Montana Space Grant Consortium

NASA

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December 18, 2007

Dr. T. Gregory Guzik
Department of Physics & Astronomy
Louisiana State University
Baton Rouge, LA 70803-4001

Dear Dr. Guzik,

Please accept the enclosed proposal "Passive High Altitude Particle Capture Experiment" for consideration for a seat on your 2008 High Altitude Student Platform. We are excited about the opportunity to fly our experiment again. I hope that we have conveyed our dedication and enthusiasm for deploying and analyzing the results of our cosmic dust collection experiment. I look forward to hearing from you the good news that our proposal has been selected.

Sincerely yours,

Jayson Nissen
BOREALIS Team Leader.

HASP Student Payload Application for 2008

Payload Title: Passive High Altitude Particle Capture Experiment		
Payload Class: (circle one) Small Large	Institution: Montana State University / Montana Space Grant Consortium	Submit Date: December 18, 2007

Project Abstract

The purpose of our experiment is to collect particles, especially those of extraterrestrial origins, from the stratosphere and return them to earth for analysis. Our collection method will be a ~900cm^2 collection plate that will passively collect dust particles as they fall through the atmosphere. An improved collection system has been designed. This collection plate will be a thin optically clear Plexiglas plate, coated with a thin film of silicone oil. Particles striking the collection plate will be trapped within the silicone oil coating. The plate will be housed within an aluminum box, which can be mechanically opened at a specified altitude, exposing the plate. The box will be closed prior to descent to prevent terrestrial contamination. The new collection plate will allow us to optically image the particles directly from the plate. Particles which appear interesting after optical analysis, will be imaged and chemically analyzed with a Field Emission Scanning Electron Microscope (FEM).

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

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Passive High Altitude Particle Capture Experiment

Project Overview

The purpose of our experiment is to collect particles, especially those of extraterrestrial origins, from the stratosphere and return them to earth for analysis. Our collection method will be an ~900 cm^2 silicone coated Plexiglas plate that will passively collect dust particles as they fall through the atmosphere. The collection plate will be housed within a sealed box, which can be mechanically opened at a specified altitude allowing the plate to be exposed. Particles striking the collection plate will be trapped within the silicone oil coating. The box will be closed prior to decent to create a mechanical seal. Particles will be optically imaged directly from the Plexiglas plates for preliminary classification. Imaging and elemental analysis of interesting particles will be conducted using a Field Emission Scanning Electron Microscope.

Cosmic dust particle flux through the atmosphere is known to be low. On the basis of an assumed flux of 40,000 tons of extraterrestrial material per year over the surface of the earth, we expect to capture 1-2 particles per flight hour (see Appendix). Results from our previous flight of this experiment indicate that our basic design can collect particles at the target altitude. Having a launch that will occur in mid-August, shortly after the Perseid meteor shower, may increase the odds of capturing cosmic dust particles.

In addition to extraterrestrial particles, we are likely to capture volcanic dust and particles from man-made space debris and rocket fuel. 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 an optical imaging system. The particles that we suspect to be extraterrestrial will be subjected to further analysis of their shape and composition with an FEM. Several students who are currently in training to operate this equipment will conduct the analysis. Any particles that we suspect to be of extraterrestrial origins will be compared to particles known to be cosmic dust. We will request these authenticated samples from NASA's Cosmic Dust Laboratory (CDL), with which we have developed a working relationship since our previous flight.

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, except that a new collection plate insert will be employed. Based on last year's experience, we have learned that we need to improve on the preflight preparation of the collection box with respect to terrestrial contamination. As well, post flight analysis of the capture fluid revealed that a removable, optically transparent collection plate would facilitate particle identification. Design criteria that address these considerations are discussed below.

Utilizing the large payload footprint we intend to expose two 450 cm^2 polished Plexiglas collection plates that have been covered with a matrix that will capture any particles that impact the surface. We believe that the optimal matrix for this purpose is Dow Corning 200 fluid at 500,000cs. Previously we used 250,000cs fluid, but have chosen to use a higher viscosity fluid to allow a very thin layer to be applied using a Hexane dilution technique employed by the CDL.

This higher viscosity fluid will ensure that the fluid will not flow off of the plates under flight conditions. The polished Plexiglas collection plate design will be an enlarged modification of the system that the CDL uses. This design will enable the particles to be directly imaged from 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 exposure from contamination below the target altitude (see attached drawing). A servo operated arm will open and close the lid of the box on command. Closing the box, the lids will form a seal against a silicone o-ring to prevent terrestrial contamination on descent and landing. The box closing and opening mechanism will operate based on logic signals from our on-board microcontroller. It will be triggered by commands sent through the HASP platform with a pressure and time-based backup to open at a specified altitude and then closed again when the balloon is on its descent. In previous flights the mechanical seal between the box lids and silicon O-ring was sufficient to develop an air tight seal. Last year's flight demonstrated that the structure and controlling components of our payload can withstand the environmental factors associated with a prolonged high altitude balloon flight.

