HASP Student Payload Application for 2014

Payload Title: EagleSat		
Payload Class: (check one) ☒ Small ☐ Large	Institution: Embry-Riddle Aeronautical University	Submit Date: 20 December 2013

Project Abstract

Designed by undergraduate engineering students at Embry-Riddle Aeronautical University's Prescott, Arizona campus, *EagleSat* is the first cube satellite designed on campus, with an expected launch date in 2016. *EagleSat* will be testing the effect of solar radiation on conventional computer memories, as well as how a CubeSat deorbits over time. Flying *EagleSat* on HASP will allow the team to test all systems for a long duration flight in an environment quite similar to space. The communications system, solar cells, and onboard computer will be vital to this test, as all will be crucial to successful operations in space, and they will be the most prone to failure from thermal issues or unforeseen impacts during launch and landing.

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ABSTRACT

Designed by undergraduate engineering students at Embry-Riddle Aeronautical University's Prescott, Arizona campus, *EagleSat* is the first cube satellite designed on campus, with an expected launch date in 2016. *EagleSat* will be testing the effect of solar radiation on conventional computer memories, as well as how a CubeSat deorbits over time. Flying *EagleSat* on HASP will allow the team to test all systems for a long duration flight in an environment quite similar to space. The communications system, solar cells, and onboard computer will be vital to this test, as all will be crucial to successful operations in space, and they will be the most prone to failure from thermal issues or unforeseen impacts during launch and landing.

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PAYLOAD DESCRIPTION

The EagleSat project is a satellite development project helmed by a group of dedicated students at Embry-Riddle's Prescott, Arizona. The final product, *EagleSat*, is a 1U CubeSat designed to investigate the effect of solar radiation on different types of computer memory, as well as using GPS data to model how such a small object deorbits due to atmospheric drag. An early development model of *EagleSat* flew on HASP in 2013; however, this was far from a full-fledged model, as it was a test of only the structure, solar panel, and the radio. For the 2014 flight, the updated *EagleSat* development model will consist of all hardware that will fly when the satellite makes it to space: the structure, solar panels, EPS, both payload modules, radio, and a deployable system for the solar panels and antennas.

EagleSat's primary mission involves testing the effects of solar radiation on various forms of commercially available computer memory and how the memory manages to operate without experiencing incidents of bit flipping. The proposed memories to be tested include Static RAM (SRAM), Ferroelectric RAM (FRAM), Magneto-resistive RAM (MRAM), Phase Change Memory (PCM), and Radiation Hardened RAM (RADHARD). Satellites and space probes must use costly radiation hardened memory to avoid Single Event Upsets (SEU) in which the onboard memory is damaged as a result of solar or cosmic radiation. This experiment seeks to discover any correlation between SEU and periods of high solar activity, and also to examine the possible strengths of using non-radiation hardened memories in low earth orbit. On HASP, this module isn't expected to experience any SEU, but as part of the overall *EagleSat* system, its presence will be vital to ensuring perfect performance of the entire system.

EagleSat's secondary mission has changed in the year since payload development began. Initially, the satellite was going to incorporate a crystal radio to use the radar beam from the Air Force's Space Surveillance System (Space Fence) to measure the decay in the time of its orbital period as the mission progressed. However, following the decommissioning of the Space Fence in fall 2013, the payload has since been adapted to use GPS signals to measure orbital decay, allowing for greater precision than before. Using the Space Fence would have added an interesting element to the mission: Typically, the Space Fence was used to find parameters on larger satellites, so using it to track a CubeSat would have been an interesting challenge. The switch to GPS has caused a reevaluation of the satellite's power consumption, and integrating the GPS antennas into the structure has also posed a new challenge for the engineers involved. Testing the GPS antennas on HASP will allow them to be flight tested in a capacity that the *EagleSat* team has lacked.

The onboard computer (OBC) for *EagleSat* is based off a PIC24 architecture and will be managing the activities of all payloads as well as the communications and EPS subsystems. For the actual mission, the OBC will be working closely with the Electrical Power System (EPS) to monitor the status of the satellite and to ensure all components are working as they were designed. The OBC will interface directly with the HASP platform to send and receive commands, as well as to send data down over the provided serial line. The EPS will be the integration board between *EagleSat* and HASP, as it will step down the 30V power coming in to the 3.3V, 5V, and 7.2V needed for the various components onboard the CubeSat.

