Payload Title: Thermal Energy Control & Particle Air Filter System (TECPAFS)

Payload Class: Small [✓ Large]

Payload ID: 09

Institution: Inter-American University of Puerto Rico

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Contact E-mail: etorresoquendo@gmail.com

Submit Date: June 27, 2014

I. Mechanical Specifications:

A. Measured weight of the payload (not including payload plate)

On the Table 1 can be appreciated a mass budget for the main components. Some of this groups the mass for little components as screws, angular, nuts, and elements for a subsystem or mechanism. The wires and weld for electronics components can't be measure until the final integration. The limitation of weight has not been reach with a total weight of 6.405kg.

Table 1 Mass Budget:

Mass Budget			
Component	**Weight (kg)**	**QTY.**	**Total Weight (kg)**
Housing Battery System	1.161	1	1.161
Sponge mechanism	0.584	1	0.584
Battery Filters System	0.300	2	0.600
Solenoid Valve	0.203	5	1.017
Couplings	0.276	1	0.276
Electronic Equipment Housing (estimated)	0.451	1	0.451
Pump	0.960	1	0.960
Heat Exchange Box	0.245	4	0.980
Phase Change Material	0.021	4	0.084
Arduino Mega 2560	0.033	1	0.033
Analog to Digital Converter	0.001	2	0.002
Temperature Sensor (estimated)	0.001	16	0.016

GPS with Circuit	0.006	1	0.006
Antenna	0.011	1	0.011
PCB's	0.035	3	0.105
Voltage Regulators	0.002	8	0.016
Db9 connector	0.005	6	0.032
Wire, electric components (estimated**)**	0.070	1	0.070
		Total (kg)	**6.405**

B. Provide a mechanical drawing detailing the major components of your payload and specifically how your payload is attached to the payload mounting plate:

At this moment, the mechanical and structure drawing is almost completed, only the circuit boards and the housing is pending on the design. Given the change from small to large payload, changes have been made to the structure for optimization of payload space. The payload is attached to the payload mounting plate by a series of screws determined by research of previous HASP payloads. The Figure 1 illustrates the Preliminary design of the TECPAFS.

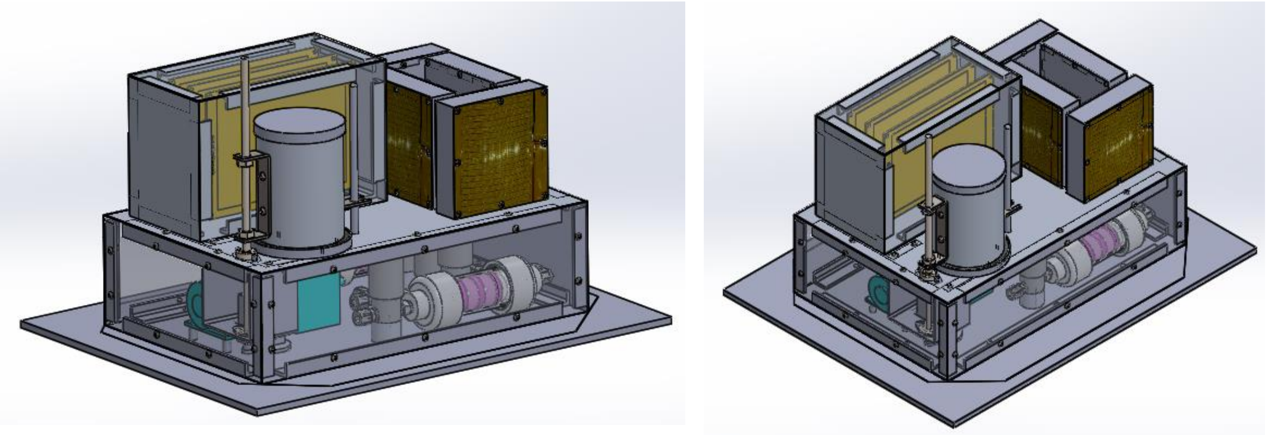


Figure 1 TECPAFS Design.

The current design is pending for:

- Circuit Boards wiring
- Fittings Tubing Connections

The TECPAFS design measures are illustrated below in figures 2 and 3 to verify parameters limitations of height from integration plate to top. The limitation of our payload is below the 30 cm as illustrated. Figure 2 shows the Sponge experiment closed and the figure 3 illustrates the sponge cap deploy at maximum height. The power screw height from the integration plate is 28.06 cm conserving above the limit. The Payload is divided in two levels, the first level is composed by a pump, solenoids and battery filters. The second level has the sponge mechanism, the circuit boards and the thermal boxes. The design is subjected to changes during the construction.

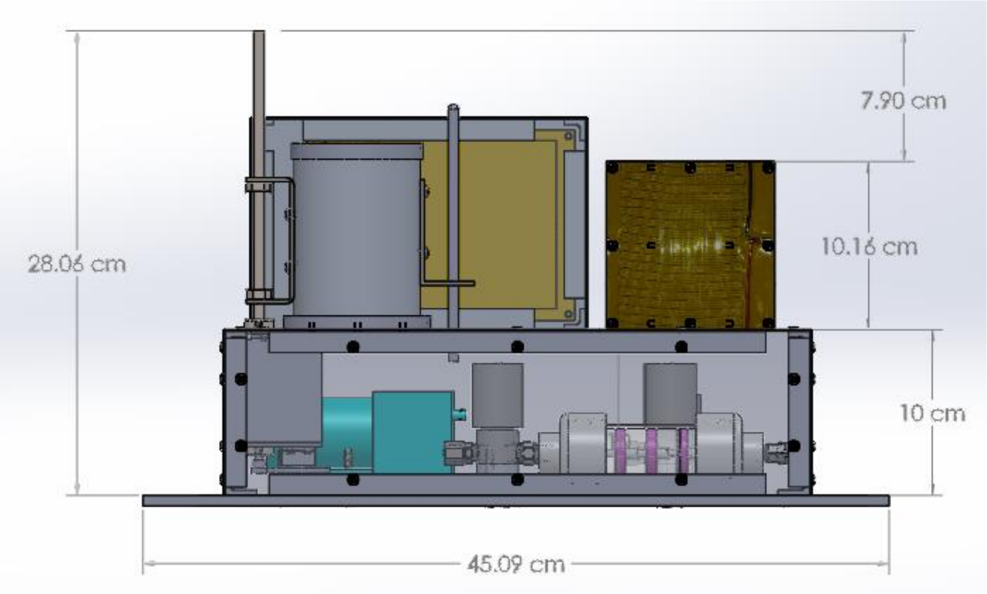


Figure 2 HASP Design Measures.

