Dr. T. Gregory Guzik December 11, 2008
Department of Physics and Astronomy
Louisiana State University
Baton Rouge, LA 70803-4001

Dear Dr. Guzik,

Attached is an application to continue participation of the BOREALIS Passive High Altitude Particle Capture Experiment aboard the High Altitude Student Platform. With the advice and assistance of our faculty advisor, Dr. Berk Knighton, we have continued refining and expanding the project while maintaining ourselves within the original frame of our proposal submitted two years ago. The team has recently collaborated with Dr. John Carlsten to develop a laser particle detector. Our continued research in the literature has revealed a windfall of papers on balloon borne particle measurement and capture experiments. We are hopeful that, in combination with our previous experiment, these resources will allow us to develop a model for the change in high altitude particle flux due to an increase in man-made space debris. We are excited to see our efforts come to a successful conclusion aboard the 2009 HASP flight.

Thank you,

Jayson Nissen

HASP Student Payload Application for 2009

Payload Title: High Altitude Particle Detection and Collection Experiment		
Payload Class: (circle one) Small (Large)	Institution: Montana State University / Montana Space Grant Consortium	Submit Date: December 19, 2009

Project Abstract
The experiment is designed to determine the concentration, size distribution and chemical composition of particles in the upper atmosphere. Measurements will be obtained via two independent methods which will be used as a means of verifying each other. A passive collection system will be used to collect particles for chemical and morphological analysis using an electron microscope. Analysis will allow for the determination of the origin of the particles. A laser particle detector will be employed to measure particle size and number density which will be correlated with the number of particles captured to determine the efficiency of both experiments. Results will be compared with similar experiments flown throughout the 1960's to determine if there is any observable change in the stratospheric particle number density as a result of an increase in man-made space debris.

Team Name:	Team or Project Website:
BOREALIS	http://spacegrant.montana.edu/borealis/

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High Altitude Particle Detection and Collection Experiment

Project Overview

The experiment is designed to determine the concentration, size distribution and chemical composition of particles in the upper atmosphere. Measurements will be obtained via two independent methods which will be used as a means of verifying each other. A passive collection system will be used to collect particles for chemical and morphological analysis using an electron microscope. Analysis will allow for the determination of the origin of the particles. A laser particle detector will be employed to measure particle size and number density which will be correlated with the number of particles captured to determine the efficiency of both experiments. Results will be compared with similar experiments flown throughout the 1960's to determine if there is any observable change in the stratospheric particle number density as a result of an increase in man-made space debris.

The particle density within the stratosphere is known to be low and highly variable.[1] Particle flux measurements for particles greater than 5 microns have yielded flux rates of $1x10^{-4}$ particles $cm^{-2}s^{-1}$, increasing by a factor of 5 - 80 following meteor showers at an altitude of 120,000 feet.[2] Previous flights of our particle collector have returned particles collected from the upper atmosphere when the particle collection rate was expected to be 1 to 10 particles per hour, with variability dependent upon meteoric activity. Having a launch that will occur in mid-August, shortly after the Perseid meteor shower, may increase the odds of capturing cosmic dust particles.[2]

In addition to extraterrestrial particles, we are likely to capture volcanic dust and particles from man-made space debris and rocket fuel exhaust. The first part of our analysis will involve categorizing the particles and determining the relative abundances of the various types of particles we recover from the stratosphere using our capture box. We will use an optical imaging system for this preliminary analysis. The particles that we suspect to be extraterrestrial or space debris will be subjected to further analysis of their morphology and composition with a field emission scanning electron microscope (FEM). Two students have been conducting analysis on the previous samples using this technique. Any particles that we suspect to be of extraterrestrial origins will be compared to some of the known cosmic dust particles in the Cosmic Dust Catalog.[3] We expect to be able to identify the space debris particles by their morphology and chemical composition.

Particle Collection Device

The particle collection device that we wish to deploy this year is essentially the same as the one that was deployed previously. Utilizing the large payload footprint, we intend to expose four 200 cm^2 polished Plexiglas collection plates that have been covered with a silicone fluid which will capture any particles that impact the surface. The polished Plexiglas collection plate design will be an enlarged modification of the system that the Cosmic Dust Lab (CDL) uses. This design will enable the particles to be imaged while on the plates, allowing for identification of cluster particles which break up upon impact but are found in groupings. These cluster particles have a high probability of being of extraterrestrial origin.