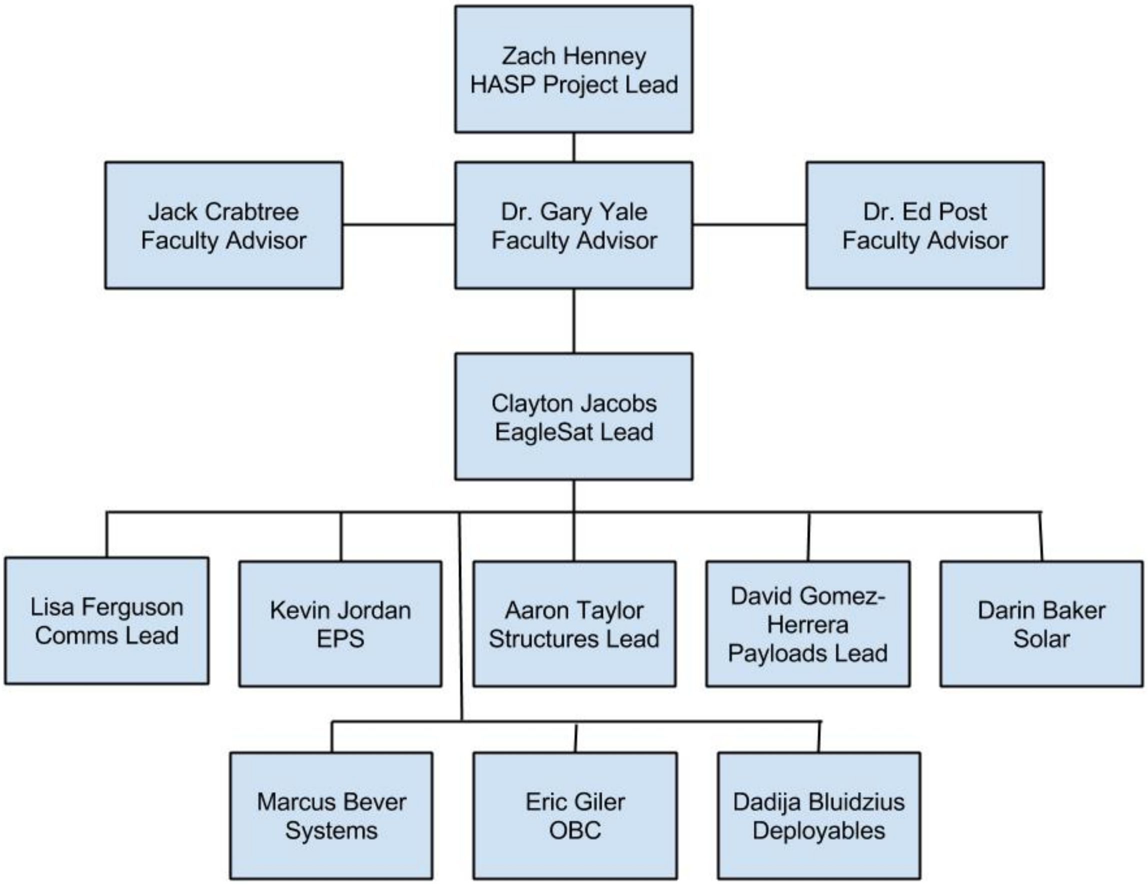
After a successful test flight on the 2013 HASP flight, the Communications subsystem seeks to test the integrity of *EagleSat's* radio and antennas once again. The antennas were fabricated from measuring tape by removing the paint and cutting them to size until they were properly tuned for operations at 436.5 MHz. For the actual satellite mission, the antennas will be wrapped around the body of the satellite until the satellite is deployed into orbit. For the 2014 HASP flight, the deployment mechanism for theses antennas will be tested. The antennas will be held in place beneath the structure by a segment of burn wire; shortly after the launch of the balloon a command will be sent to deploy the antennas, the success of which will be verified by a radio transmission from the satellite. Deployment of the antennas should not pose any safety risks for any other payloads onboard, but spacing between payloads is an issue that will need to be considered as the design moves forward. During the flight, the Comms team will be using the radios to check the status of the satellite alongside the data being recorded by HASP, as well as using the radios to beacon out the position of the balloon via APRS.

The structure used for *EagleSat* will be a Pumpkin CubeSat structure: although last year's flight flew a student built and fabricated structure, trade studies done by the structures team showed the Pumpkin structure to be a better, stronger, and simpler option for the final design. Therefore, the structure will be a ten centimeter cube, and will have solar panels mounted on all sides for additional testing as well as thermal protection. The previous iteration of *EagleSat* on HASP only had a solar panel at the top of the structure with panels of space blanket on the sides: while this allowed for a successful test of the soldering method used on the solar panel, this year's flight seeks to be a realistic test of the solar panels' abilities to generate electricity.

To better integrate *EagleSat* onto the HASP platform, part of the 2013 ERAU payload will be recycled. The lower payload module, then called *Phoenix*, an aluminum structure 13 centimeters on a side and 5 centimeters tall. It had ports for the EDAC connector to run through the payload, as well as mounting holes on top to fit the *EagleSat* test article. For the 2014 flight, the *Phoenix* module is being renamed the *Nest* Integration Module, and will house the circuitry necessary to reroute the power and serial lines to *EagleSat.* This module will be insulated with space blanket, and will be mounted directly to the HASP mounting plate.

TEAM MANAGEMENT

The EagleSat program is one of many projects being developed by members of Embry-Riddle's NASA Space Grant, and with more than 60 active members, the program has grown to be one of the largest engineering projects on campus. Therefore, the chart below only lists the members in charge of the various subsystems, as a full organization chart grows too large to be easily read. The project is led by Clayton Jacobs, a junior majoring in Electrical Engineering, and the HASP project is being led by Zach Henney, a junior majoring in Aerospace Engineering. For both projects, Jack Crabtree, Dr. Ed Post, and Dr. Gary Yale serves as the main faculty advisors. It is anticipated that the project lead and at least one of the faculty advisors will be travelling to Palestine, Texas to oversee integration, and depending on the launch date, it is not yet known how many team members will be able to travel to Ft. Sumner, New Mexico for the flight.

