



# HASP Student Payload Application for 2008

Payload Title: UAH Thermal Radiation Isolation Balloon Experiment (TRIBE)		
Payload Class: (circle one) <b>Large</b>	Institution: University of Alabama in Huntsville	Submit Date: 12/18/07
<p>Project Abstract</p> <p>The purpose of the University of Alabama in Huntsville (UAH) HASP infrared project is to gain a better understanding of the thermal effects that a high-altitude balloon experiences during flight. These thermal effects directly effect the flight duration, altitude changes and ballast requirements. Successful acquisition of the thermal data could help improve future balloon endeavors and possibly span other applications. Our project will build upon past HASP experiments but will introduce new techniques to acquire more meaningful and accurate data. Our previous infrared experiments have utilized off-the-shelf infrared temperature sensors, and pre-arranged thermopile arrays. For this experiment the main focus of the study will center on an array of finely tuned thermopiles measuring a viewable spectrum from the Earth to the balloon and for this reason, it is proposed that the project will require a large payload footprint. The students involved with the project will manage mechanical, thermal, and instrument components for the duration of the project and throughout the data analysis. Previous balloon testing experience coupled with the information gathered from previous models, will greatly add to the understanding of high altitude balloon dynamics towards achieving longer duration balloon flights. This project is supported by the Alabama Space Grant Consortium.</p>		
Team Name:  TRIBE		Team or Project Website: http://spacehardware.uah.edu/
Student Team Leader Contact Information:		Faculty Advisor Contact Information:
Name:	Bob Hawkins	Dr. Georgia Richardson
Department:	Mechanical & Aerospace Engineering	Mechanical & Aerospace Engineering
Mailing Address:	MAE – TH N274 Attn: Space Hardware Club, Richardson	MAE – TH N274
City, State, Zip code:	Huntsville, AL 35899	Huntsville, AL 35899
e-mail:	<a href="mailto:hawkinr@email.uah.edu">hawkinr@email.uah.edu</a>	richaga@eng.uah.edu
Office telephone:	N/A	(256)824-6209
Cell:	(256)684-1513	N/A
FAX:	(256)824-6758 Attn: Space Hardware Club, Richardson	(256)824-6758 Attn: Space Hardware Club, Richardson

## **Payload Description**

### **UAH / TRIBE**

We propose to continue the student designed and built infrared measurement system for determining the temperature of the high-altitude balloon. All components will be designed and fabricated by University of Alabama in Huntsville (UAH) students, with the exception of some Dexter thermopile IR units. Our project is supported by the Alabama Space Grant Consortium and will be supervised by two faculty advisors with involvement from a NASA mentor with a background in high-altitude balloon instrumentation.

One of the main problems to achieving ultra-long duration balloon flights is the lack of understanding of balloon flight dynamics based on the thermal performance of zero-pressure balloons during flight. Our student group is the first to attempt temperature measurements of a high-altitude balloon. Attempts at thermal modeling have been performed and our goal is to determine the validity of these models (Cathey, AIAA 96-0695). The motivation for such a study is to better understand and as a result improve flight dynamics allowing longer duration balloon flights. The equipment we propose to use has been proven to perform in the harsh environment of these altitudes.

The instrument proposed is designed for a single payload configuration. The new fine-tuned thermopile sensors that will be used are a continuation of last year's design and will take the place four 8x1 thermopile arrays that were utilized in an arc formation. The possibility of including the older sensors with the newer sensors is wholly dependent on space and time requirements. The sensors will be positioned to the outer most corner of the payload placing the viewing area on the outer edge of the main HASP gondola. We have included configuration drawings with this proposal with regards to placement on the HASP gondola. The instrument will be fully automated and will not require uplink commands.

As outlined in our management plan, three student leads will manage the mechanical, thermal and systems components of our project. These students are part of our multidisciplinary UAH Space Hardware Club which consists of science, engineering and business/management students. The timeline also includes a post analysis plan for the data received from the flight.

### **Why, What and How**

As mentioned above, the goal of this project is to measure the balloon surface temperature. This is important since the flight dynamics and duration depend on the thermal performance of the balloon including altitude changes and ballast requirements. Understanding the balloon thermal performance will allow improvements in balloon flight configurations and possibly provide other avenues of thermal research developments.