After final integration with the HASP platform, the experiment will be removed and shipped to the Johnson Space Center where the CDL has volunteered their facilities for final cleaning and assembly. The experiment will be then shipped to Fort Sumner where it will be reintegrated onto the HASP platform prior to launch.

References

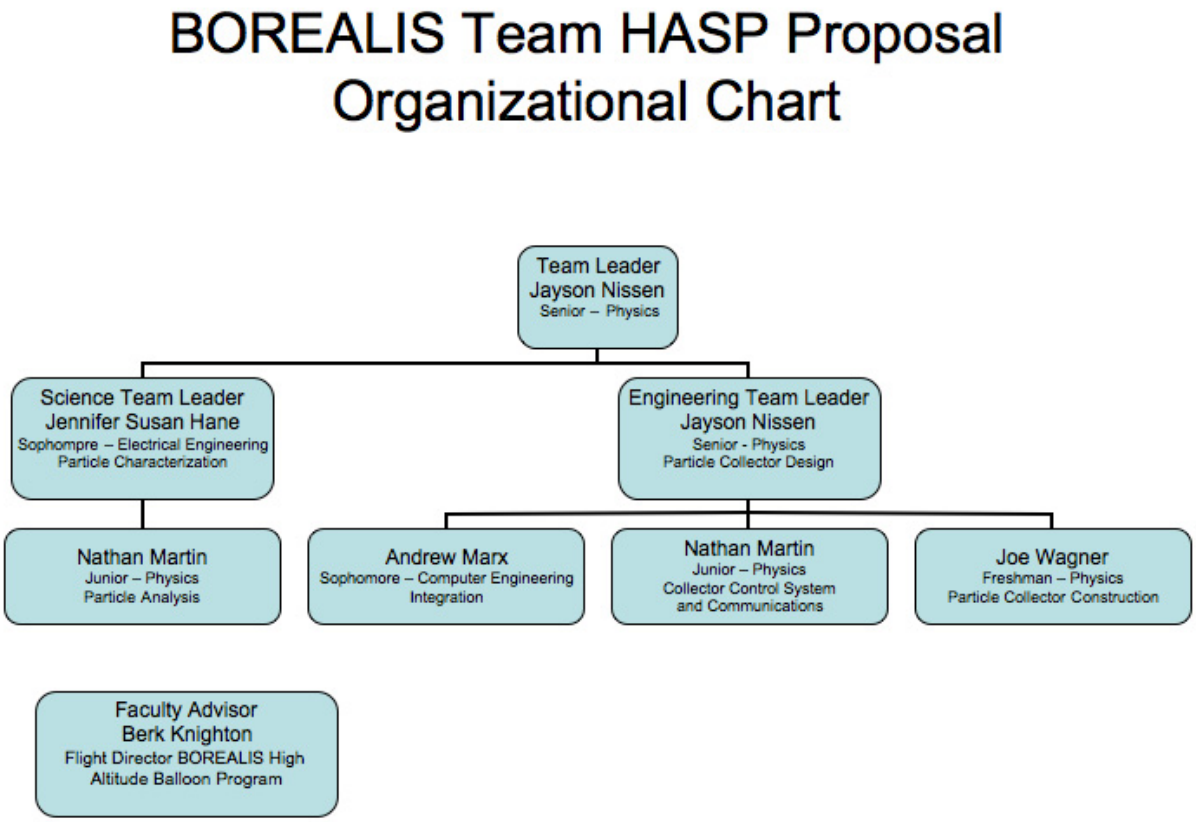
[1] Cosmic Dust Catalog web edition http://www-curator.jsc.nasa.gov/dust/cdccat16/contents.pdf

[2] Love S. G. and D. E. Brownlee, A Direct Measurement of the Terrestrial Mass Accretion Rate of Cosmic Dust, Science, 262, 550-553, 1993.

[3] Rietmeijer J. M. and P. Jenniskens, Recognizing Leonid Meteoroids among Collected Stratospheric Dust, Earth, Moon and Planets, 82-83, 505-524, 2000.

BOREALIS Team

The BOREALIS team currently has six 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 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**
(Intend to reuse pad from last year)	
Height will conform to maximum	**30 cm**
(Same device as used for last flight)	
Collector lid mechanism	
- Microprocessor initiated	
- Redundant pressure sensor initiation	
o Operates using servo motors	
Power requirement	**~1.5 Amp at 28V**
- Servo heating circuit 1A at 28V	
- Servo motors 0.5A at 28V	
- Electronics control and operation 100 mA at 5V	
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 to continuously monitor 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, or 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. A redundant pressure sensor system will be designed and constructed that will open the box at 100 mbar if no command has been sent and then initiate its closure when the pressure rises above 100 mbar.