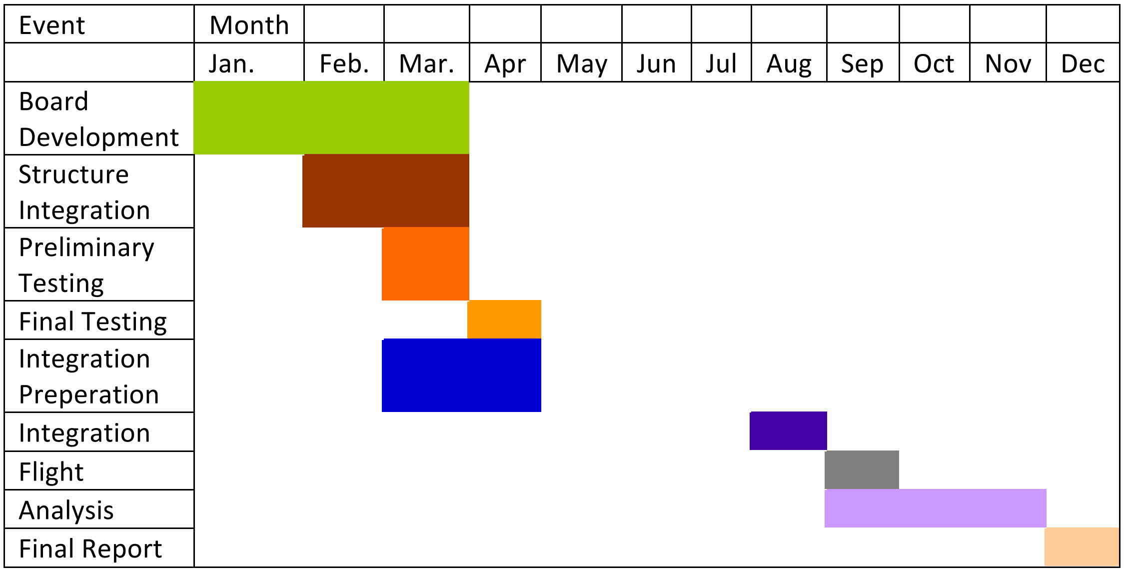


Organization chart for the 2014 ERAU HASP team leads.

Contact for the team leads and the faculty advisors is listed as follows:

Title	*Name*	*E-mail Address*	*Contact Information*
Project Lead	Zach Henney	henneyz@my.erau.edu	707-570-6111
EagleSat Lead	Clayton Jacobs	jacobsc6@my.erau.edu	661-492-4814
Faculty Advisor	Jack Crabtree	crabtrej@erau.edu	928-777-6916
Faculty Advisor	Gary Yale	yaleg@erau.edu	928-777-3896

Given that *EagleSat* is on a schedule of its own to meet its delivery date to NASA, there are no issues in meeting the development schedule necessary to fly on the 2014 HASP flight. According to this schedule, all construction and testing of the payload will be completed by the end of April, with an integration-ready payload packed and ready for delivery to Palestine by the end of the spring semester.



Development schedule for *EagleSat* on HASP.

PAYLOAD SPECIFICATIONS

With all antennas fully deployed, *EagleSat* will be 15 centimeters tall, with a base filling all of the 15 centimeter square on the mounting plate. The antennas will extend nearly 12.5 centimeters outside of the envelope allotted by the mounting plate, however, they will be fifteen centimeters off the plate and were proven to not interfere with any other payloads during last year's flight. To handle the temperature ranges experienced by a high altitude balloon flight, both parts of the payload will be covered in space blanket, which was proven to be a good insulator on the 2013 flight. However, it is not yet known if *EagleSat* will need to have onboard heaters even with the external insulation, so tests will be conducted to determine the insulating properties of only solar panels. It is anticipated that the total mass of the payload will be 1525 grams, well within the 3000 gram requirement. This mass allows for a margin of 1475 grams, which makes for a safe buffer should any additional components be added.

Element	*Mass (g)*	*Multiplier*	*Total*
Standard PCBs	55	5	275
Structure	185	1	185
Batteries	40	2	80
GPS	24	1	24
Transceiver	81	1	81
Solar Mounted	215	1	215
Solar Deployed	190	2	380
Antennas	35	1	35
Integration Module	250	1	250
Total (g)			**1525**
Margin (g)			1475

Anticipated mass budget for *EagleSat* on HASP 2014.

For power use, *EagleSat* will be drawing power from HASP as well as using the power generated by its solar panels. Having both sources available will allow *EagleSat* to rely on a steady source for the duration of the mission, therefore preventing any unnecessary failures due to a loss of power, while also monitoring the power generation capabilities of the experimental solar array. Given the limited power generation capabilities on orbit, however, most components on *EagleSat* are conservative about their power usage, leading the payload to only use 2.84 W out of the supplied 15 W.