The particle collection plates need to be housed within a box that will prevent them from being exposed to contamination below the target altitude (see attached drawing). A servo operated arm will open and close the lids of the box on command. When the box is closed, the lids will form a seal against a silicone o-ring to prevent terrestrial contamination on descent and landing. The box's closing and opening mechanism will be operated by logic signals from our on-board microcontroller. Commands sent through the HASP platform will trigger the box to open at a specified altitude and close again when the balloon begins its descent. During previous flights the mechanical seal between the box lids and silicon O-ring was sufficient to develop an air tight seal. However, this year we intend to add a lid-locking mechanism, which would be activated just after closing for additional security. This lock would help protect our samples in the event of a problematic landing. Last year's flight demonstrated that the structural and controlling components of our payload can withstand the environmental factors associated with a prolonged high altitude balloon flight.

Laser Particle Detector

The particle detector is designed after the instrument developed by Rosen et al. [4,5] It will use a triple pump system to pull air into the measurement volume. The pump system will periodically pressurize the volume with particle-free air to make background measurements. The particles entering the detection volume will intercept the laser beam and scatter some of its light. This light will then be collected by a convex lens and focused onto a photomultiplier tube. The magnitude of the voltage produced by the photomultiplier tube will be proportional to the size of the particle. The pumping system will allow the instrument to use smaller optics and remain completely isolated from external light. Data will be collected and recorded by an electronic system integrated with the collection box. Data will be continuously reported to ground control as a precaution against instrument failure. The laser particle detector will be active throughout the flight, except when it needs to be shut down to free up electrical power for capture box operations.

References

[1] Rosen J. M., *Stratospheric Dust and Its Relationship to the Meteoric Influx*, Space Science Reviews, **9**, 58-89 (1969).

[2] Coon R., J. Dugan, D. Hallgren, C. Hemenway, *Balloon-Top Collections of Particles from Meteor Showers*, Astronomical Journal, **70**, 671 (1969).

[3] Cosmic Dust Catalog web edition http://www-curator.jsc.nasa.gov/dust/cdccat16/contents.pdf

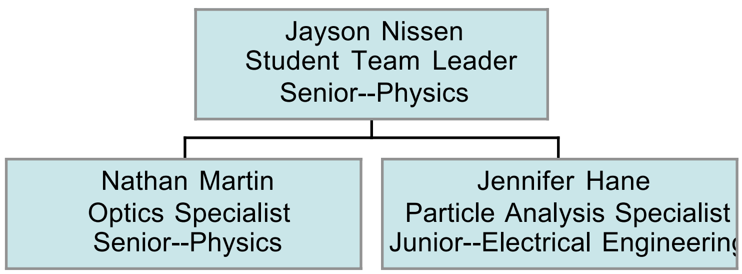
[4] Rosen, J. M., *The Vertical Distribution of Dust to 30 Kilometers*, Journal of Geophysical Research, **69**, 4673-4676 (1964).

[5] Hofmann, D.J., J. M. Rosen, T. J. Pepin, R. G. Pinnick, *Stratospheric Aerosol Measurements I: Time Variations at Northern Midlatitudes*, Journal of Atmospheric Science, **32**, 1446-1456 (1975).

BOREALIS Team

The BOREALIS team currently has three student team members and a faculty advisor. The organizational chart shown below reflects the team organization for the preparation of the proposal. In the event that our proposal is selected for a seat on the 2008 HASP flight, the team will be restructured to address the design, construction and testing of the particle collector. Jayson Nissen will remain the team leader for the duration of this project. All of the students are expected to participate in the design, construction and testing of the particle collector as well as analysis of any collected particles.