Thermopile sensors operate on the same principles as thermocouples and, in essence, act as an array of thermopiles that are sensitive to infrared radiation. Last year's UAH Thermal Imaging Balloon Experiment (TIBE), was initially designed for a thermal imaging camera. Upon inspection, it was discovered that many off the shelf thermal imagers utilize banks of these thermopile sensors to compile thermal signatures overlaid on optics. Thus, a more affordable

solution presented itself with Devantech thermopile arrays used on HASP in 2006. These particular sensors each contained thermopiles arranged in an 8x1 row which allowed us to arrange them in a 90 degree arc configuration in an attempt to more accurately map the type of radiation conditions the balloon experiences. The purposed experiment will be to utilize more finely tuned thermopile sensors that will solely focus on the thermal radiation in the near infrared spectrum. In an attempt to “cancel” out reflected radiation and other sources that might adversely effect the signatures coming from the balloon, an array of these new thermopiles will be used in a similar fashion as last year’s HASP project. This will hopefully allow the post processing of data to distinguish between such things as reflected radiation from Earth, and transmitted radiation from deep space and begin to narrow down the actual thermal readings absorbed by the balloon.

Due to the nature of this data acquisition a large payload footprint would be ideal. With the equipment needed for the interfacing of many thermopile sensors a larger payload would allow more data acquisition equipment, and thermal controls to compliment the sensors. The data collected can be compared against past data and against numerical models to help determine the emissivity of the material and the validity of our readings. The system will be fully self contained and will house a processing unit for data transfer, data storage and thermal and power controls. All of our equipment has flown on previous flights, save for new thermopile sensors, and are proven to work at these altitudes. Our previous flights on NASA funded Deep Space Test Bed (DSTB), HASP 2006 and HASP 2007 continue to support the possible detection of these measurements. We have continued to study the balloon material since our previous flights and have a better understanding of the IR sensitivity of the material and the elusiveness it provides for our previous equipment to measure it. NASA/Wallops have performed initial testing on the balloon material and have provided this information to us. This study, however, was performed over ten years ago and would be greatly benefited by the pursuit of understanding these balloon materials. The data collected from this instrument will require analysis of course and our student teams will be responsible for this analysis as is laid out in the management plan.

This proposal includes the following components; the team structure and management section outlines our management plan, student team members and team responsibilities. This section includes Figure 1, a flow chart showing our management structure. The payload specifications section includes Table 1 showing our basic requirements. Also included in this section are descriptions of our thermal control, power management and structural plans. Figure 2 is an illustration of our integration configuration. Figures 3 and 4 are technical drawings of our sensors and modular components.

## **Team Structure and Management**

The UAH student team will consist of an overall team lead who will act as the integrations lead (OL), a mechanical systems lead (ML), a thermal systems lead (TL), and an instrument lead (IL). Each lead will be responsible for one or more student team support members (Figure 1). The students are recruited from the UAH Space Hardware Club and have prior experiences dealing with high altitude ballooning. Bob Hawkins, the club mentor, will use this experiment as a vehicle for research concerning his Master's Thesis. There will be two UAH faculty advisors and one NASA/MSFC advisor available for student consulting and guidance throughout the project. Advisor and student name/contact information is given following this section.

The OL primary responsibility is to oversee the ML, TL, and IL through engineering support and logistics management. These duties include integration management between each of the three divisions and integration of the instrument onto HASP. This person will effectively be the go-between to assure compatibility between groups and compatibility with HASP. The OL will also oversee the 24-hour mock testing at UAH of the final integrated instrument in its HASP before integration at LSU.

The primary responsibilities of the ML, TL, IL, and support teams are to design, purchase, fabricate, and test the necessary components to complete their associated goals;

The goals of the *Mechanical Systems Team* include designing a proper mounting bracket to the HASP mounting plate(s), fabrication of appropriate detector housings and load analysis for the NSBF structural requirements. Depending on the housing design and HASP space availability, different instrument configurations will be explored. This group will aid in the final testing to evaluate the performance of their proposed design.

Goals for the *Thermal Systems Team* include designing a thermal system appropriate for the chosen detector and electronic packages. This team will determine possible thermostat requirements for autonomous temperature control and perform temperature and pressure tests. Facilities at UAH for testing include a cold box and a thermal vacuum chamber.

The *Instrument Systems Team* will be responsible for choosing appropriate instrumentation, discerning the proper power allowance for the imager, sorting out the telemetry and data storage needs, correlating the imager into an autonomous working system with proper wiring for the chosen configuration. Tests to determine detector operation in an ambient environment will be done. This team will also be in charge of post analysis on data from the flight. However, post analysis will not be restricted to team members from this team only.

The HASP integration in June will require up to two students and one advisor. Ideally we would like for the OL, ML, and IL students and at least one advisor to travel to LSU for integration. Flight operations in Fort Sumner, NM will be performed by the necessary personnel for the final instrument check.