Component	*Current (mA)*	*Volts (V)*	*Power (mW)*
SRAM	11	3	33
PCM	50	3	150
RADHARD	89	3	267
FRAM	26.4	3	79.2
MRAM	181.5	3	544.5
Radio	290	7.2	500
EPS			65
GPS			1200
Total (W)			2.8387
Margin (W)			12.1613

Anticipated power budget for *EagleSat.*

To control the payload during the flight, a combination of serial and radio commands will be used. Radio commands will be received at 436.5 MHz and will be controlled at all times by licensed amateur radio operators. For serial commands, a preliminary commands list is inserted below. This list anticipates any operations that may be requested of *EagleSat* during the flight, though changes may be added to it for the PSIP or FLOP. Discrete commands will be used to toggle the power to *EagleSat* and therefore allow for tests of the solar panels and batteries; it is anticipated that such a test will take place at least three times during the flight.

		Command Number					Command Description
1	2	01	00	3	D	A	Wake
1	2	02	00	4	D	A	Sleep
1	2	03	00	5	D	A	Ping
1	2	04	00	6	D	A	Transmit callsign
1	2	05	00	7	D	A	Beacon ON
1	2	06	00	8	D	A	Beacon OFF
1	2	07	00	9	D	A	Power burn wire, deploy antennas
1	2	08	00	10	D	A	Switch Antennas
1	2	09	00	11	D	A	Send status report

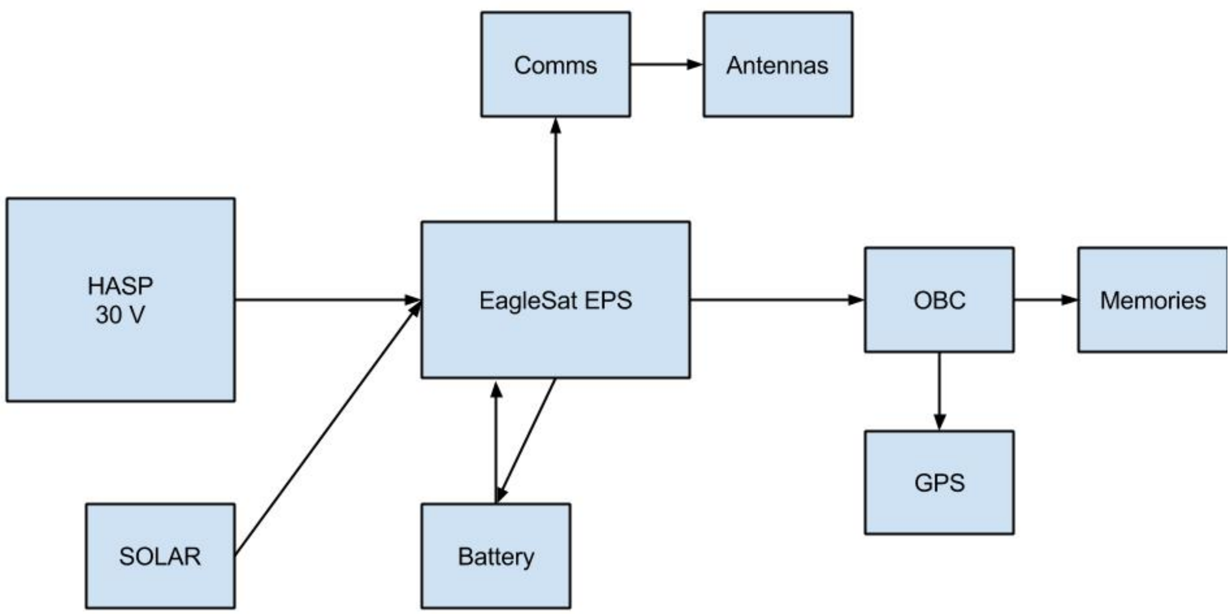
Preliminary serial commands list for *EagleSat.*