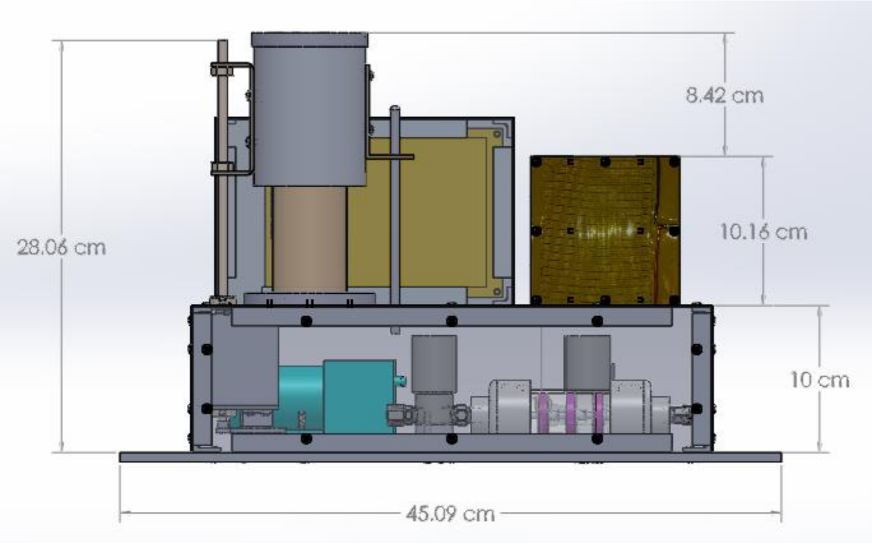


Figure 3 HASP Design Measures.

The Parts fixed to mounting Plate are illustrated in figure 5 were is described the screws needed to fix the components. The table illustrated a side of the TECPAFS illustration is detailed as attached. The figure 4 below illustrates the bottom and top view of the TECPAFS with the screws pattern display and its parts. The structure of the TECPAFS is attached with angular L shape of 1/8 in thickness and 0.5 X 0.75 with 10 M6 X 10mm screws. The other components attachment is detailed below at figure 5.

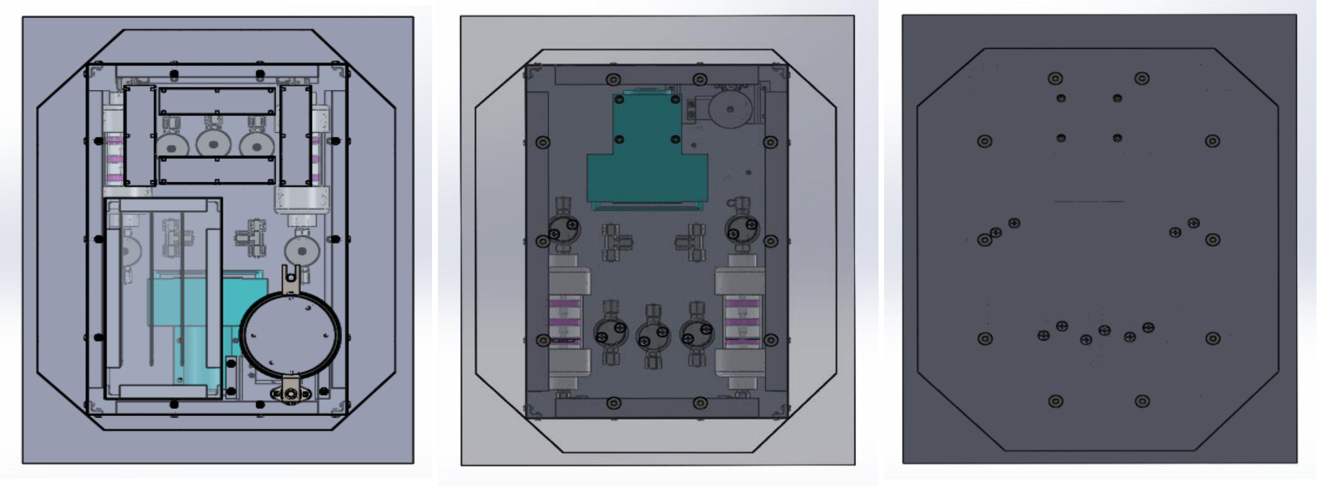
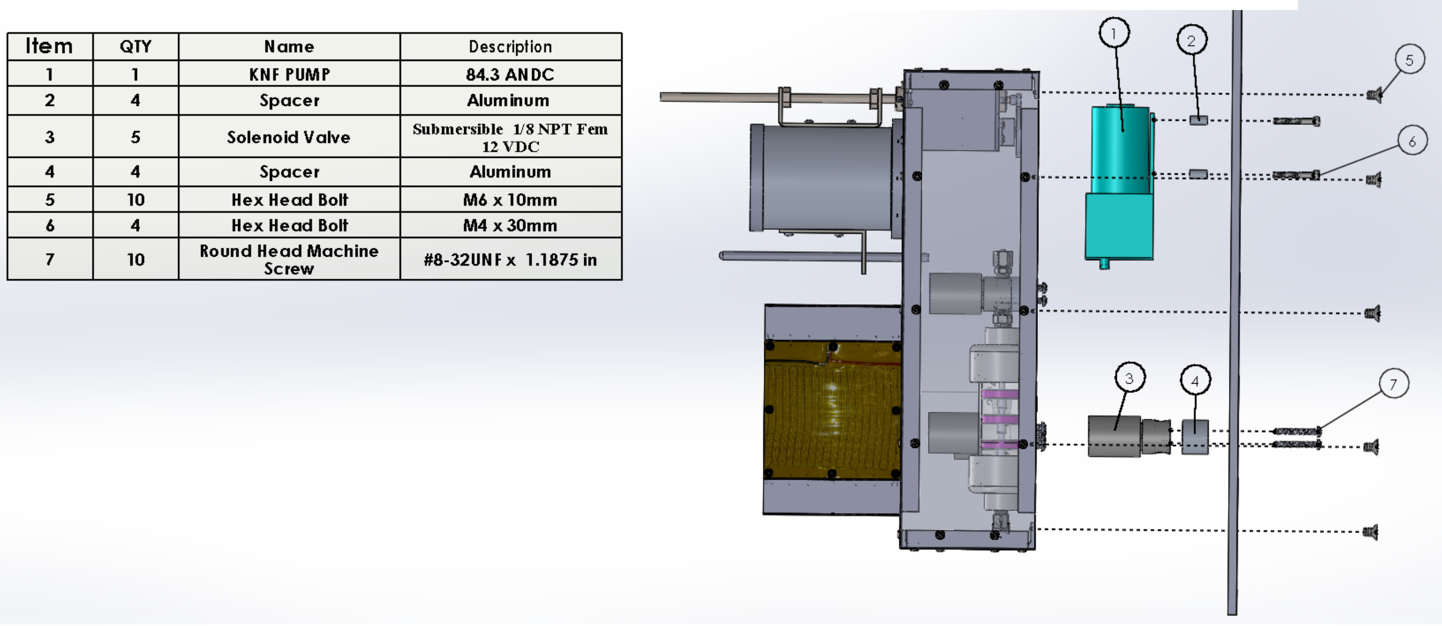