### **Student Team Members**

(Mail correspondence should be sent through: Attn: G. Richardson, University of Alabama in Huntsville, MAE TH N274, Huntsville, AL 35899)

Robert Hawkins, Student Lead / Integration Lead  
Mechanical and Aerospace Engineering  
Phone: (256) 684-1513  
Email: hawkinr@email.uah.edu

James Mulroy, Thermal Systems Lead  
Electrical Engineering  
Phone: N/A  
Email: jdm0006@uah.edu

Seiya Shimizu, Mechanical Systems Lead  
Mechanical Engineering  
Phone: (225) 571-8896  
Email: shimizs@email.uah.edu

Jason Wunningham, Instrument Lead  
Computer Systems Engineering  
Phone: (256)824-6132  
Email: jdww@eng.uah.edu

### **Faculty Advisors**

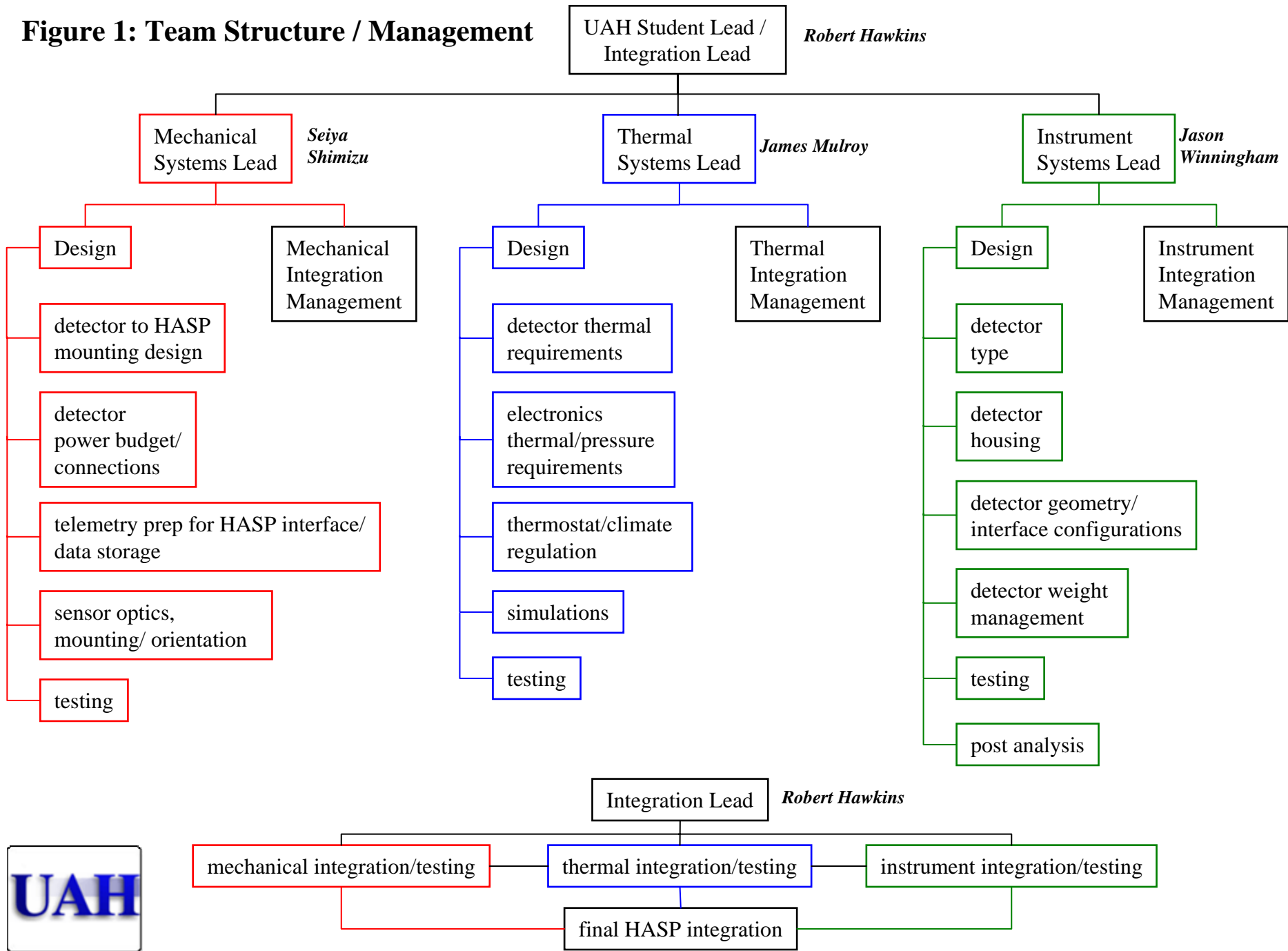
Dr. Georgia Richardson, Asst. Professor Mechanical and Aerospace Engineering UAH  
Address: UAH, TH N274, 35899  
Phone: 256-824-6209  
Email: richaga@eng.uah.edu

Dr. Gerry Karr, Professor Mechanical and Aerospace Engineering UAH  
Phone: 256-824-6330  
Email: karr@eng.uah.edu

### **NASA Advisor**

Dr. Jessica Gaskin, Research Scientist VP62, NASA – Marshal Space Flight Center  
Address: NSSTC, 320 Sparkman Dr, Huntsville, AL 35805  
Phone: 256-961-7818  
Email: jessica.gaskin@nsstc.nasa.gov

**Figure 1: Team Structure / Management**



## Payload Specifications

Values in Table 2 are given for the complete configuration of an individual module.