BOREALIS HASP Student Team Organization Chart



Borealis Team Contact Information

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Payload Specifications
Passive High Altitude Particle Capture Experiment

Size will conform to maximum footprint **38cm x 30 cm**

Height will conform to maximum **30 cm**
(Same device as used for last flight)

Collector lid mechanism
- Microprocessor initiated
- Redundant pressure sensor initiation
    - Operates using servo motors

Power requirement (max) **~2.4 Amp at 28V**
- Servo heating circuit 1A at 28V
- Servo motors 0.8A at 28V
- Electronics control and operation 100 mA at 5V
- Laser 0.5A at 28V
- Combined air pump 1.5A at 28V
- Air pumps do not run when box is opening/closing/heating

Communications **RS-232**

Interfacing with the HASP platform

The collection box must be sealed at all times on the ground, but be able to open at altitude and then reseal on the descent. To accomplish this, the sealing mechanism will be controlled by a Parallax Basic Stamp 2 microprocessor module. Temperature monitoring will be integrated into our payload; it will continuously monitor its critical components and feed this information back to command and control. These microprocessors are designed with built in RS-232 communications commands, which will allow the Basic Stamp 2 to receive commands via the HASP Serial Command Uplink interface. Alternatively, the Basic Stamp 2 can receive logic inputs from the HASP Student Payload Discrete Command Interface. This type of communication will allow the sealing or unsealing process to be initiated from the ground.

Thermal Management

Previous flight experience has shown that our insulated electronics box kept the electrical system components within their operating temperature ranges and fully functioning. Integrated temperature sensors will continuously monitor the temperature of critical components. This data will be downloaded to command and control. Reflective white tape will be used to shield all of the electronic components from radiative heating. Heating of our servo motors will be required to bring them to an operational temperature, >0 C, for opening and closing the box. Note that these motors will not be continuously heated throughout the duration of flight, but will only be heated to bring them to operational temperatures and maintain that temperature through the execution of opening or closing of the box lids. This heating cycle will be initiated by a ground command. The air pumps associated with the laser particle detector will be shut down during the heating cycle, to keep the current drawn by our experiment within its limitations. The laser particle detector will be designed to maintain its components at their required operating temperatures. We plan to test the detector in an environmental chamber which will simulate the temperatures and pressures that will be encountered during the actual flight.

Project Timeline

January 20 – May 15:

- Design locking mechanism for capture box
- Complete design of laser particle detector and submit design to MSU optics professors for review
- Purchase parts for laser particle detector

May 15 – July 1:

- Repair of existing capture box and construction of locking mechanism
- Construction and testing of laser particle detector.
- Testing of pre- and post-flight operations procedures
  - The BOREALIS Program will be producing its own version of the BEMCO to test our flight hardware in.