Figure 4 Payload Mounting Plate.



Item	QTY	Name	Description
1	1	KNF PUMP	84.3 ANDC
2	4	Spacer	Aluminum
3	5	Solenoid Valve	Submersible 1/8 NPT Fem 12 VDC
4	4	Spacer	Aluminum
5	10	Hex Head Bolt	M6 x 10mm
6	4	Hex Head Bolt	M4 x 30mm
7	10	Round Head Machine Screw	#8-32UNF x 1.1875 in

Figure 5 TECPAFS Integration Plate Parts.

The mechanism constructed to perform the sponge experiment is illustrated below at figure 6. The parts of the mechanism designed are illustrated below at figure 7 were specifies the parts description. The mechanism time of rise is aproximately one minute. The limit of rise of the sponge cap is to be designed with Limit switches to control the higher and lower limits.

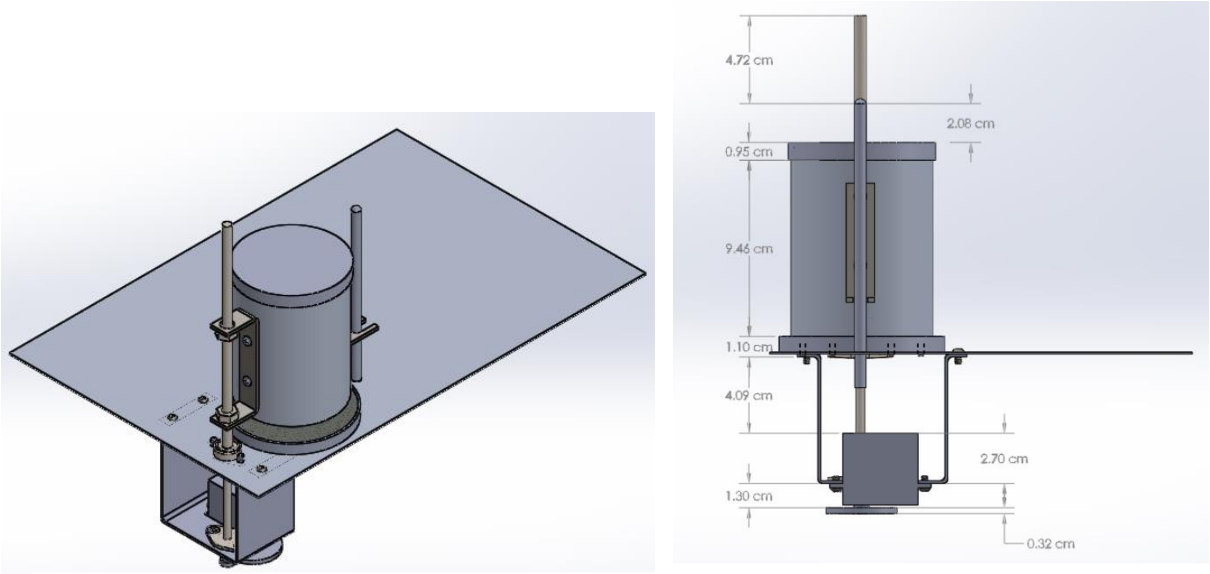
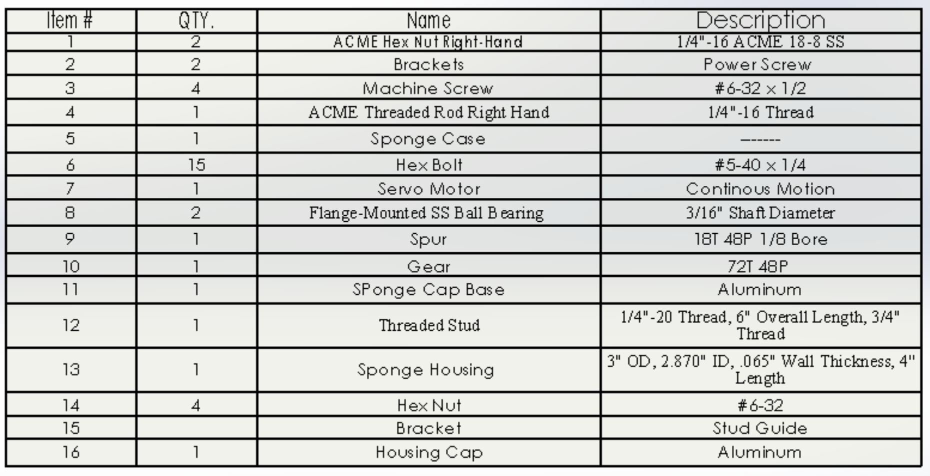


Figure 6 Sponge Mechanism Dimensions.



