# HASP Student Payload Application for 2009

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| Payload Title: Hatchling I | | |
| Payload Class: (circle one) Small Large | Institution: Embry-Riddle Aeronautical University | Submit Date: 18 December 2008 |

Project Abstract

The Embry-Riddle HASP payload will provide a test bed for the multi-mission satellite subsystems under development at ERAU for future proposed Nanosat class spacecraft. This core satellite bus will consist of power, command and data handling, and communications subsystems. The bus is being developed to accommodate a variety of scientific payloads. For the 2009 HASP Project, a cooperative demonstration payload experiment under development by Pima Community College Northwest Campus Science Department will be included. This experiment will provide calibration of sun photometers which is critically dependent on the extraterrestrial (ET) constant, i.e. the intensity of sunlight at the top of the atmosphere using an array of detectors and, measurement of the downwelling infrared radiation caused by the major greenhouse gases aside from water vapor using an IR thermometer. An ERAU developed position/attitude determination experiment will be included in payload slot 2.

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18 December 2008

**High Altitude Student Platform**

**Payload Seat Application**

**for Embry-Riddle Aeronautical University Hatchling I Payload**

**In Response to Call for Payloads 2009 RFP dated October 1, 2008**

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The ERAU Space Eagles team of Embry-Riddle Aeronautical University in Prescott, Arizona is pleased to submit this Payload Seat Proposal for the 2009 High Altitude Student Platform program. The payload described herein will be predominantly student designed and built. Only minimal faculty and advisor guidance and design critique will be involved. Managed by the Embry-Riddle Space Grant director, his assistant, and the Space Eagles Student team leader, individual task teams will design , build, test, and deliver their respective contributions to the overall Hatchling I payload package. The Space Eagle team will perform final payload integration and test of the payload System. Details of the project management plan for the Hatchling I project is expanded later in this document. Past experience over the past two years in the Arizona Space Grant Consortium high altitude balloon ASCEND! program will help ensure success in the execution of the 2009 HASP Hatchling I Project.

The Hatchling I Payload will be a test bed for the ERAU multi-mission spacecraft bus, which ERAU plans to incorporate into future Nanosat class satellite programs. ERAU will develop this bus to accommodate a variety of scientific payloads. The bus will include a electrical power subsystem module, a command and data handling module, and a RF communications module. An interface between modules similar to the PC104 bus interface will provide connectivity between modules including mission specific scientific experiment modules. For the HASP 2009 program, two experiments will be included, a spectral photometer sensor array and, an inertial measurement sensor.

1. **Payload Description**
   A. Electrical Power Subsystem (EPS) - The EPS module will receive nominal 30 VDC power from the HASP gondola and condition it to the voltages required by the rest of the Hatchling I payload system. It is anticipated that 12 VDC will be required by the communications module, while 5 VDC will be required by the command and data handling module. This will be accomplished by two independent switching DC-to-DC power supplies efficiently converting the input voltage to the required outputs. Off-the-shelf switching power supply modules will be incorporated onto a printed

circuit board that will also contain any additional filtering and load switching circuits. Heating circuits if required, will be powered and controlled from the EPS module. The EPS module will be designed to incorporate the provided EDAC 516 pigtail wiring harness. The EPS module will be designed and tested to accept 28 to 34 VDC with a maximum current draw of 500 ma.

B. Command and data handling subsystem (C&DH) - The C&DH subsystem module will accept serial commands from the communications subsystem module and the gondola serial connector interface. While it is anticipated that most commanding will be done through the gondola data interface, the Space Eagle team would like to schedule several brief periods where the Hatchling I communications interface can be exercised and tested. The C&DH module will also accept up to two discrete open collector commands via the EDAC 516 connector. All gondola commands would comply with the formats specified in the HASP Student Interface manual. Telemetry will be generated by the Hatchling I C&DH subsystem and provided to the gondola serial interface and the communications subsystem module. Again, whileit is anticipated that most telemetry will be sent via the gondola interface, we would like to schedule several brief periods where the communications interface can be exercised and tested. Up to two analog signals will be provided via the EDAC 516 connector interface. All telemetry format specifications have been reviewed, are understood, and will be complied with. Command and data processing will be performed by a student-built microprocessor which will do A/D conversions, packet stuffing, any on-board required processing, and serial and discreet interfacing. Recent class experience with ATMEL and PICAXE processors will contribute to the low risk design for this project.

C. Communications subsystem (COM) - The COM subsystem will consist of an UHF transceiver module and a data modem. The transceiver will operate in the 420-450 MHz amateur radio band. Transmit output power and operation time will be minimized to preclude electromagnetic interference (EMI). HASP level electromagnetic compatibility (EMC) testing is anticipated and welcome. The COM payload will operate under the call sign of N7ERU, licensed to the ERAU Eagle Amateur Radio Club. Automatic Packet Reporting System (APRS) protocol will be incorporated into the RF Communications operations. Licensed control operators will activate all RF transmissions. A one-quarter wave (approximately 6 inch

long) whip antenna will be mounted on the top of the Hatchling I payload. This may require a waiver to the overall height requirement.

D. Payload Experiment 1 (E1) -E1 will consist of two parts:

I. Measurement of the ET (extraterrestrial constant)- The calibration of sun photometers is critically dependent on the extraterrestrial (ET) constant, i.e. the intensity of sunlight at the top of the atmosphere. Our experiment will compare the ET constant from the ground, using the Langley method, and from space. Using an array of detectors that lie on the periphery of a spherically shaped sensor head we will sample radiation levels at various angles. During the flight, an identical set of detectors will be used on the ground to make Langley plots. The basis for this circuitry for has been designed by Dr. Forrest Mims and has been utilized many times.