July: Integration

Post Integration: Final cleaning and assembly of experiment at MSU

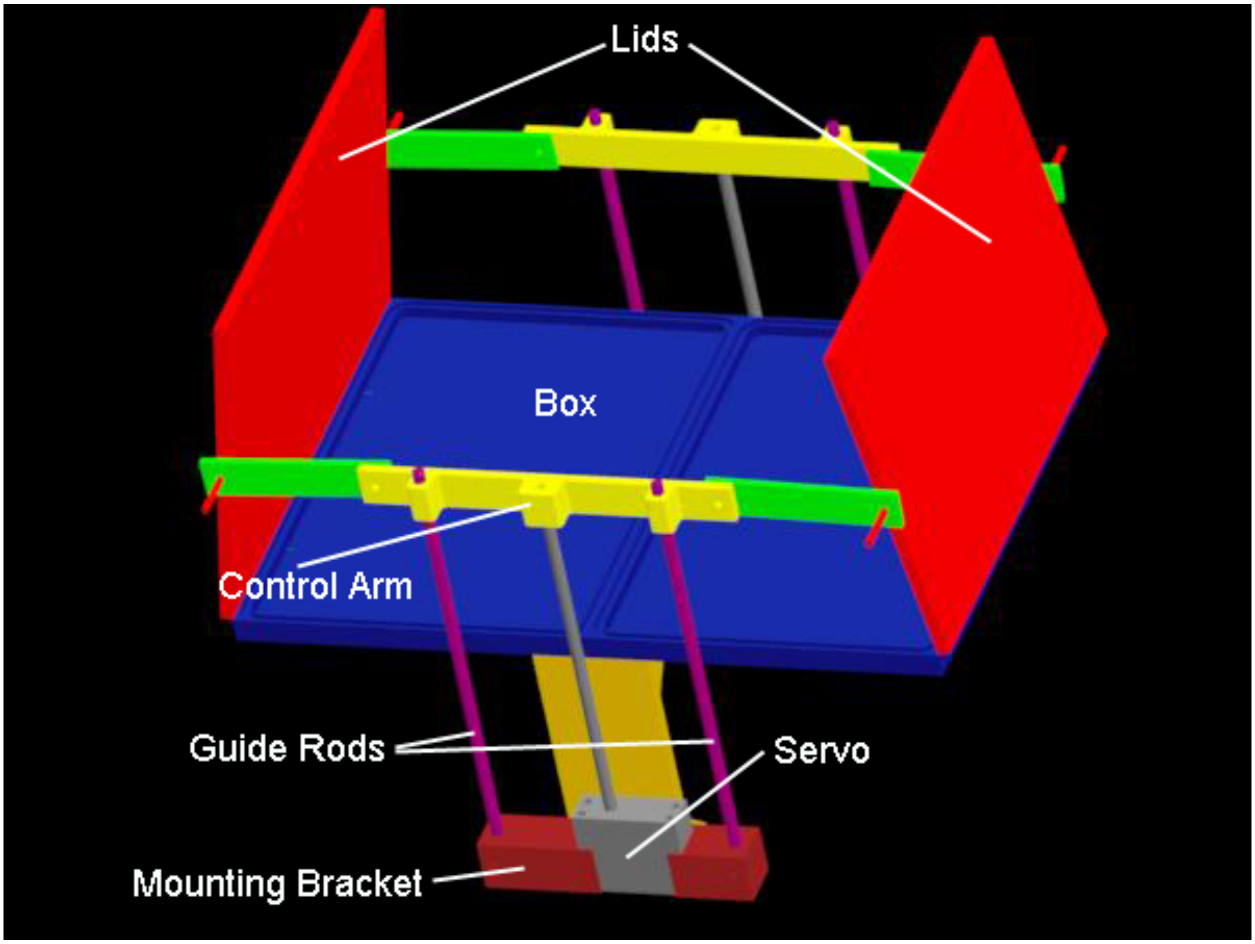
Integration Procedures

The entire experiment will be mounted to the base plate and needs only to be connected to HASP. A test command to verify proper communications should be done at integration; communications tests are easily reproducible from the HASP specifications, so no problems are anticipated. Tests will also be necessary to ensure that the experiment can downlink data to command and control. After integration is complete, the capture box portion of the experiment will be removed from the HASP platform and shipped to MSU for cleaning and assembly. Final integration will occur on the flight line at Fort Sumner.