Thermal Management

Previous flight experience has shown that the insulated electronics box kept the electrical system components within their operating temperatures and fully functioning. Due to the extreme temperature gradient encountered on the previous flight, temperature sensors will be integrated to 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 from a ground command.

Project Timeline

January 20 – May 15:
- Design Plexiglas collection plates.
- Student training of ICAL facilities.
- Update pre and post flight procedures

May 15 – July 1:
- Construction and testing of Plexiglas collection plates.
- Testing of pre and post flight operations procedures

July: Integration
Post Integration: Final cleaning and assembly of experiment at CDL

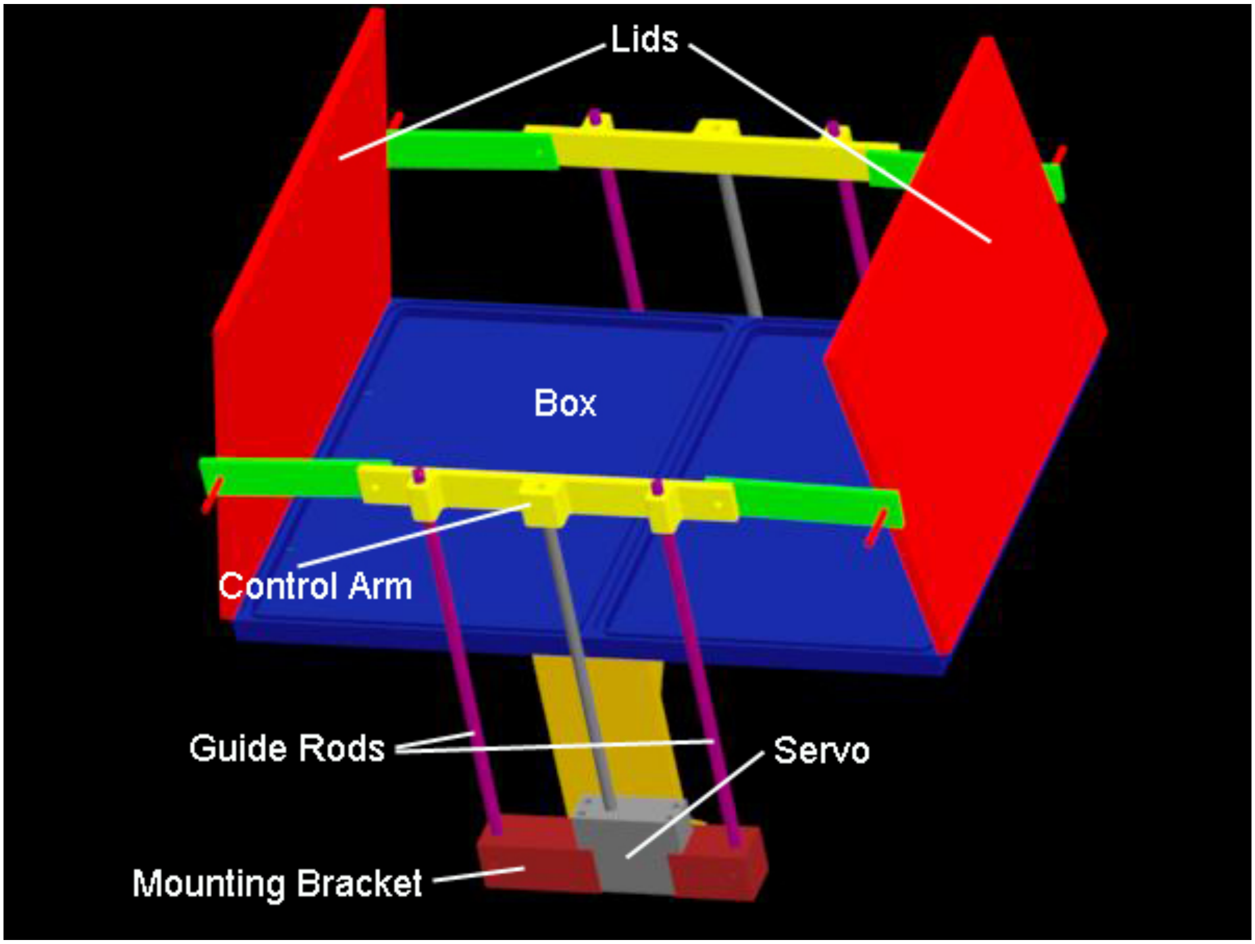
Integration Procedures

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, although communications tests are easily reproducible from the HASP specifications, so no problems are anticipated. Only an uplink command is required for the payload, so telemetry testing is not necessary. The experiment will be removed from the HASP platform and shipped to the CDL for cleaning and assembly. Final integration will occur on the flight line at Fort Sumner.

