFS team

Name	Gender	Ethnicity	Race	Std. Status	Disability
Emmanuel Torres	M	Hispanic	American-Indian	Undergrad	N/A
Gabriel Rodríguez	M	Hispanic	American-Indian	Undergrad	N/A
Rafael Peña	M	Hispanic	African-American	Undergrad	N/A
Christian Morales	M	Hispanic	White	Graduated	N/A
Christian Santiago	M	Hispanic	White	Undergrad	N/A
Ivan Muñiz	M	Hispanic	American-Indian	Undergrad	N/A
Raymond De Jesús	M	Hispanic	American-Indian	Undergrad	N/A
Francisco Cruz	M	Hispanic	American-Indian	Undergrad	N/A
Luis Santiago	M	Hispanic	American-Indian	Undergrad	N/A
Alexander Rivera	M	Hispanic	American-Indian	Undergrad	N/A
Dayna Rivera	F	Hispanic	American-Indian	Undergrad	N/A
Angel Ortiz	M	Hispanic	African-American	Undergrad	N/A
Daniel Muñiz	M	Hispanic	American-Indian	Undergrad	N/A
Nicolle Torres	F	Hispanic	White	Undergrad	N/A
Jihad Chamseddine	M	Non-Hispanic	White	Undergrad	N/A
Julio Martínez	M	Hispanic	African-American	Undergrad	N/A
Steven Quiñones	M	Hispanic	American-Indian	Undergrad	N/A

Francisco Cruz is a graduate student since he is the manufacture laboratory technician for the university campus. The only new graduate for this year is Christian Morales; he is currently working as an Electrical Engineer at InfoTech in Aguadilla, Puerto Rico.

Conclusions

The experiments were completely successful on the HASP platform for the TECPAFS payloads, but more research and preparations have to be made to get big results from the tests. The phase change materials demonstrate changes in temperature at the time of the phase change but not sufficient as the theory suggests. A further test with even more variable analysis has to be done to corroborate the data at hand. The particle filters problem of not collecting any particles at all is still undergoing more investigation as for the reason for these results since the vacuum pump and solenoid valves were functional during flight. As for the polyurethane foam sponge, the test results are inconclusive since the machinery for the analysis of the extraction is not functional at the time. Once the Varian 450-GC coupled to an ion trap mass spectrometer Varian 240 MS is fixed, the extraction will be analyzed for final results of the gases collected by the polyurethane foam sponge.