Item #	QTY.	Name	Description
1	2	ACME Hex Nut Right-Hand	1/4"-16 ACME 18-8 SS
2	2	Brackets	Power Screw
3	4	Machine Screw	#6-32 x 1/2
4	1	ACME Threaded Rod Right Hand	1/4"-16 Thread
5	1	Sponge Case	-------
6	15	Hex Bolt	#5-40 x 1/4
7	1	Servo Motor	Continous Motion
8	2	Flange-Mounted SS Ball Bearing	3/16" Shaft Diameter
9	1	Spur	18T 48P 1/8 Bore
10	1	Gear	72T 48P
11	1	SPonge Cap Base	Aluminum
12	1	Threaded Stud	1/4"-20 Thread, 6" Overall Length, 3/4" Thread
13	1	Sponge Housing	3" OD, 2.870" ID, .065" Wall Thickness, 4" Length
14	4	Hex Nut	#6-32
15		Bracket	Stud Guide
16	1	Housing Cap	Aluminum

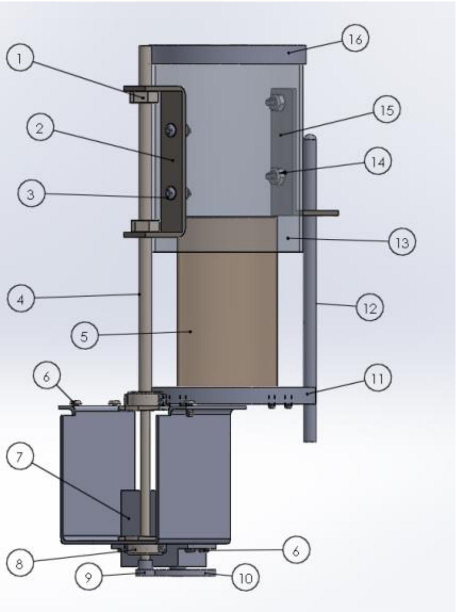


Figure 7 Sponge Mechanism Parts.

The mechanism of the sponge cap is detailed as an assembly below in figures 8 and 9. The servo motor rotate a configuration of spur and gear of 4:1 since the spur is 18T and the servo gear is 72T the torque generated is calculated to make shure it will lift the sponge cap mechanism. A power screw is used to rise and lower the cap and a rod is used to guide the cap straight up during the rise or lowering the cap. The servo is attached with an aluminum bracket to fix and align the servo gear with spur. The power screw is aligned with ball bearings to reduce the friction during rotation.

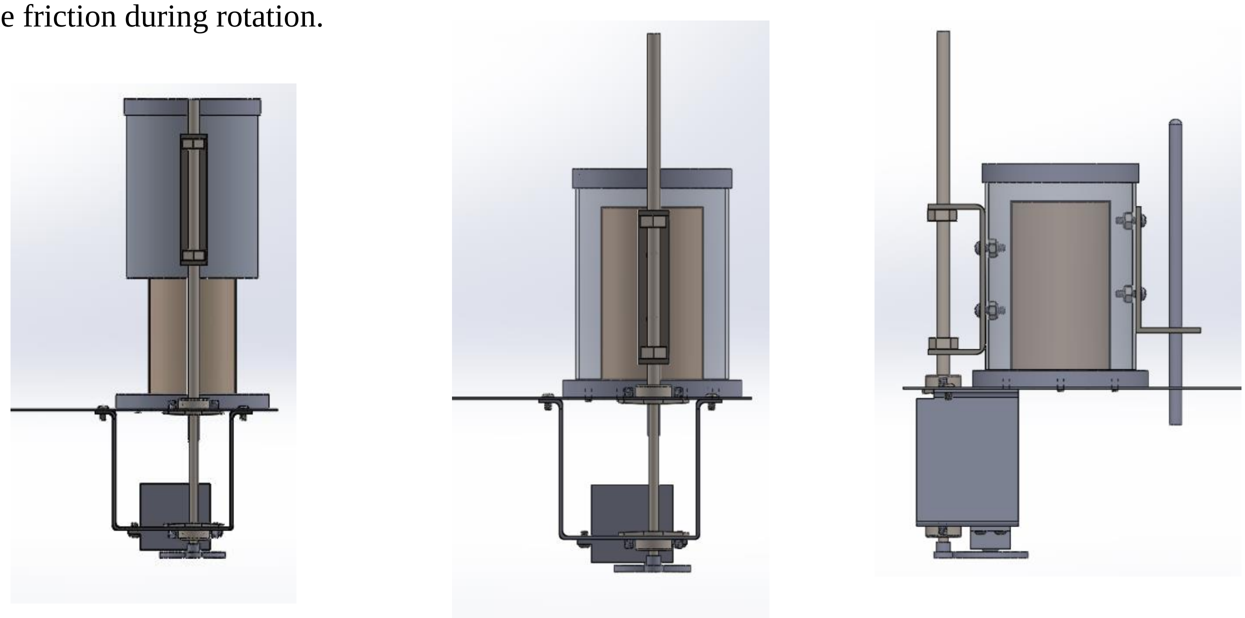


Figure 9 Sponge Mechanism Views.

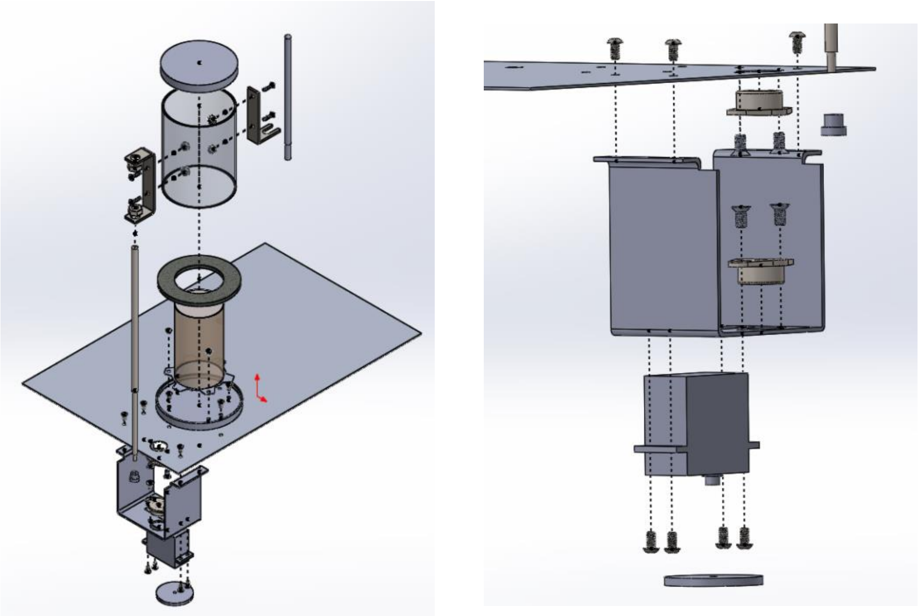
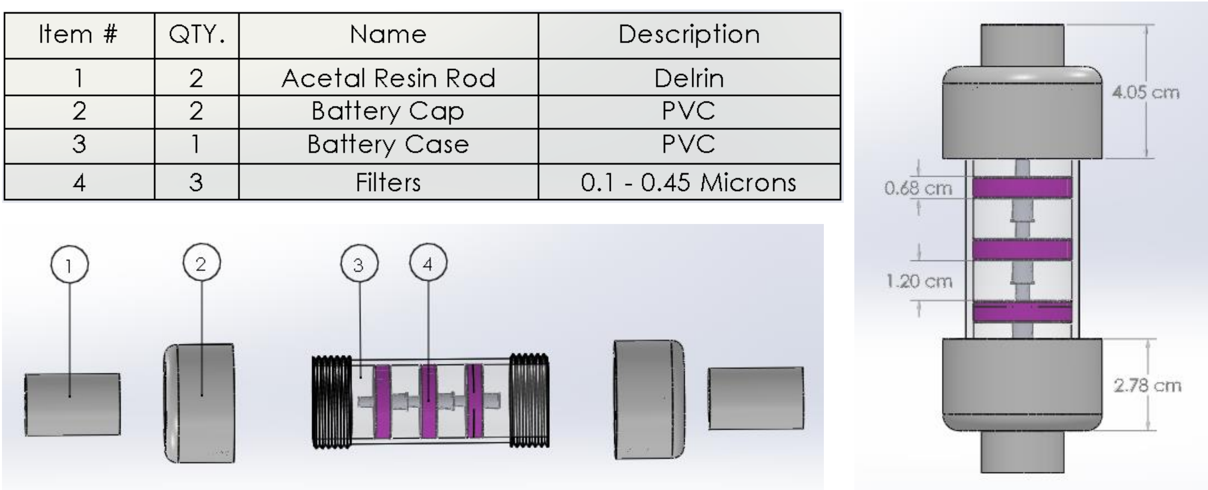