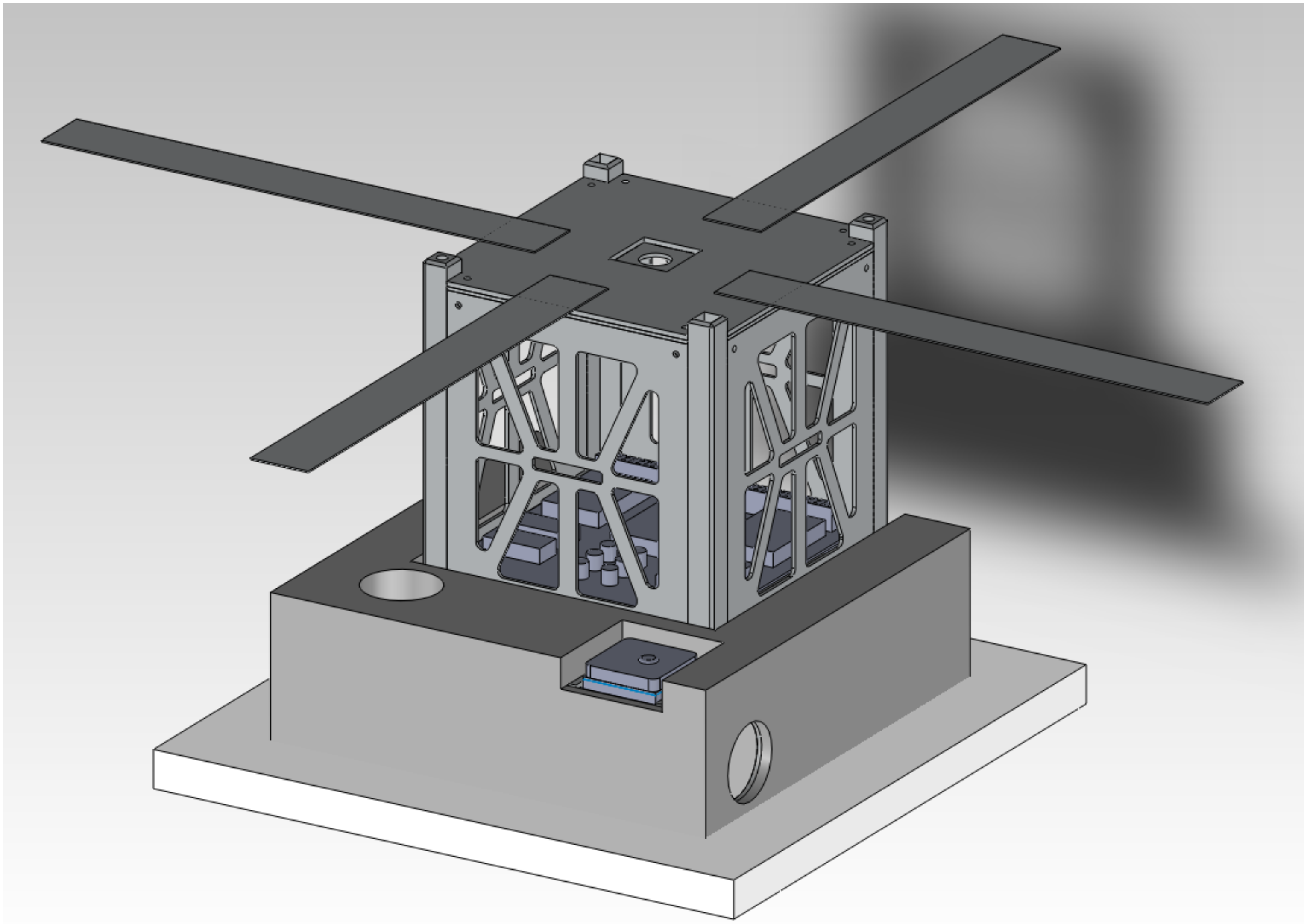
To test the deployable systems as well as the integrity of the solar cells, *EagleSat* will be carrying batteries onboard, as it would if it were orbiting the earth. These cells will be lithium ion cells, and will be fully enclosed inside the payload. The deployable system will rely on its own lithium battery, which will be used once to deploy the antennas at the start of the flight. It is not anticipated that these batteries or the deployment of the antennas will endanger the safety of the other payloads or the HASP platform, however the Embry-Riddle team is willing to submit to extra tests and certifications to ensure the safety of all payloads onboard.

Prior to integration at the Columbia Scientific Balloon Facility, the Embry-Riddle team will be testing the *EagleSat* payload in thermal and vacuum tests using equipment at the Embry-Riddle Prescott campus. Vibration and shock testing will also be conducted to ensure the structural integrity of the structure during launch and landing. It is hoped by that by conducting these tests before leaving the campus, integration at CSBF will go smoothly and quickly.

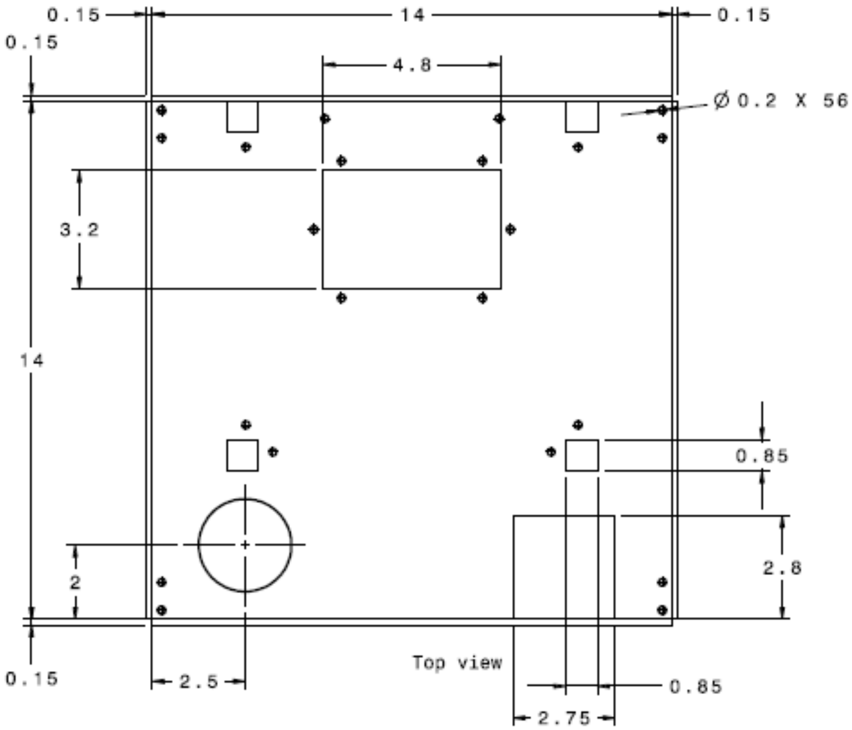
PRELIMINARY DRAWINGS

Preliminary power diagram for *EagleSat.* Note that both HASP and the solar panels on the satellite serve as power sources.