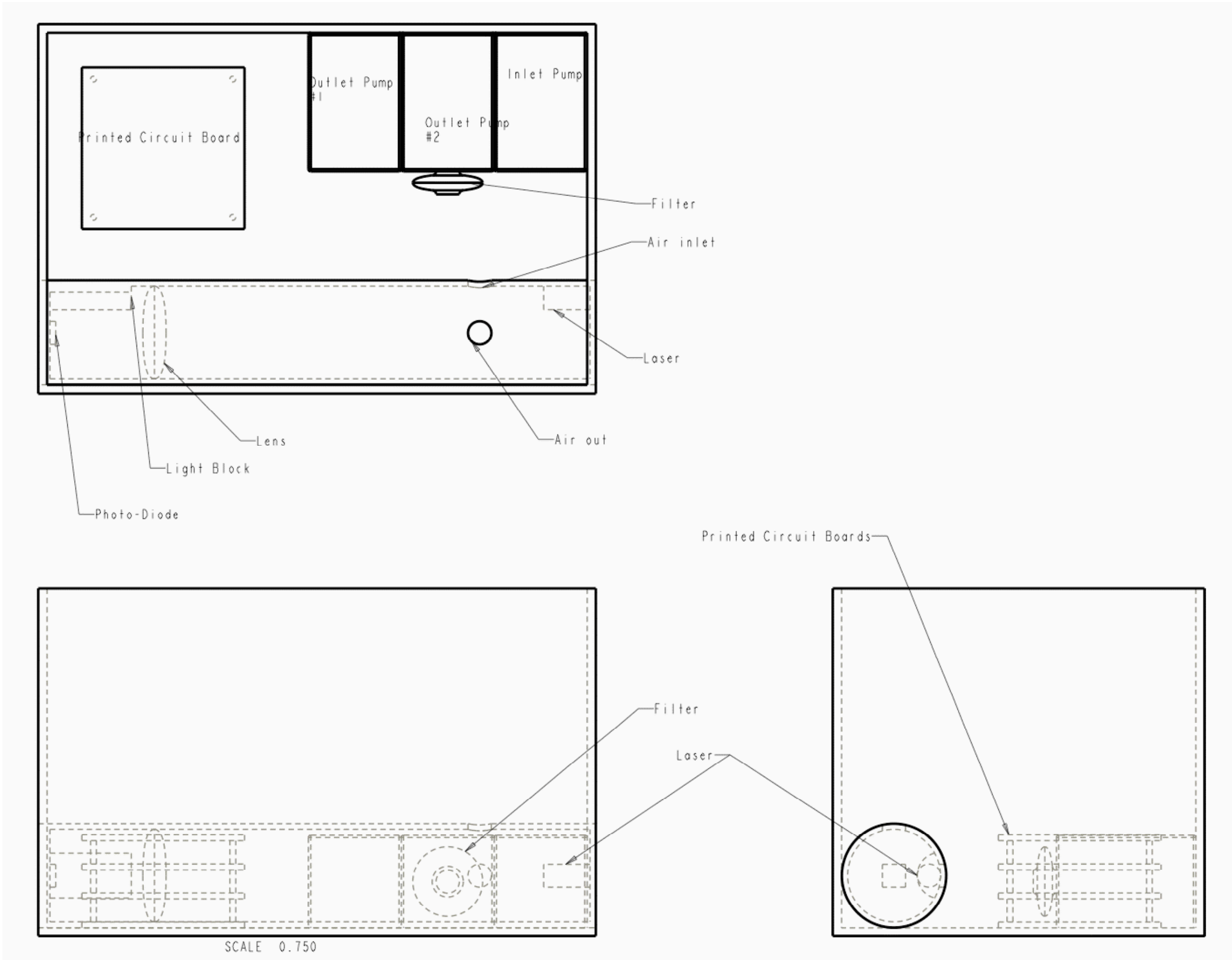
Integration and Flight Personnel

Presently two of the BOREALIS team members are planning to attend the integration and flight campaigns.

Drawing showing the structural components of the BOREALIS payload.



Laser Particle Detector—Preliminary Schematics



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December 17, 2007

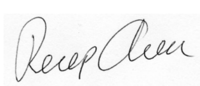
Dear Dr. Guzik,

This letter is in support of the Montana State University student proposal entitled "Passive High Altitude Particle Capture Experiment" that has been submitted as a project to be flown on your 2008 High Altitude Student Platform. It is a pleasure to offer our personnel, equipment and expertise to this exciting student proposal on the capture and analysis of cosmic dust particles.

The ICAL facility has a comprehensive list of complementary analytical techniques, and a wide range of multidisciplinary experience and expertise that can be readily used for the proposed research. These techniques and their function are given on the ICAL webpage www.physics.montana.edu/ical/ical.html. In particular, our experience in surface characterization techniques such as x-ray photoelectron spectroscopy, scanning Auger and electron microscopy will be very valuable in characterizing your cosmic dust particles. We will be willing to train and guide the students that will be participating in the proposed research and help them with the acquisition, analysis, characterization and interpretation of the data in these areas. ICAL has wide experience in working with multidisciplinary groups and has trained hundreds of users, including undergraduate and graduate students, postdocs and faculty in the use of the equipment as well as in interpreting the data.

I wish you my best and I am looking forward to hearing from you the good news that your proposal has been selected.

Sincerely Yours,



Prof. Recep Avci, Director of ICAL