Figure 8 Sponge Mechanism Assembly.

The figure 10 below illustrates the battery used to capture atmosphere particles. The battery is constructed with PVC pipe repair kit and two pieces of acetal resin rod to fix the filters. The rod is also used to complete fittings conections from batteries to pump or solenoids. The fittings connections used are 1/8 NPT.



Item #	QTY.	Name	Description
1	2	Acetal Resin Rod	Delrin
2	2	Battery Cap	PVC
3	1	Battery Case	PVC
4	3	Filters	0.1 - 0.45 Microns

Figure 10 Battery Assembly and Dimensions.

The structure assembly illustrated below at figure 11 gives specific detail of the parts and screws used to attach the structure. The screw used are #5-40 1/8" length the quantity are 36 screws to fix the sides of the structure and 10 screws to fix the top plate were the sponge mechanism is constructed.

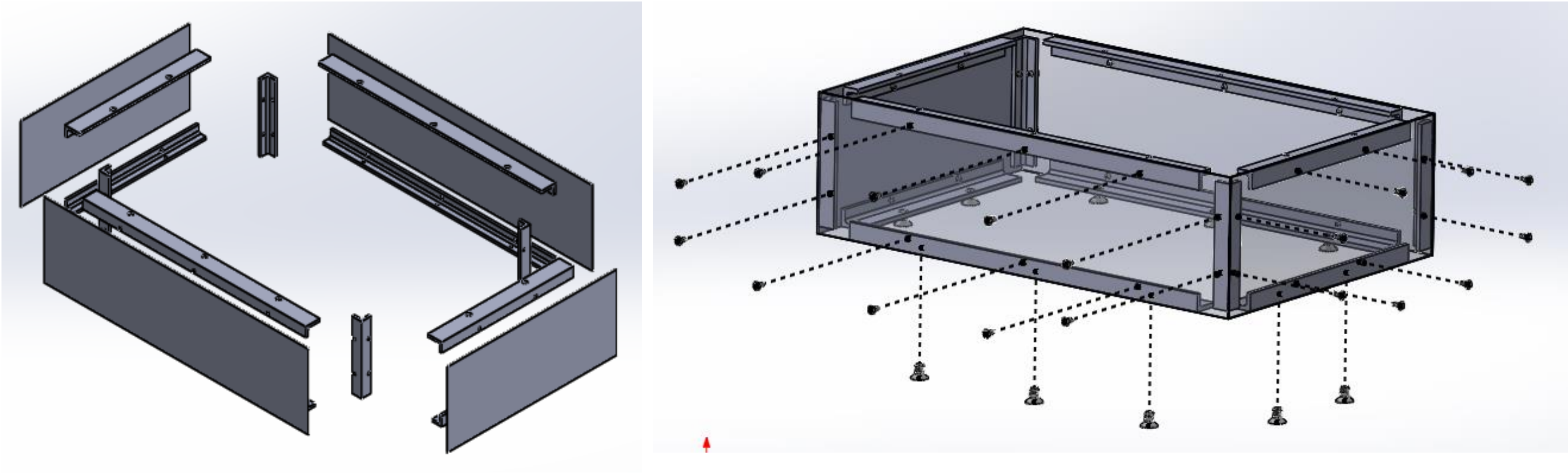


Figure 11 Electronic Equipment Structure Assembly.