Integration and Flight Personnel

Presently all of the BOREALIS team members are planning to attend the integration and flight campaigns. The group will include the six team members and their faculty advisor.

Drawing showing the structural components of the BOREALIS payload.



Appendix

Estimated cosmic dust capture rate calculations

Using estimates of 40,000 tons of cosmic dust falling to the earth each year we will calculate the number of particles we expect to capture with our surface based on the following: average of 40,000 tons/year of cosmic dust falling to the earth's surface, average particle radius of 5 μm, an average particle density of $2 g/cm^3$, a collection surface of $900 cm^2$ ($30cm \times 30cm$), an average flight time of 15 hrs, and a mean earth radius of $6.37 \times 10^6 m$.

1. Convert $40{,}000 \frac{tons}{year}$ to $\frac{g}{hr}$

$$\frac{40{,}000 \text{ tons}}{\text{year}} \times \frac{1 \text{ year}}{365 \text{ days}} \times \frac{1 \text{ day}}{24 \text{ hr}} \times \frac{9.07 \times 10^5 g}{1 \text{ ton}} = 4.14 \times 10^6 \frac{g}{hr}$$

2. Divide the rate at which the particles fall over the surface area of the earth.

$$SA_E = 4\pi r^2 = 4\pi (6.37 \times 10^6 m)^2 = 5.10 \times 10^{14} m^2$$

so we have $$\frac{4.14 \times 10^6 g/hr}{5.10 \times 10^{14} m^2} = 8.12 \times 10^{-9} \frac{g}{hr \cdot m^2}$$

3. Find rate of particles hitting earth's surface.

$$\text{Volume of particles} = \tfrac{4}{3}\pi r^3 = \tfrac{4}{3}\pi (5 \mu m)^3 \times \left(\frac{1 cm}{10{,}000 \mu m}\right)^3$$

$$= 5.24 \times 10^{-10} cm^3$$

$$\text{Mass of particles: } \frac{2 g}{cm^3} \times \frac{5.24 \times 10^{-10} cm^3}{\text{particle}} = 1.05 \times 10^{-9} \frac{g}{\text{particle}}$$

$$\text{rate of particles reaching surface: } 8.12 \times 10^{-9} \frac{g}{hr \cdot m^2} \times \frac{1 \text{ particle}}{1.05 \times 10^{-9} g} = 7.73 \frac{\text{particles}}{hr \cdot m^2}$$

4. Find total number of particles in one flight.

$$\text{Total particles} = \frac{7.73 \text{ particles}}{\text{hr} \cdot \text{m}^2} \times \frac{15 \text{ hr}}{\text{flight}} \times \frac{1 \text{m}^2}{(100)^2 \text{cm}^2} \times 900 \text{cm}^2 \text{ collection surface}$$

$$= 10.4 \frac{\text{particles}}{\text{flight}} \text{ for a } 900 \text{cm}^2 \text{ collection surface}$$

This calculation shows that our 900cm^2 collection surface over an average flight time of 15 hrs should yeild roughly 10 ~~pa~~ cosmic Dust particles.

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Dr. T. Gregory Guzik
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December 17, 2007

Dear Dr. Gusik,

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

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Dr. T. Gregory Guzik
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December 18, 2007

Dear Greg:

This letter is in support of the Montana Space Grant Consortium/Montana State University student proposal "Passive High Altitude Particle Capture Experiment" that has been submitted as a project to be flown on the 2008 High Altitude Student Platform. I have been pleased to observe the dedication and enthusiasm exhibited by MSGC BOREALIS students as they proposed, researched and defended the experiment that they describe within their proposal – this has truly been a student-driven project from the start.

The project proposed is a refinement of the students' Cosmic Dust capture experiment flown on HASP in 2007. The students rightly wish to fly again, as they have learned a tremendous amount from the first flight, from diverse sources such as the NASA JSC Cosmic Dust Lab, and, certainly not least, yourself and the HASP team. I'm confident that a second flight will provide greatly enhanced science results, and yield stories and outcomes that the HASP program will be proud of.

As Director of the Montana Space Grant Consortium I offer my support of this proposal and have agreed to financially support this project. I also offer the use of our personnel (Space Grant and Physics Department) equipment and facilities to this exciting student proposal on the capture and analysis of cosmic dust particles.

Sincerely yours,

William A. Hiscock
Professor and Head, Department of Physics
Director, Montana Space Grant Consortium