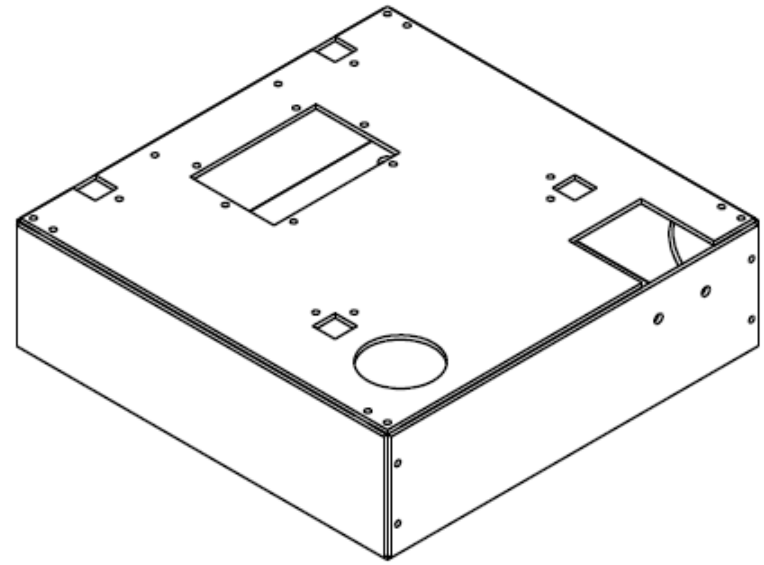




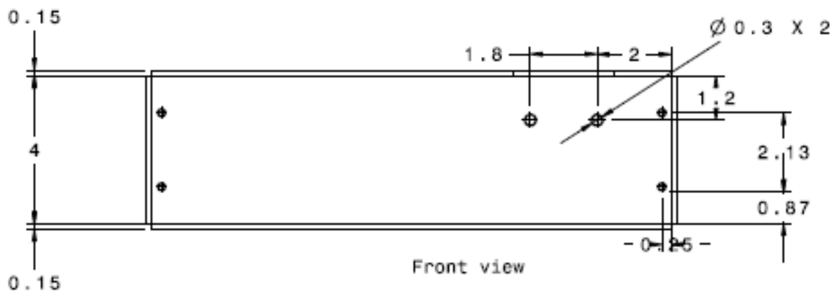
Mockup of EagleSat mounted to Nest integration module. Note the Nest module was also part of the 2013 ERAU payload.