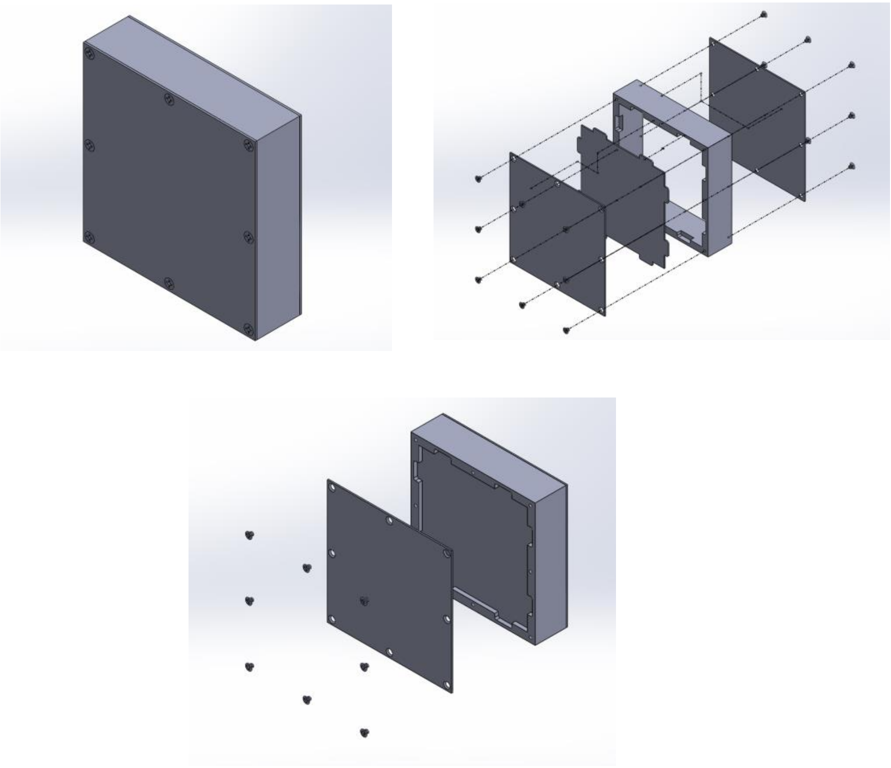


Figure 12 Thermal Experiment for Solid Material

The thermal experiment consists on control of temperature using phase change materials. The experiment housing, Figure 12, was manufactured with aluminum with dimensions of 10 cm height, 10 cm width and 2.54 cm of thickness. The main frame is cover by two caps each one has 8 screws #4-40 with a length of 1/8in. An internal wall was created at 3mm of depth from the external cap. On this box will be a paraffin material on the 3mm space which will change from solid to liquid to maintain a small temperature difference when heated.

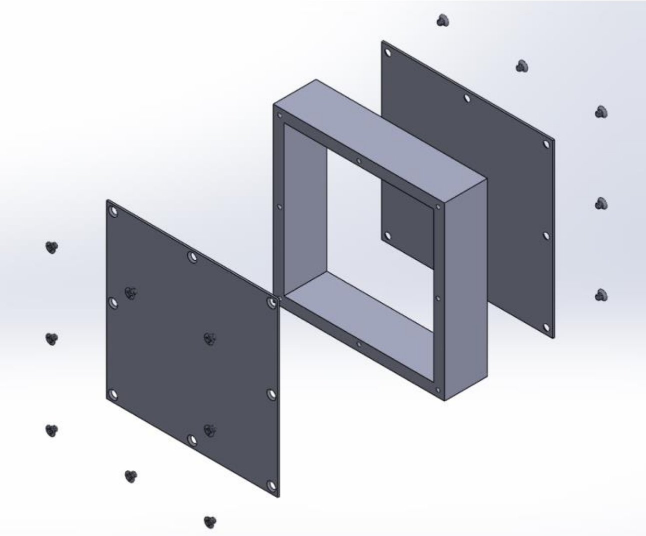


Figure 13 Thermal Experiment for Granulated and Powder Material

As well as before, the experiment housing was manufactured with aluminum with dimensions of 10 cm height, 10 cm width and 2.54 cm thick. The main frame is cover by two caps each one has 8 screws #4-40 with a length of 1/8in. But on this box will be a paraffin material, granulated and powdered which will change from solid to liquid to maintain a small temperature difference when heated.

C. If you are flying anything that is potentially hazardous to HASP or the ground crew before or after launch, please supply all documentation provided with the hazardous components (i.e. pressurized containers, radioactive material, projectiles, rockets…)

N/A

II. Power Specifications:

A. Measured current draw at 30 VDC:

Table 2 - Power Budget

Component	Voltage(V)	Current(mA)	Power(W)
Vacuum	12	1600	19.2

Solenoids	12	650	7.8
Heating Films	7	2.1	14.7
Arduino Mega	5	500	2.5
GPS	5	200	1
Temp Sensors	5	150	0.75
A/D Converter	5	80	0.4
Servo	5	500	2.5
Power Consumption (nominal)	---	---	---
Power Consumption (max)	---	---	---
Power Consumption (estimate)	**30**	**---**	**48.85**
Power Limit	**30**	**2500**	**75**
Power Margin	**30**	**---**	**26.15**

Complete system integration is due for power nominal and max values. Until now sub-systems and components had been tested separately. Having an estimate power consumption and having an average efficiency on DC-DC Converters of 70%, we can estimate current:

$$\frac{48.85W}{30V} = 1.63A$$

Applying average DC-DC Converters efficiency of 70%:

$$\frac{1.63A}{0.70} = 2.32A$$

B. If HASP is providing power to your payload, provide a power system wiring diagram starting from pins on the student payload interface plate EDAC 516 connector through your power conversion to the voltages required by your subsystems.