The optics and detectors of the ground instrument(s) should be identical to the balloon instrument. This experiment will employ a dozen or more photo detectors maintained at ~25$^{o}$ C and include the following:

- blue sensitive LED
- green sensitive LED
- red sensitive LED
- 816 nm sensitive LED
- 940 nm sensitive LED
- a set of filtered photodiodes having spectral responses identical to the LEDs

II. Measurement of the downwelling infrared radiation caused by the major greenhouse gases aside from water vapor - We are proposing a method of experimentally measuring the downwelling infrared radiation caused by the major greenhouse gases aside from water vapor. An IR thermometer will be pointed as vertically as possible without including the balloon envelope in the field of view. The apparent sky temperature will fall sharply as the altitude increases due to the reduction in water vapor over the balloon. Eventually, the water vapor column will probably fall to less than a millimeter. We will investigate whether or not there is a measurable change in the temperature with altitude that indicates the presence of $CO_2$, which is much more uniformly distributed through the atmosphere than water vapor. In an ideal scenario, water vapor would be completely

eliminated above the balloon so that only the major greenhouse gases, including the ozone layer, contribute to downwelling IR.

E. Payload Experiment 2 (E2) - E2 will consist of two parts:
   I. GPS Position - A Trimble Lassen IQ GPS receiver module will be utilized to provide position and altitude data in a NEMA serial format. This receiver will be connected to an active patch antenna at the top of the Hatchling I payload, within the overall height requirement. This receiver and antenna combination has been tested on several Arizona Space Grant Consortium ASCEND! balloon flights and operation at altitudes over 90,000 feet has been verified.
   II. Inertia Measurement System - A Spark Fun ADXRS300 6 degrees of freedom IMU will measure payload accelerations and position with Roll, Pitch, and Yaw gyro sensors including a total of 3 tilt axes. All measurements will be sent to the C&DH subsystem for periodic transmission to the ground. Sample rates will be commanded from the ground.

F. Structure - The Hatchling I payload will be enclosed in a light weight composite structure. This structure will consist of high density foam sandwiched between two composite panels. The foam is lightweight and provides insulation from the extreme temperatures experienced at the HASP float altitude. Total weight of the Hatchling I payload will be less than 2.0 kilograms.

**2. Management and Team Structure -** The Hatchling I project will be supervised by faculty of Embry-Riddle Aeronautical University. Day to day supervision will be provided by Adjunct Professor Jack Crabtree. Jack is a retired Engineering manager with 26 years of aerospace experience with Lockheed Martin in Denver Colorado. Jack is responsible for the ERAU Space Systems Laboratory. He is also the founder of Edge of Space Sciences (Denver, CO) and Arizona Near Space Research (Phoenix, AZ) both of which are non-profit organizations that support high altitude balloon student projects for the Colorado and Arizona Space Grant Consortiums respectively. Associate Professor Dr. Ron Madler, the ERAU Director for Space Grant, will provide top level management of the project. Seth Guberman, a junior aerospace engineering student will be the student lead for the ERAU Space Eagles. The Space Eagles team will be responsible for the power subsystem, communications subsystem, Experiment 2, structure, and overall system integration and test. Seth is a Space Grant intern and will be provided

compensation for his lead activities. Other members of the Space Eagle team will be volunteers drawn from students, including members of the Society of Women Engineers (SWE), and the ASCEND! project. The ERAU Computer and Engineering Department Head, Dr. Cone, has opened a CE 499 Technical Elective course to develop the C&DH subsystem. He has four students that will be assigned to this project and they will receive course credit for their participation in this subsystem development. Payload Experiment 1 will be provided by the Pima Community College Northwest Campus Science Department of Tucson, AZ. Four students and four faculty at PCC will be involved in this aspect of the project. An external advisor, Forest Mims III will also contribute the this experiment.

3. **Project Funding** - Any required funding for the Hatchling I payload project will be provided by the Arizona Space Grant Consortium.
4. **Data Submissions and Reviews -** The overall schedule for the HASP project has been reviewed and a detailed implementation schedule will be developed in January, 2009. All data submissions and design review requirements and deadlines will be met.
5. **Detailed Specifications -** Overall requirements for payload weight, size, data interface and acceleration and temperature environments have been reviewed and subordinate flowdown requirements will be generated and documented in January as the Spring semester starts. With the exception of the communications antenna possibly protruding above the 30cm height limit, all requirements will be met.
6. **Drawings -** Detailed mechanical and interface drawing generation will commence in January as the new semester begins. In summary, the Hatchling I payload will consist of a stack of PC boards contained in a cube shaped structure no larger than 15 cm (l) x 15 cm (w) x 30 cm (h). Only the interface cables, and the communications antenna will extend past the structure body. Near the top of the payload the four sides will contain the rows of LEDs used for Experiment 1.

7. **Conclusion** - The Embry-Riddle Space Eagle team hopes for favorable consideration of this proposal and is excited at the prospect of working with the Louisiana State University Department of Physics & Astronomy as well as the NASA Wallops Flight Facility Balloon Program Office on the 2009 HASP project. Feel free to contact the Student and/or Faculty lead designated on the attached cover page.