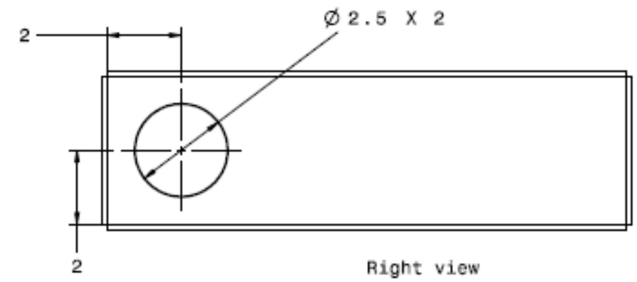
Top view



Isometric view
Scale: 1:1



Front view



Right view

All units in centimeters

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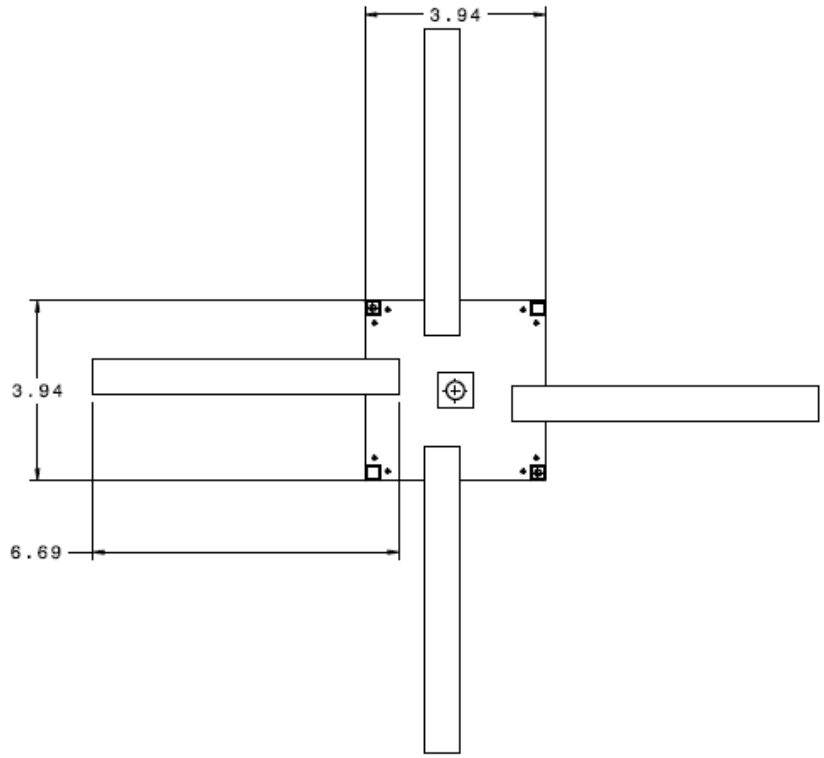
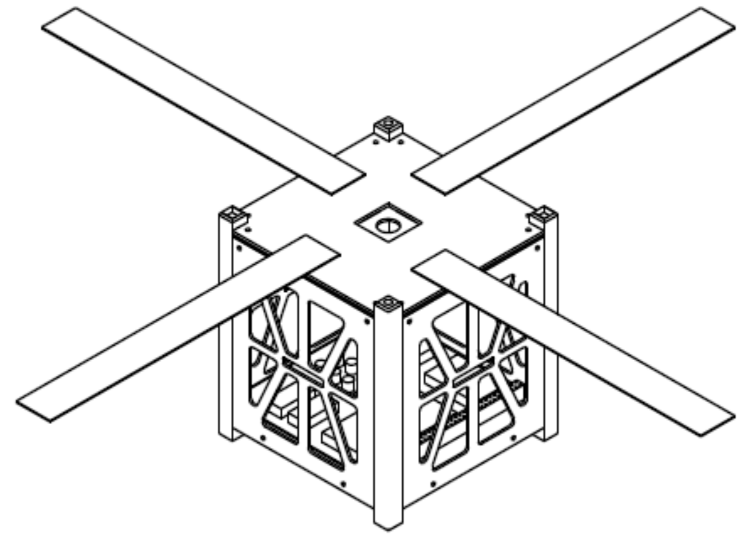
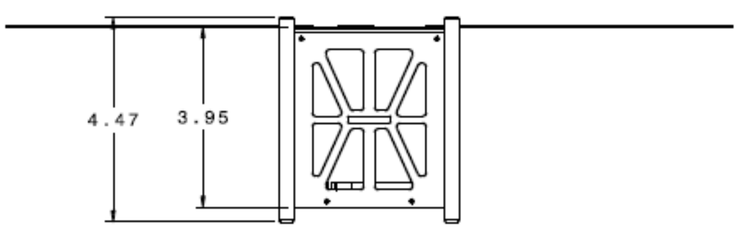
DRAWN BY Mo Sabliny	DATE 5/21/2013	DRAWING TITLE Phoenix				
CHECKED BY Zach Henney	DATE 5/21/2013	SIZE C	DRAWING NUMBER 004			REV B
DESIGNED BY Zach Henney	DATE 5/21/2013	SCALE 1:1	WEIGHT(kg) XXX		SHEET 1/1	