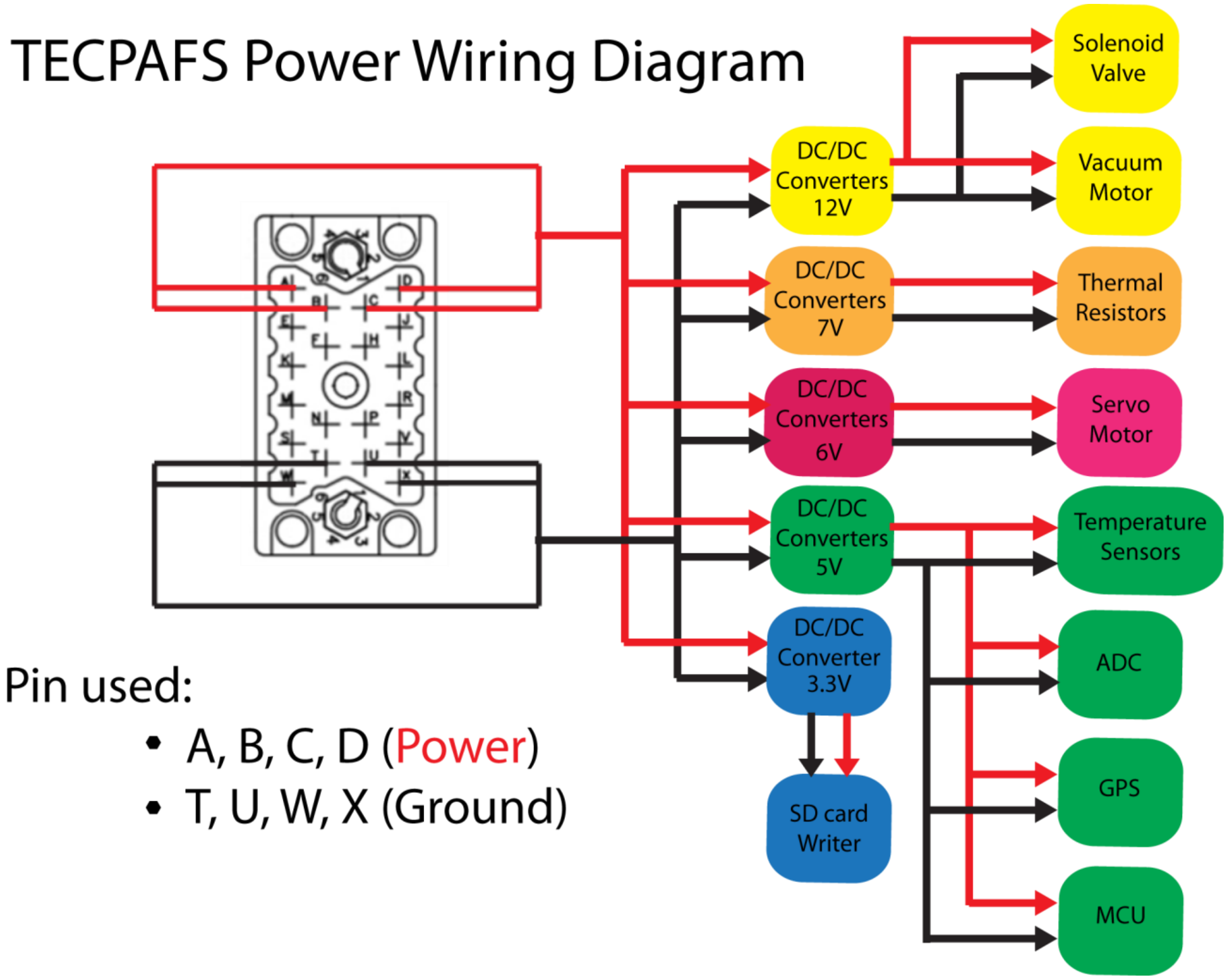


Figure 14 - Wiring Diagram

The TECPAS will use the HASP platform power source, consisting of 30V and 2.5A. It will be connected by an EDAC 516 connector, using the A, B, C, D wires for the +30V and the T, U, W, X for the ground connected respectively together. Using the LM2576HV DC/DC converters will step down the +30V to the desired voltages of: 12V, 7V, 6V, 5V and 3.3V. The 12V DC/DC is for the solenoid valves and the vacuum motor, the 7V DC/DC are for the thermal resistors, the 6VDC/DC is for the servo motor, the 5V DC/DC is for the temperature sensors (thermistors), analog to digital converters (ADC), Global Position System (GPS), the micro-controller unit (MCU), and the 3.3VDC/DC for the SD card Writer.

III. Downlink Telemetry Specifications:

A. Serial data downlink format: Stream [✓ Packetized] (circle one)

B. Approximate serial downlink rate (in bits per second)

The downlink data will be sent at a rate of 4800 bps baud. The data packets sent will be of approximate 82 bytes (656 bits).

C. Specify your serial data record including record length and information contained in each record byte.

The TECPAFS payload will send data packets of approximate 82 bytes at a regular interval of 180 seconds (three minutes), after reaching a 36 km height. The serial data record will contain the altitude, date and time info from the GPS, and the temperature sensors placed inside the thermal boxes on the payload surface. For the information contained in each record byte, refer to Table 3.

The TECPAFS will contain an SD card mount so the MCU can autonomously keep a record of the data. This data will be saved at a shorter interval of the serial data send by the MCU to HASP I/O process. Recorded data on the SD card will be used for post-flight analysis and validation.

D. Number of analog channels being used:

Analog channels will not be used.

E. If analog channels are being used, what are they being used for?

N/A

F. Number of discrete lines being used:

Discrete lines will not be used.

G. If discrete lines are being used what are they being used for?

N/A

H. Are there any on-board transmitters? If so, list the frequencies being used and the transmitted power.

No transmitters are being placed on-board.

I. Other relevant downlink telemetry information.

Since the serial downlink data rate is 4800 bps, it takes 0.2083 milliseconds (1/4800bps) to send 1 bit. Therefore, the estimated time to send 82-byte packets will be of 0.1367 seconds. This is acquired by dividing the packet size by the data rate (baud rate):

Data Transmission Time = (82 bytes * 8 bits) / 4800 bits/s = 0.1367 seconds

Table 3: Downlink String Format

Byte	Byte Content
0	Start of Header (ASCII character ‘#’)
1-4	UTC Year
5	Dash Separator (‘-‘)
6	UTC Month (1-12)
7	Dash Separator (‘-‘)
8-9	UTC Day (1-31)
10	Comma Separator (‘,’)
11-12	UTC Hour (0-23)
13	Colon Separator (‘:’)
14-15	UTC Minute (0-59)
16	Colon Separator (‘:’)
17-18	UTC Second (0-59)

19	Comma Separator (‘,’)
20-23	GPS Height
24	Slash Separator (‘/’)
25	Thermal Box ID
26	Colon Separator (’:’)
27-28	Temperature Sensor Reading
29	Comma Separator (‘,’)
30-31	Temperature Sensor Reading
32	Comma Separator (‘,’)
33-34	Temperature Sensor Reading
35	Comma Separator (‘,’)
36-37	Temperature Sensor Reading
38	Slash Separator (‘/’)
39	Thermal Box ID
40	Colon Separator (’:’)
41-42	Temperature Sensor Reading
43	Comma Separator (‘,’)
44-45	Temperature Sensor Reading
46	Comma Separator (‘,’)
47-48	Temperature Sensor Reading
49	Comma Separator (‘,’)
50-51	Temperature Sensor Reading
52	Slash Separator (‘/’)
53	Thermal Box ID
54	Colon Separator (’:’)
55-56	Temperature Sensor Reading
57	Comma Separator (‘,’)
58-59	Temperature Sensor Reading
60	Comma Separator (‘,’)

61-62	Temperature Sensor Reading
63	Comma Separator (‘,’)
64-65	Temperature Sensor Reading
66	Slash Separator (‘/’)
67	Thermal Box ID
68	Colon Separator (’:’)
69-70	Temperature Sensor Reading
71	Comma Separator (‘,’)
72-73	Temperature Sensor Reading
74	Comma Separator (‘,’)
75-76	Temperature Sensor Reading
77	Comma Separator (‘,’)
78-79	Temperature Sensor Reading
80	Slash Separator (‘/’)
81	End of Header (ASCII character ‘#’)

IV. Uplink Commanding Specifications:

A. Command uplink capability required: [✓ Yes] No (circle one)

B. If so, will commands be uplinked in regular intervals: Yes [✓ No] (circle one)

C. How many commands do you expect to uplink during the flight (can be an absolute number or a rate, i.e. *n commands per hour*)

Since the uplink commands available are to determine the health and status of the payload, the TECPAFS team has decided that should be sent every 15 minutes during Phase 1 (before reaching a 36 km height). That equals an approximate of eight (8) commands, four (4) per hour, to verify the status of the vacuum and solenoid valves.