**Table 2: Instrument Specifications**

Parameter	Single Module
Weight	20 kg
Mounting Footprint	see figure
Height	30 cm
Power	72 W (2.5A)
Telemetry Rate	4800 bps
Uplink	None

### **Thermal Control**

The instruments to be flown will require coarse control of temperature to insure that they are within their operating range. We propose to achieve this through a combination of insulation and onboard heaters. In our previous balloon flight experience on DSTB, HASP 2006, and HASP 2007, the heaters were turned on at launch and the package was well insulated. The temperature history of these experiments showed that the temperature stayed within acceptable limits throughout the flight. There are some changes in the proposed payload that will require changes in the thermal management approach. The increased size of the payload and mass will require more insulation and thermal control due to the thermal sensitivity of the thermopiles. These differences will require that we carefully size the heater for the extremes in temperature experienced during ascent and descent, and that we be able to control the heaters automatically to avoid both a too low and a too high temperature. We were able to avoid the use of heater controls in the DSTB experiments because of the thick insulation and the high thermal mass allowed the use of rather modest heaters that could be left “on” for the duration of the experiment. We utilized mechanical temperature controllers for HASP 06 and HASP 07 that worked exceptionally well.

### **Power and Grounding**

We plan to use dc-to-dc converters to power all instruments at voltages specified from the supplied 29V – 33V. The solid-state converters are readily available and provide safe and efficient power management at small converter mass and size. The heaters (simple resistive heaters) are the potentially largest power requirements for the system and the size can be controlled by careful thermal design.

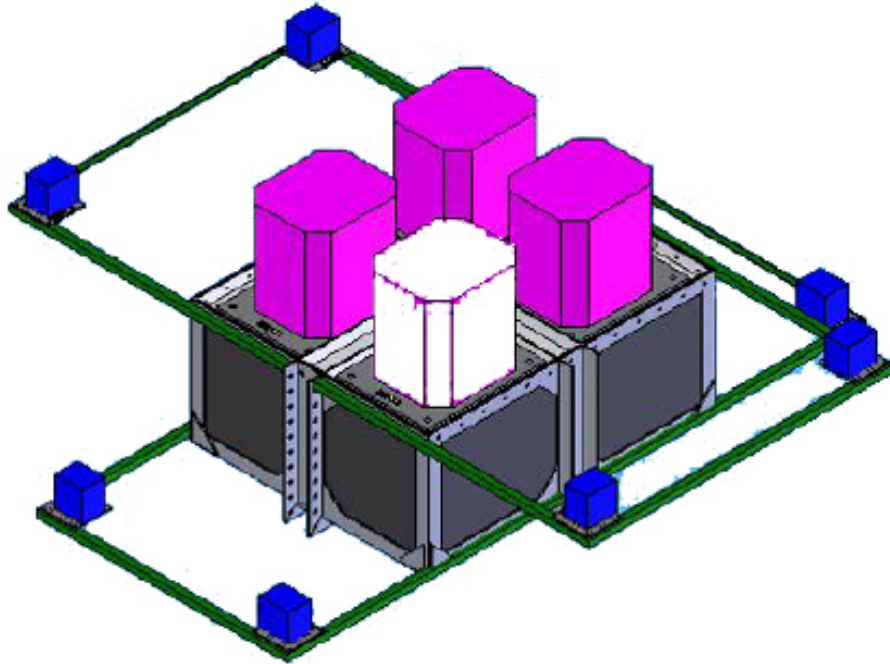
The importance of a safe grounding plan is recognized for the safety of personnel and the minimum interference (EMI) to all experiments flying on HASP. We were able to avoid ground loop problems in the DSTB, HASP 06, and HASP 07 experiments with the use of the dc-to-dc converters and careful attention to grounding straps and shielded cables for communication between the controller and instruments. Further attention is needed however in that our DSTB data showed periods of EMI which could likely be eliminated by additional shielding and testing under strong EMI conditions, though HASP 06 and HASP 07 showed minimal problems.

### **Structure**

Our modules will be designed to attach flush with the mounting plate and with appropriate constraints to ensure the vertical and horizontal shock parameters. Our instruments will be designed and tested for these parameters. An additional level of security is given in that the instruments are fully contained within the module.

## Figure 2: UAH IR Experiment Configuration

Our instruments will be housed within one of the larger payload slots. Any of the four available positions are capable of fulfilling our requirements. Shown below is just one option for positioning. Our team is open to other options if they fit the needs of the HASP gondola.





**Figure 3: Individual IR sensor housing and components**