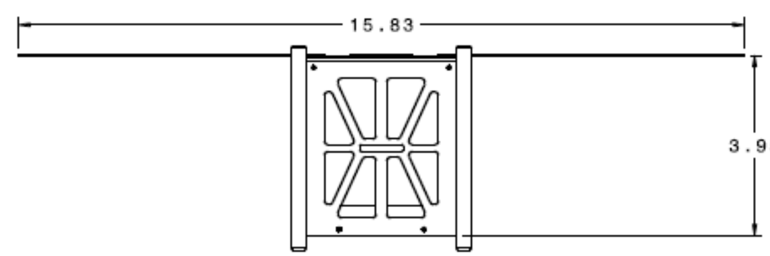
Top view
Scale: 1:2



Isometric view
Scale: 2:3



Front view
Scale: 1:2



Right view
Scale: 1:2

All units in centimeters

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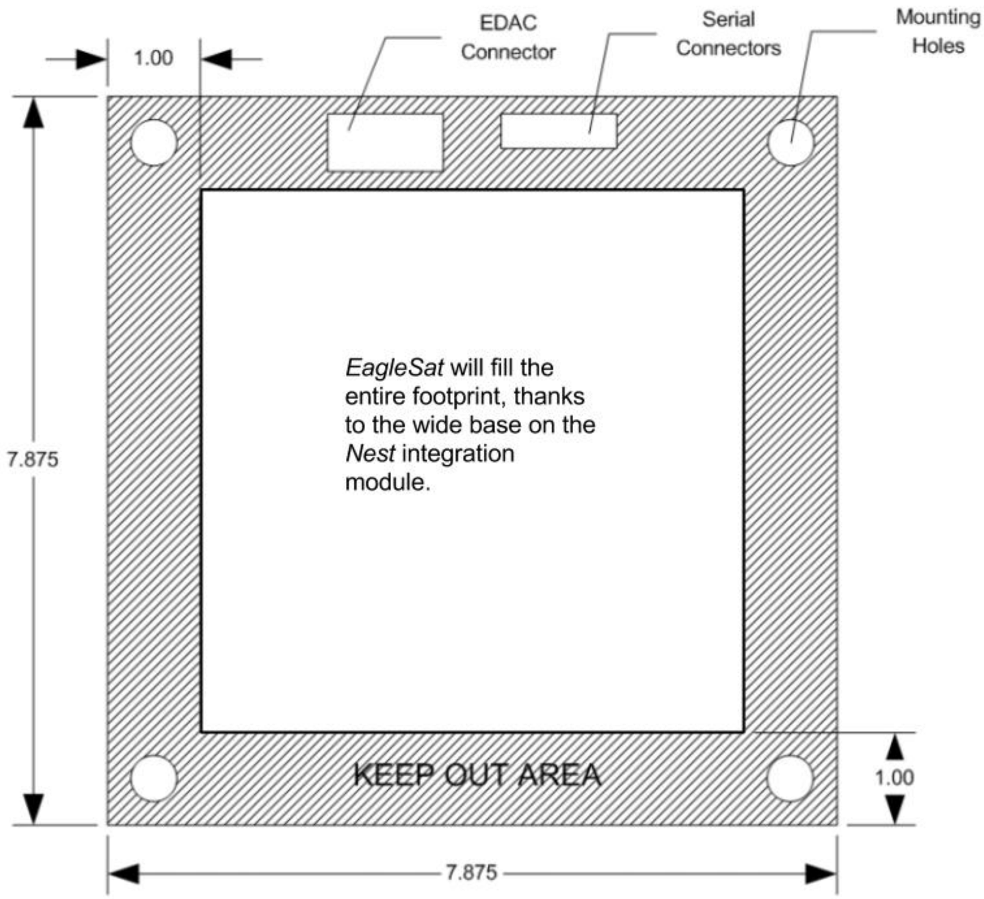
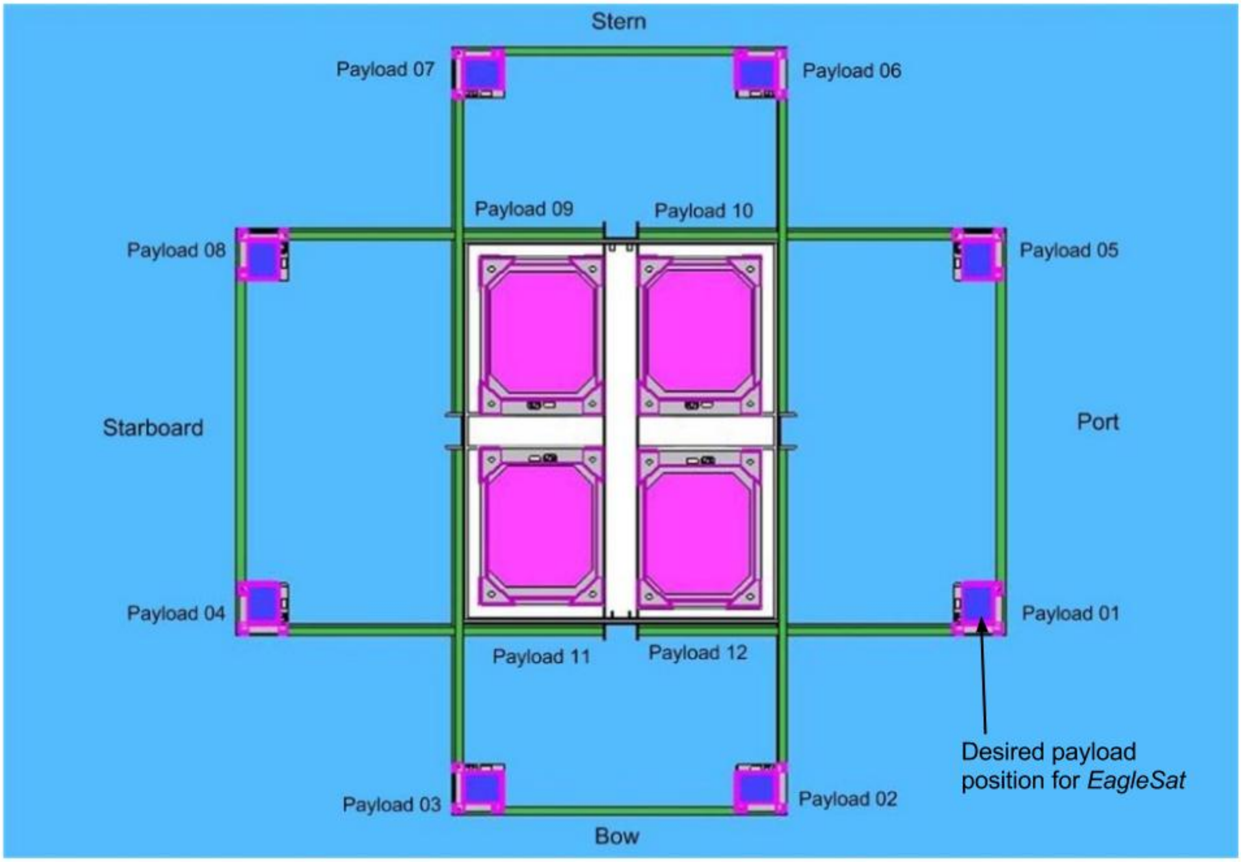
DRAWN BY Mo Sabliny	DATE 5/21/2013	DRAWING TITLE EagleSat					
CHECKED BY Zach Henney	DATE 5/21/2013	SIZE C	DRAWING NUMBER 002				REV B
DESIGNED BY	DATE	SCALE 1:2	WEIGHT(kg) XXX			SHEET	



EagleSat will fill the available footprint of the mounting plate, as the wide base on the *Nest* integration module will be 15 centimeters on a side when thermal insulation is applied.



The desired payload location for *EagleSat* will be Payload 01.