After reaching such height, no commands monitor the payload are needed to be uplinked during Phase 2 (only in a critical case, i.e. temperature sensors not reading, etc.).

NOTE: A command to terminate "listening mode" must be sent on flight descent**.**

D. Provide a table of all of the commands that you will be uplinking to your payload

Table 4: Uplink Commands

Command	Hex Byte	Critical?	Description	Response
PVS	31	No	Turn ON Phase 1 devices	Command Received: "PVS"
THM	32	No	Turn ON Phase 2 devices	Command Received: "THM"
STS	33	Yes	Verify payload status	Command Received: "STS"
RST	34	Yes	Reset MCU	Command Received: "RST"
OFF	00	Yes	Turn OFF listening mode	Command Received: "OFF"

*For more command info refer to "**Other relevant commanding information"** section.

Example of Command Uplink String

The following table shows an example of the uplink string of the **RST** command:

"01029034030D0A"

Table 5 - Example of command string

Byte	HEX Value	Description
1	01	Start of Heading (SOH)

2	02	Start of Text (SOT)
3	90	Payload ID + Checksum
4	34	Reset Command
5	03	End of Text (EOT)
6	0D	Carriage Return (CR)
7	0A	Line Feed (LF)

E. Are there any on-board receivers? If so, list the frequencies being used.

The TECPAFS payload will contain a LEA-6H GPS receiver, operating at a 1575.42 MHz frequency.

F. Other relevant uplink commanding information.

The payload MCU is programmed to run the most autonomously possible, therefore, not all uplink commands are critical or needed. They are designed for payload health purposes.

A brief description of each command is available below:

- **PVS:** Prepares the payload for the mission's Phase 1 (Particle Air Filter System). Activates the solenoid valves and vacuum. The MCU is programmed to do this automatically.
- **THM:** Prepares the payload for the missions Phase 2 (Thermal Energy Control). Activates the thermal resistors, the servo motor, and the temperature sensors. The MCU is also programmed to do this automatically.
- **STS:** Sends back a string packet with the payload current status.

- **RST**: Resets the MCU from the start. Needed if any anomaly is detected with data sent during flight. The MCU determines the mission's phase left off before reset, depending on GPS height.
- **OFF**: Terminates listening mode, and prepares payload for power-off. This command must be sent to the payload on flight descent, since no data is going to be downlinked afterwards.

NOTE: Commands are subject to change.

V. Integration and Logistics

A. Date and Time of your arrival for integration:

The TECPAFS integration team will be arriving July 29, 2014 to Palestine, Texas. The time of arrival will be around noon, but it will depend on the flight schedule. Possible changes may occur depending on any information given on the month of July.

B. Approximate amount of time required for integration:

The approximate amount of time for the successful integration of the TECPAFS team payload will be no more than three (3) hours.

C. Name of the integration team leader:

Christian J. Santiago Pérez

D. Email address of the integration team leader:

csantiago.ingmec@gmail.com

E. List **ALL** integration participants (first and last names) who will be present for integration with their email addresses:

Table 6 - Integration Participants

Participants Name	Participants Email
Christian J. Santiago Pérez	csantiago.ingmec@gmail.com
Raymond De Jesús Cruz	ray18djc@gmail.com

Francisco J. Cruz Figueroa	fcruzf@bayamon.inter.edu
Rafael M. Peña Díaz	rafaelmpena@gmail.com
Gabriel Rodríguez Vázquez	gabrielrodz92@gmail.com
Emmanuel M. Torres Oquendo	etorresoquendo@gmail.com
Ángel M. Ortiz Carreras	angelmanuelortiz@gmail.com
Iván L. Muñiz Rivera	il.muniz@live.com

F. Define a successful integration of your payload:

A successful integration for the TECPAFS team is that the payload meets all HASP requirements for a large payload, such as a total current draw of, no more than, 2.5A at 30VDC and that the weight does not exceed 20 kg. Another important aspect is to validate that there are no electrical problems present on our payload since on several payloads for HASP earlier years have failed by current spikes. Ensure the payload withstand the current spikes at power on. The TECPAFS payload data rate to the HASP platform has to be of 4800 bits per second (bps) or lower. Also, the successful communication from the microcontroller to the HASP platform and software efficiency. In addition, the payload dimensions have to be equal or smaller than 30 x 38 x 30 cm, and functionality at temperature ranges from -60°C to 50°C, as well as a pressure up to 10 mbar.

G. List all expected integration steps:

1. Weight the payload and verify that it is within the HASP requirements.
2. Provide detailed drawing with payload description and measurements.
3. Attach the payload efficiently to the mounting plate and the HASP platform.
4. Power up the payload for a power consumption analysis of not exceeding HASP requirements.
5. Provide a detailed wiring diagram.
6. Successful communications from the GPS and data storage on the SD card.

7. Provide a list of all the Up-link commands.

8. Present the mission plan of TECPAFS to the HASP.

H. List all checks that will determine a successful integration:

Table 7 - Check List Integration

Check List		
Integration Step:	Requirements:	Check:
Weight the payload.	20 kg or less.	
Payload drawing	Detail drawing of the structure with the major components dimensions and attachment to the mounting plate.	
Power Consumption	At 30 V no more than 2.5 A	
Wiring diagram	Power system wiring diagram from the EDAC 516 connector and DB9 pin connector through the power conversion and components.	
Software Control	Successful Up-link commands and data storage. Full Arduino control of the payload.	
Down Link	4800 bps	
T/V Test	Withstand -60°C to 50°C and pressure up to 10 mbar.	
Con – Ops	TECPAFS mission plan.	

I. List any additional LSU personnel support needed for a successful integration other than directly related to the HASP integration (i.e. lifting, moving equipment, hotel information/arrangements, any special delivery needs…):

N/A

J. List any LSU supplied equipment that may be needed for a successful integration:

- Power supply 30 V @ 3A (with cables)
- 3 Multimeters (with cables)
- Oscilloscope (with cables)

- Soldering iron
- Desoldering pump
- Drill
- Screwdrivers
- Tweezers
- Pliers
- Hex tools